Climate Smart Dairy Cattle Feed Resources and Manure Management Innovations for Productivity Enhancement in Urban Areas of Uganda



Dairy cattle feed resources innovations



Dairy cattle manure management innovations

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DEDICATION

*This book is dedicated to **the women dairy cattle farmers in Uganda.** The women are largely responsible for feeding, watering, and milking the cows as well as cleaning the stalls and managing the manure. These are activities that must be undertaken every day or the health and productivity of the cow will be jeopardized. Dairy cattle farming has led to positive changes in the lives of women farmers, economically and socially. The women have become very stable, financially, and are able to increase their daily milk output. Socially too, women feel they are better recognized now than before. Today, women have roles to play on behalf of other female farmers in the dairy sector. Women should therefore be supported with improved technologies, innovations and management practices to participate in dairy cattle production as a full time employment with sufficient income generated on a regular basis.*

ABBREVIATIONS/ACRONYMS

%	Percent
AI	Artificial insemination
AMS	Automated Milking Systems
ARTs	Assisted Reproductive Technologies
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
AU-IBAR	African Union-Inter-African Bureau for Animal Resources
AWARD	African Women in Agricultural Research and Development
AWARFA-N	African Women in Animal Resources Farming and Agribusiness Network
BSFL	Black soldier fly larvae
BSG	Brewery spent grain
CIP	International Potato Center
CMR	Calf Milk Replacer
CMT	The California Mastitis Test
COB	Clot-on Boiling
CSA	Climate-Smart Agriculture
Cu	Copper
DAFAN	Dairy Farmers Network
DANIDA	Danish International Development Agency
DDA	Dairy Development Authority
DE	Diatomaceous Earth
DM	Dry Matter
EU	European Union
FAO	Food and Agriculture Organization
Fe	Iron
g/ml	grammes per millilitre
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GPS	Global Positioning System
HTST	High Temperature Short Time
ICT	Information Communication Technologies
ILO	International Labour Organization
ILRI	International Livestock Research Institute
IPM	Integrated pest management
IUI	Intrauterine Insemination

KARLO	Kenya Agricultural and Livestock Research Organization
KCCA	Kampala Capital City Authority
kgs	Kilogrammes
KIPPRA	Kenya Institute for Public Policy Research and Analysis
KPIs	Key Performance Indicators
LAB	Lactobacillus
LOS	Line of Separation
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
MAS	Markers Assisted Selection
Mn	Magnesium
MOET	Multiple ovulation and Embryo Transfer
NAADS	National Agricultural Advisory Services
NAGRC&DB	National Animal Genetic Resources Centre and Databank
NaLIRRI	National Livestock Resources Research Institute
NARO	National Agricultural Research Organization
OECD	Organisation for Economic Cooperation and Development
ONBP/ CNBP	Open and Closed Nucleus Breeding Programs
PKC	Palm Kernel Cake
PLF	Precision Livestock Farming
PPE	Personal Protective Equipment
SDGs	Sustainable Development Goals
SNF	Solids Non-Fat
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TMR	Total Mixed Ration
UBOS	Uganda Bureau of Statistics
UFAAS	Uganda Forum for Agricultural Advisory Services
UHT	Ultra-High Temperature
UN	United Nations
UNBS	Uganda National Bureau of Standards
UV	Ultraviolet
VUST	Valley University of Science and Technology
Zn	Zinc

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FOREWORD

Livestock farming is integral to Uganda's agricultural economy, contributing about 9% to the national Gross Domestic Product (GDP) and supporting approximately 58% of rural households. The sector provides a variety of products, including meat, milk, eggs, hides, and manure, which are essential for both domestic consumption and export. Additionally, livestock serves as a source of financial security and social status in many communities. Over the years, the development of livestock farming in Uganda has seen substantial progress, driven by various government initiatives, private sector involvement, and international support.

The dairy cattle industry contributes to food and nutrition security. Due to the potential positive effects on household poverty reduction and foreign currency reserves, the dairy sector has gained a solid place on the list of priority commodity value chains for Government of Uganda interventions in the medium to long term.

The number of farmers particularly the women keeping improved dairy cows in urban areas of Uganda has increased during the last 10 years. This could be due to the high demand for dairy products by the increasing population in urban areas; the need to improve household nutrition; and to provide an alternative source of income. With the recent advances in breeding technologies, many farmers have gained access to high-quality dairy cattle genotypes. However, inadequate feed supply and inappropriate manure management have been identified as some of the major constraints affecting profitability of dairy cattle enterprise in urban areas.

Inadequate feed supply in urban areas is due to many interacting factors, which include among others, shortage of land due to increased human population, high cost and/or poor quality of feeds, lack of knowledge on alternative feed resources, labour shortage, water scarcity and climate risks. The bulk of the agricultural food is transported from rural areas to urban areas in its raw form, thus compounding the net effect on large deposits of agricultural wastes in urban food markets, around homes and in slums as well as in various dumping grounds thereby polluting the environment and becoming hazardous to human and animal health. Some of these agricultural wastes have high nutritional composition that make them suitable for use as partial substitutes for conventional feeds in dairy cattle diets with advantages such as lower environmental impact, greater abundance, and lower cost compared to conventional feeds.

Inappropriate dairy cattle manure management in zero grazing units is a source of flies, odour, conflict with neighbours and human and animal diseases. Cattle manure can be processed into products such as: fuel for heating (biogas and briquettes); electricity; fertilizers; pesticides; liquid soap; paper; bathing soap; shampoo and hand wash. The methane, or natural gas from biogas production can be used as fuel for cars and generators. Conversion of cattle manure into commercial products subscribes to a sustainable urban dairy cattle production system and a source of income for youth and women.

This publication is intended to provide farmers, service providers, researchers, policy makers, youth and extension staff with innovative and practical technologies to address the challenges of inadequate feeding and poor manure management in dairy cattle production systems in urban areas. The information in this book will go a long way to improve the dairy cattle sector in the whole of Uganda and neighbouring countries.

Dr. Enos Rwasheema (PhD)
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We extend our sincere appreciation to the dairy cattle farmers in Uganda. Thank you for providing us with the finest dairy products and for your unwavering commitment to quality. Dairy cattle farming is a “labour of love” that requires passion and commitment 365 days a year. A stressful life is ‘a silent killer’--- a cow is a great friend that will always cheer you up and keep you inspired.

It is not be possible to name each and every one of those who have sacrificially contributed to the production of this book. May you please accept this note as a gesture of appreciation to your contribution for so you highly deserve.

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PROF. JOLLY MARY L. KABIRIZI has had an illustrious career as a farmer, researcher, trainer, and consultant whose work has greatly benefited the agriculture sector not only in Uganda but also across many countries. A strong advocate for *"practicing what she preaches,"* she has coordinated and implemented numerous research and development projects, particularly aimed at improving smallholder dairy cattle farming in Uganda, Kenya, Rwanda, Burundi, Tanzania, and Ethiopia (among other nations). She has introduced, evaluated and promoted 30 forage species to improve feed availability and dairy cattle productivity. She has supervised and women, students at undergraduate, Master's degree and PhD levels.

She has collaborated with various national and international organizations and donors, including Heifer International; Ministry of Agriculture, Animal Industry and Fisheries; Send-a-Cow; International Potato Centre (CIP); Danish International Development Agency (DANIDA); African Union –Interafrican Bureau for Animal Resources (AU-IBAR); European Union (EU); African Women in Animal Resources Farming and Agribusiness Network (AWARFA-N); Uganda Forum for Agricultural Advisory Services (UFAAS); International Livestock Research Institute (ILRI- Kenya and Ethiopia); the World Bank; Kenya Agricultural and Livestock Research Organization (KARLO); Food and Agriculture Organization (FAO) of the United Nations (UN); the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) and others.

For most of her career, Prof. Kabirizi served as a Senior Principal Research Officer at the National Livestock Resources Research Institute (NaLIRRI) (1975-2018). She has published 150 manuscripts in various peer reviewed Journals and conference proceedings and authored farmer's manuals and books. She has shared the vast knowledge generated from her research widely through countless farmers' conferences, workshops, seminars and clinics. She served as an Assistant to the Presidential Advisor on Agriculture in Uganda (1991-1992). She is a recipient of several local and international awards including the top 12 winners of 2014 Uganda Best Farmers Competition; best presenter during local and international scientific conferences; top 5 winners of the *"2014 All Africa Young Professionals and Women in Science Competition Finals held at Ghion Hotel, Addis Ababa, Ethiopia"* and 2017 International Women Day Presidential Golden Jubilee Medal.

Her Kyakuwa Farm in Seguku, Cell 4, Makindye Ssabagabo Municipal Council, Wakiso District, has proved a multi-functional resource hub for farmers over the years. Through the farm's initiatives, she has worked to realize her hearty objectives of empowering communities, enhancing agricultural productivity and promoting resilience against climate change. Today, the farm plays a vital role in shaping the future of urban agriculture in East and Central Africa, solidifying its place in the region's agricultural landscape. After retiring from public service, Prof. Kabirizi has dedicated herself to working as a local and international consultant, focusing on improving smallholder dairy cattle production, mentoring students especially fellow women and packaging information for farmers, policy makers, and youth. She was appointed a Professor at Valley University of Science and Technology in Bushenyi district, making for a worthy crowning of her robust academic journey which features a Bachelor's degree, a Master's degree, and a Doctorate of Philosophy (all in agriculture from Makerere University) and many post graduate certificates (from within and outside Uganda) in the field of dairy cattle production. **Contact:** (E-mail: jmkabirizi@gmail.com).

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improve livelihoods. Throughout his career, Mr. Asiimwe has been dedicated to bridging the gap between theory and practice. As the Head of the Agriculture Department, he strives to inspire and mentor students, equipping them with the skills and knowledge needed to make meaningful contributions to the agricultural sector. His work extends beyond the classroom, as he actively engages in community outreach programs, promoting sustainable farming practices and rural development initiatives.

His life's mission is to empower individuals through education and to champion innovations that transform agriculture into a more efficient, inclusive, and environmentally friendly industry. When he is not working, Asiimwe enjoys spending time in nature, exploring new agricultural techniques, and contributing to projects that enhance community resilience. He is committed to making a lasting impact in the field of agriculture and education.

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ROBERT MUMBERE is a Ugandan youth passionate about farming. He is currently working as a Farm Manager at Valley University of Science and Technology. He is also a student at VUST pursuing Bachelor's degree of Agribusiness Management and Rural Development. Mumbere has attended and conducted several agricultural workshops and trainings organized both locally and nationally which have equipped him with vast expertise with knowledge on various agricultural value chains and climate smart farming innovations. He worked with Keirere Green Africa Agency (KEGRA) an NGO in Bushenyi town as Assistant Farm Manager from 2021-2023 among other farming community organizations in western Uganda.

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VALLEY UNIVERSITY OF SCIENCE AND TECHNOLOGY (VUST) campus is located in Bushenyi town, along Mbarara-Ishaka Highway, approximately 54 kilometres, by road in the Western Region of Uganda. VUST is a private University licensed by the National Council of Higher Education under Reg no. UI.PL.028. It is wholly owned by Mukaira Foundation Limited, a company limited by shares, incorporated in Uganda. The objective is to bridge the gap by supporting Government in promotion of sciences. In October 2015, the proprietors of the University received accreditation from the Uganda National Council for Higher Education, to start the institution. The vision of VUST is to be a leading university for societal transformation through science and technology. The mission is to develop skills, innovations and new technologies to enhance societal development. The university objectives are to: (a) deliver high-quality student-centered education that fosters critical thinking, and problem-solving skills using "hands-on approach"; (b) promote a culture of research excellence by supporting research initiatives, and promoting interdisciplinary collaboration; (c) promote innovation among students, and staff by providing opportunities for innovative solutions for societal challenges and; (d) engage with various stakeholders to address community needs.

NATIONAL LIVESTOCK RESOURCES RESEARCH INSTITUTE (NaLIRRI) is one of the 16 semi-autonomous Agricultural Public Research Institutes of National Agricultural Research Organisation (NARO) established by the Uganda's National Agriculture Research act of 2005. NaLIRRI is mandated to carry out livestock research in relation to health, nutrition, breeding, socio-economics, Marketing and Apiculture. NaLIRRI headquarters are currently at Nakyesasa in Namulonge Wakiso District and soon it will be relocated to Maruzi, Akokoro sub-county in Apach District.

CHAPTER 1: DAIRY SUB-SECTOR POTENTIAL IN UGANDA

Livestock farming is a vital component of Uganda's agricultural sector, contributing significantly to the nation's economy and rural livelihoods. The sector provides a variety of products, including meat, milk, eggs, hides, and manure, which are essential for both domestic consumption and export. Over the years, the development of livestock farming in Uganda has seen substantial progress, driven by various government initiatives, private sector involvement, and international support. The National Livestock Census Main Report (2021) revealed that there were about 6.8 million households that were keeping at least one livestock type.

Under the livestock sub-sector, the dairy cattle industry has become the most important industry in terms of its growth and contribution to Uganda's exports. The dairy industry employs over 4.5 million people who are engaged in various economic activities along the dairy value chain, particularly in milk production, collection, bulking and transportation, processing, distribution and marketing as well as provision of inputs and support services.

Milk is one of the commodities selected by the Government of Uganda under the Vision 2040 development framework *"A transformed Ugandan society from a peasant to a modern and prosperous country within 30 years".* From a livelihoods perspective, the dairy sector provides perhaps the one commodity, "**milk**" that is available most of the year. Apart from providing body needs, milk is a source of income and employment, when processed into various products like butter, yoghurt, casein which is a special protein used to make specialized feeds for athletes, cheese production among others. Ugandan milk production is largely dominated by smallholder farmers who own over 90 percent of the national cattle population. Due to the potential positive effects on household poverty reduction and foreign currency reserves, the dairy sector has gained a solid place on the list of priority commodity value chains for government intervention in the medium to long term.

1.1. Smallholder Dairy Production Systems in Uganda

An estimated 80 to 90 percent of milk in developing countries such as Uganda is produced in small-scale farming systems. These operations are based on low inputs, so production per dairy animal is quite low. Most milk produced by smallholders in developing countries comes from one of the following production systems:

1.1. 1. Rural Smallholder Dairy Cattle Production System

Dairying is often part of a mixed farming system in which manure is used for cash crop production. Dairy animals are fed on grass, crop residues and cultivated fodder. Supplementary feeding is practised only when feasible.

1.1.2. Pastoral/Agropastoral Dairy Cattle Production System

These systems are land-based and milk is often the most important subsistence item. Dairy production is generally associated with cropping, but nomadic pastoralists practise little or no agriculture and roam the land in search of grazing grounds and water.

1.1.3. Semi-Intensive Dairy Cattle Production System

Farmers usually mainly keep pure or cross-bred cattle of East African Zebu or Ankole and Holstein Friesian in kraals, paddocks and cattle barns/stalls and feed them with high-quality feed comprising of cultivated pastures, concentrate feed as well as crop residues. Average herd size varies between 1 to 5 animals for small farms; 5 to 15 animals for medium farms, and of more than 20 animals for large farms. In most cases, animals are crossbreeds. The major products are milk and beef.

1.1.4. Intensive Dairy Cattle Production System (Zero Grazing System)

Intensive dairy cattle production in Uganda is a system where 1 to 10 pure or crossbred cattle are housed or confined ("stall feeding" or "zero grazing") and fed on fodder and sometimes concentrates. The main feedstuff under intensive dairy cattle system include high yielding fodder crops such as napier grass commonly known as elephant grass, Giant Setaria, Guatemala grass, in addition to crop residues and supplementation with concentrates. The system is both capital and labour intensive, and mainly practised in urban and peri-urban areas where land is scarce. The system is on the rise in these areas due to ready market for milk and other livestock products that include skin and hides, cheese and butter.

1.1.5. Landless Urban Dairy Cattle Production System

In Uganda, gazetted cities, municipalities and town councils are defined as **urban areas** as per the Local Government Act 2000. Regardless of the population size, all district headquarters are urban areas by law because they are located in Town Councils and all Town Councils are urban areas. Urban development is listed among the key fundamentals in Uganda Vision 2040 to be harnessed due to the key role it plays in the development process. According to the FAO report (2019), Uganda's human population is expected to more than double by 2050 and 44% of the people will live in urban areas compared to the 22% today. The report adds that the Gross Domestic Product per capita will increase by 175% and consumption of livestock products will more than triple. On the other hand, the report adds that cattle population that is supposed to feed the needs of the growing population will slightly reduce. That means farmers keeping dairy animals will have to be more innovative so as to raise the cows in an intensive or semi-intensive production system.

Properly planned urban development aids the provision of basic services for the growing population, promotes clean living and sustainable urban areas hence enhancing production and improving standards of living. Urban population in Uganda was reported at 13,005,977 in 2023, according to the World Bank report. More than one in five Ugandans are residing in urban areas and the urban population is expected to triple in the next two decades.

Much as dairy farming is viewed as a profitable venture in a spacious land or farm in the countryside, this has changed in recent times due to the growing population that is in need of land for settlement and cultivation of foods.

Smallholder dairy cattle farming is emerging as an important component of the milk production systems in urban areas of Uganda. More dairy farmers have since shifted to urban areas where people are keeping 1-10 dairy cows. It is based on pure (Friesian, Ayrshire, Jersey and Guernsey) and/or their crosses. The system is contributing immensely towards filling in the large demand–supply gap for milk and milk products in urban areas, where consumption of milk and milk products is remarkably high. Existence of dairy farming is mainly motivated by availability of good market for dairy products; agricultural and agro-industrial by-products which can be processed into high quality feeds; need for creation of employment opportunities and financial constraints of urban dwellers. Urban areas have limited space for dairying and due to small land holdings, "intensive or zero grazing dairy cattle production system" is common. In this system cattle do not graze but are rather confined in a shed or stall where feed and water are brought to them.

Opportunities of Landless Urban Dairy Cattle Production System

- Urban dairy cattle farming provides a source of income for many families and youth. It creates jobs for farm workers, veterinarians, and other support services.
- Provides fresh milk and dairy products to urban populations. Urban consumers are willing to pay premium for fresh, high-quality dairy products.
- Contributes to better nutrition, especially for vulnerable groups.

- Decreases reliance on long-distance milk transportation, preserving product quality.
- The system utilizes agricultural and agro-industrial wastes from markets and farms as feed, reduces transportation emissions, and promotes sustainable agriculture.
- Urban dairy cattle farming fosters community engagement and social cohesion
- Supports genetic diversity and preservation of dairy cattle breeds.
- Encourages adoption of efficient, space-saving dairy farming practices.

Challenges Affecting Profitability of Urban Dairy Cattle Production System

Challenges affecting profitability of dairy cattle enterprise in urban areas frequently mentioned by farmers are described below (not in order of importance).

1. Land Scarcity

Dairy farms in urban areas are under remarkable pressure to expand production mainly due to rapid urbanization and human population growth. Most farmers keep their dairy cows within their own residence compound. In rural areas farmers have many animals and large hectares of land compared with those living in the town/urban.

2. Shortage of Feed Resources

Feed shortage due to land scarcity and lack of knowledge on alternatives feed resources are some of the limiting factors for increasing production and productivity of dairy cattle in urban areas of Uganda. Feeding strategies vary according to factors as social categories, household income and distance to the city centre. Commercial dairy farms located in urban areas purchase conserved feeds and fodder for their animals. As a result, feed makes up over 60 percent of the operating expenses. In addition, the system is extremely profit-driven and intensive feeding of a lot of concentrates to the animals to increase milk production. Resource-poor farmers make the best of what they have. Some farmers lack the financial means to buy commercial feed and the labour availability to collect or cut feed while producing fewer household residues. In most urban areas, roadsides, school and church compounds, swamps and empty plots on the outskirts are a source of cut grass, and/or are used to produce green fodder. In addition, agricultural and agro-industrial by-products are used. Dairy cattle farmers have adopted feeding strategies based on conserved forages (hay, silage and haylage) because of the increasing number of farmers and youth who produce conserved feeds for sale. But for dairy farmers to remain in production, researchers in the livestock sector have outlined various feeds and feeding technologies that will help urban dairy cows to remain productive.

3. Shortage of Labour

Farm labour represents a major cost in dairy cattle enterprises and is increasingly becoming a key challenge facing dairy farmers in urban areas of Uganda. Although there is a labour market to bridge labour gaps in farm production, rising wage rates renders hiring labour prohibitive and tremendously erode net benefits. Many potential workers particularly the youth prefer to be engaged in informal, less labour-intensive and probably better paying jobs.

4. Genotype Related Constraints and Reproductive Wastage

Improved cross breeds and pure exotic dairy cows and heifers are in short supply and when available the high cost is a major problem. Reproductive efficiency is a critical component of profitable dairy cattle operations. Low fertility reduces the profit by decreasing average milk production and the number of calves per cow per year. Reproductive performance is influenced by the interactive effect of genetic, environment, management, and animal health factors.

5. High Cost of Artificial Insemination (AI)

Artificial insemination (AI) is very important for genetic improvement, especially in dairy

cattle breeds. Limitations of using artificial insemination include:

- Failure to detect heat is one of the major causes of low reproductive efficiency on farms.
- Skilled personnel are required to carry out proper insemination.
- Timely communication to the inseminator for timely insemination is needed.
- Lack of AI inputs, for example, liquid nitrogen is a major setback to proper functioning of an AI system.
- If selection of AI bulls is not done properly, undesired hereditary defects can be widely spread within a very short time.
- The regular use of AI in a certain area requires a well-organized AI system with continuous recording and monitoring and well trained AI personnel (inseminators).

6. Water Scarcity

Water is a very important nutrient for the dairy cow to maintain body functions and for milk production. However, this important resource is not adequate in most parts of urban areas of Uganda. Dairy cattle keeping competes for water resources with humans as the demand for water for this activity is not taken into account by the supply services. Moreover, water availability varies between locations and dairy farms located in urban areas face acute shortage of water. As a result of water shortages during the dry season, free water intake of lactating dairy cows is reduced and limits milk production and reduce health status. In many slum areas water has to be bought and therefore other water sources, which are often contaminated, are accessed for livestock.

7. Animal Health Problems

Diseases affect reproduction, milk production, milk quality and cause for mortality and morbidity of dairy animals and calves. The animal health services provided are insufficient, the cost of drugs is very high and sometimes the drugs are adulterated, while the diagnostic services are not readily accessible to the dairy farmer.

8. Limited Knowledge on Livestock Husbandry Practices

Adequate and effective extension services, advice on animal feeding management, training in milk handling, processing and marketing, hygiene, disease control, reproduction, farm management and dairy production efficiency are not always available to farmers. A shift towards a developed urban and peri-urban dairy cattle production system requires more support from consultative services and more active links with research services.

9. Weak Extension-Researcher-Farmer Linkage

The flow of information systems from agricultural research such as new technologies, extension service and policy to dairy cattle farmers is weak. This weakness is partially from the absence of sound linkage polices in the agricultural knowledge generation and transfer systems. There are shortages of qualified personnel, poor education and management expertise of farmers, ignorance of the experience and knowledge of local farmers, lack of knowledge gained through research to farmers, absence of forums for consultation and discussion with the farmers.

10. Limited Availability of Credit to the Dairy Farmers

The credit services existing to dairy cattle production is by far minimal compared to crop production. Women face significant barriers when it comes to accessing credit, largely due to the fact that they are less likely than men to own fixed assets such as land or property. Fixed assets are commonly used as collateral in traditional lending models, which puts women at a disadvantage.

11. Improper Dairy Cattle Manure Disposal

Dairy cattle manure disposal is a serious problem in urban areas. Cow dung is often disposed of in piles, which can lead to significant emissions of the greenhouse gas

methane, as well as environmental degradation, negative health impacts, and the loss of valuable nutrients that could be added to soil. Poorly managed cow dung and urine is a source of bad odour and flies, source of conflict with neighbours, and source of zoonotic diseases. Dairy farmers in urban dairy system complain that manure disposal incurs cost.

12. Impact of Climate Change and Environment on Dairy Farming

Direct negative effects on the climate from dairy cattle farming include the emission of enteric methane that arises from the digestion of plant material within the cow; or methane emission from manure, where similar fermentative processes continue even after the digestive process is complete. Dairy cows have difficulties coping with extreme heat and increased temperatures often lead to lower milk yields, and higher susceptibility to diseases and other physical problems. So heat stress is one problem that might become a more critical issue for dairy farming in the future.

The production of milk requires a number of resources that might decrease in the future, such as fossil fuels, quality soils, and water. Large quantities of water are needed to produce milk during feed production, animal husbandry and the milking process. If water becomes a limited resource due to drought, milk production faces big problems**.**

As extreme weather events become more frequent, ensuring a constant supply of high quality feed and fodder for dairy cows will become a concern. Having lower yields of forage due to extreme climatic events results in serious problems in providing enough high quality feed for dairy cows and an increase in costs for the farmers having to buy in additional feed.

13. High Prices and/or Poor Quality Inputs

An increase in input costs can shift the aggregate supply curve to the left, resulting in decreased overall supply and potentially higher prices. Common factors contributing to rising input costs include wage increases, higher prices for raw materials, and increased energy costs.

CHAPTER 2: FACTORS TO CONSIDER WHEN STARTING AND MANAGING A PROFITABLE DAIRY CATTLE BUSINESS IN URBAN AREAS OF UGANDA

Starting and managing a profitable dairy cattle enterprise in urban areas presents unique challenges and opportunities compared to traditional rural settings. There are many factors to consider but a farmer should *"venture into dairy cattle farming not purely for the financial gains, but because you are passionate about it".* Dairy farms take capital to start up, way more than a meat operation does. Some of the factors to consider when setting up and managing a profitable dairy cattle business in urban areas are described below:

1. Local Regulations on Keeping Livestock in the Area

Before embarking on urban dairy cattle farming, it is crucial to understand the zoning regulations and local ordinances governing livestock keeping in your area. Some urban areas have restrictions on the number of animals allowed per property, noise ordinances, waste management requirements, and other regulations that impact dairy farming activities. Consulting with local authorities can provide clarity and help you navigate compliance issues.

2. Develop a Business Plan

It is important to remember that a dairy cattle farm is a **business**. A **business plan** is a document that details a farm's goals and how it intends to achieve them. Business plans can be of benefit to both start-ups and well-established farms. Established businesses can find one useful for staying on track and not losing sight of their goals. It is important to consult experts in the dairy industry as you develop your business plan and design your management system. Development of a detailed Business Plan and analysis of your Strengths, Weaknesses, Opportunities, and Threats (SWOT) of your plan is critical to the success of your business (land, source of feeds, labour and capital to buy cattle, build shelters, inputs, equipment, overheads and others).

3. Understand The Market and Demand for Dairy Products

The market is crucial to make profitable dairy cattle farming business decisions. Research market for dairy products (milk, ice cream and others) which can command higher prices in niche markets. Explore collaborations with other farmers, competitors, processors, retailers and capture new market opportunities.

4. Choose Suitable Dairy Cattle Breeds

Selecting the right dairy cattle breed is essential for a profitable business. Consider breeds known for their adaptability to varying climates, good temperament, and productivity in smaller spaces. **Smaller dairy cattle breeds can be particularly suitable for urban environments due to their reduced space requirements, and manageable size.** Farmers should select good cross breeds because they do not only give high milk yield and high butterfat content, when managed properly but are also tolerant to some diseases. **Start with a few high yielding cows that you can manage well and expand later**. Remember, *"The man who moves a mountain begins by carrying away small stones".*

Characteristics of Common Exotic/Purebred Dairy Cattle Breeds in Uganda

Dairy cattle breeds can be categorized into purebreds (exotics) and crossbreds. Purebred dairy cattle are characteristically large consumers of forages and water, producing between 15 to 40 litres of milk per day, depending on factors such as nutrition, disease control, cow comfort and overall management.

Friesian

- Friesian breed is large, black and white marked.
- It produces about 8000 litres per lactation.
- Average butter fat content is 3.4%.
- A female Friesian weighs an average of 680 kgs.
- Due to its large body size, Friesian breed is characteristically the largest consumer of forage among the exotic breeds.

Guernsey

- Guernsey has yellow to reddish-brown with white patches.
- Milk has a golden colour due to high content of carotene which is a source of vitamin A.
- An Ayrshire cow weighs 450 – 500kgs while the bull weighs 600 - 700kg.
- Guernsey cow produces about 6000 litres of milk per lactation.
- Average butter fat content is 4.5%.

Ayrshire

- Ayrshire breed has white and red marks.
- The female weighs between 450 – 600kgs while a male animal weighs 635 – 900kgs.
- Ayrshire produces about 8000 litres per lactation.
- Average butter fat content is 4.0%.

Girolando

- The Girolando is a breed of dairy cattle created in Brazil by crossing Gyr cattle from India, a Bos indicus (Indian humped cattle) breed which is resistant to hot temperatures and tropical diseases, with Holstein cows, a Bos taurus breed.
- Coat colours vary from black to black-and-white.
- It is capable of yielding 30 to 40 litres of milk a day, and this can even go up to 60 to 70 litres under very good management.
- Average weight for adult dairy cattle is 617 kg.
- Average butter fat content is 4%.
- Girolando's reproductive efficiency is its strong point (short Service Period, ideal calving interval, and higher number of calves per cow).

Fleckvieh

- The body of Fleckvieh cattle is muted, pied, speckled from dark red-brown to light yellow on white base colour. Lower belly, feet, tail switch and head are mainly white.
- Average milk yield is 5825 litres during the first lactation, and over 6796 kg milk in the later lactations.
- Average butter fat content is 4.2%.
- Fleckvieh have a faster growth rate compared to than other beef and dairy breeds.
- If fed and managed properly a calf can weigh 300kgs in six months.

Jersey

- Jersey breed comes in all shades of brown from light tan to dark brown. They are frequently fawn in colour. All purebred Jersey cows have a lighter band around their muzzle.
- A female Jersey weighs 400 – 500kgs while a male Jersey weighs between 540 – 820 kgs.
- Jersey cow produces about 5700 litres of milk per year.
- Average butter fat content is 5.5%.

Managing a dairy cow in urban areas is more expensive than in rural areas because a farmer has to buy most of the feeds since they do not have land nearby to grow pastures. Even if a farmer has land outside the urban area where they grow pastures, they incur daily costs to transport fodder to the farm. To effectively cater for the cost of feeding and other expenses, the **cow should give you at least 20 litres/day during the first 3 months of lactation**. Good feeding entails using both fresh and dry feeds.

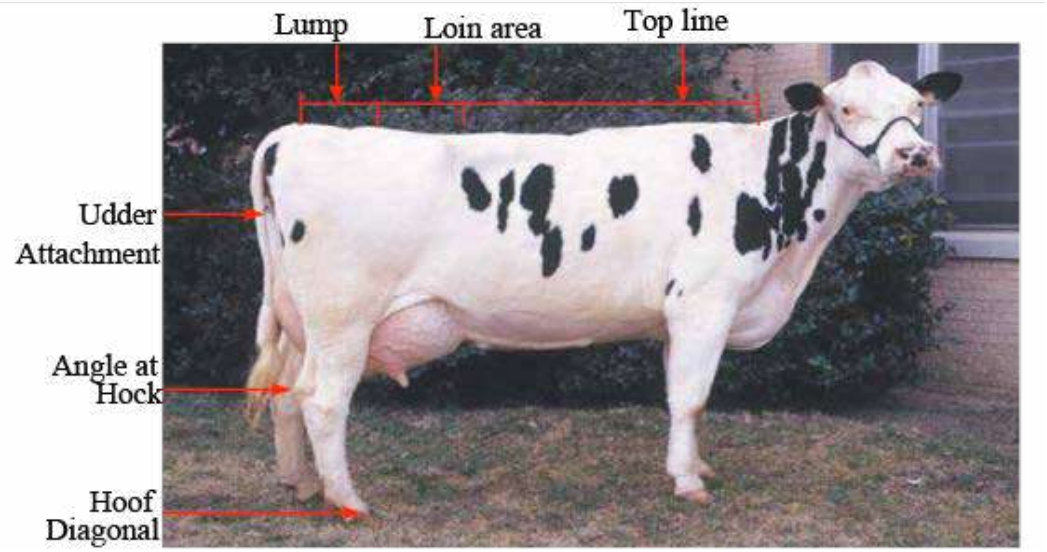
Important Traits to Consider While Buying a Dairy Cow

A black and white, brown or any other colour does not qualify that cattle to be a good dairy animal. The **production and reproduction records of her parent and the findings of the veterinary officer about the cow are key in dairy cattle selection.**

- Contact government institutions, universities, veterinary officers, and established dairy farms and ask for information/records to help you make the decision. Inspect all dairy animals personally before buying, including several milking tests.
- Ideally, purchase the animals right after calving, on its second or third lactation (when milk production is highest).
- Always buy disease-free animals, and keep them isolated from other animals during transportation to your farm.
- Quarantining new arrivals (and animals that fall sick) is recommended, especially if they do not have trustworthy, recent health records. Your local government or veterinarian can give you specific advice about diseases in your area.

Characteristics of a Good Dairy Cow

A cow with good dairy character is one who is sharp, particularly at the shoulders and withers, and one who shows no excess flesh or fat. A long, lean neck showing refinement and not coarseness is desirable. Thickness at the shoulders, neck, withers or thighs indicates a lack of dairy character. Table 1 shows some of the characteristics of a good dairy cow.



Characteristics of a good dairy cow (Source: Lukuyu et al., 2012).

Table 1. Some of the characteristics of a good dairy cow

Physiology	Character	Description	Desired
Size	Size	Stature (height in cm at rump or withers)	• Jersey = 120, Guernsey = 125, Ayrshire = 130, Friesian = 135
	Chest width	Distance between the front legs	• Should be large to give room for the heart and lungs
	Rump width	Distance between the pin bones	• Should be big to ease calving and allow wide rear udder attachment
Dairy character	Angularity body frame Dairy type	Reflects the appearance that the cow has the will to milk	• Rib structure: ribs wide apart, rib bones wide, flat, long and free from excess flesh • Neck: long, lean and blending smoothly into shoulders • Barrel: width tending to increase towards rear
	Rump angle (pelvic angle)	Angle from hooks to pins	• Pins should be slightly lower than hooks (about 2.5 cm). Improper angle can hinder reproductive performance and mobility
	Topline	Level of backbone from shoulders to pelvis	• Should be strong and level
Udder	Fore udder attachment	Attachment to trunk	• Attachment of fore udder to trunk should be almost level
	Udder depth	Distance between bottom of udder and ground in relation to height.	• Should be shallow and above the hock. Deep udder is prone to injury. Consider age and stage of lactation
	Rear udder height	Distance between vulva and udder fold	• Should be attached high
	Udder suspension	Udder cleft—suspensory ligament	• Should be clearly visible and continue upwards. Should be strong to keep udder firm and prevent teats • From pointing outwards
	Teat placement	Direction of teats	• Should point straight down or slightly inwards (for ease of milking)
	Teat length		• 5 cm ideal for machine milking; slightly longer for hand milking
Legs and feet	Rear leg set	Angle at hock viewed from side should not be straight	• Ideally, pin bone, hock and dew claw should be in one line. Should be • Straight from the rear
	Hoof diagonal	Distance between point of toe and top of heel	• Intermediate desirable

***Source**: Lukuyu et al., 2012).*

Challenges Farmers Face When Purchasing Dairy Cows

Many farmers/traders are selling cows or in-calf/heifers to farmers in urban areas due to the high demand for milk and milk products. However, the **following serious challenges have been noted regarding some of the cows that are sold to farmers**:

- Currently, a crossbred in-calf cow (second lactation) purchased from Uganda costs about Ushs 6 million. A cow purchased from Kenya costs over Ushs 8 million.
- Disease-carrying ticks are a major problem for cows bought from some areas of Uganda. Some farmers practicing open grazing system have reported cases of acaricide resistance. Traders transport cows from these farms to urban areas with no cases of ticks. Healthy looking cows may be carrying a disease to another farm.
- Cows kept under open grazing take 2-3 weeks to adjust to zero grazing production system. During this time, cows lose weight and this affects their performance.
- Majority of farmers who keep cows under open grazing system do not keep proper records but they convince a farmer/trader that the cow produces more than 20 litres/day. The truth is, many cows that are sourced from farms practicing open grazing system produce less than 15 litres/day (at peak period, 3 months after calving) even under very good feeding and management. This is not economic under zero grazing system.
- Majority of farmers sell their cows when they cannot afford to feed them or if they are poor performers. **Very few farmers will sell their best cows**.

5. Create a Breeding Plan

Dairy bulls have a reputation for dangerous behaviour, and in any case raising one all-year-round in an urban area gets expensive and can be dangerous. The safest and cheapest option is using artificial insemination (AI) or "embryo transfer".

6. Plan to Transform Your Herd

Whether to sell, slaughter, or keep an animal is one of the toughest questions for a dairy farmer. You must appreciate the fact that culling poor performing cows allows you to enhance the genetic quality of your herd by replacing a low-yield animal with a higher milk yielding replacement. Both of those factors are important, but perfecting them without a plan lead to massive costs on every single decision you make in the herd, especially costs on replacement animals. Take this into account in your business plan, and include the cost/profit of producing each male and female calf as well as raising them.

7. Plan for Space and Housing

Urban dairy cattle farms often operate with limited space, so efficient use of available area is key. Design a functional layout that includes space for cow and calf housing; feeding, treatment and resting areas; milking facilities and storage. Utilize vertical space for feed storage or equipment to maximize ground space. Provide comfortable and well-ventilated housing for dairy cows, heifers and calves ensuring they have access to clean bedding, shelter from weather extremes, and adequate ventilation to prevent heat stress and maintain air quality.

8. Invest in Capital

A farm requires a large one-time expenditure to get started. Make sure you have the following facilities:

- a sterile facility for storing milk, and for pasteurizing if required in your area;
- dry, sunny sheds protected from bad weather;
- milking parlour;

- a cattle crush for holding the animal safely while they are examined, marked, or given veterinary treatment;
- feed and manure storage areas;
- forage chopping area;
- separate living space for calves;
- equipment (forage chopper, milking machine etc) storage area ;
- a store for farm inputs and;
- a reliable source of high quality feeds and water

9. Consult the Experts

Attend field days and farmer workshops in your area and other parts of the country *("Once you stop learning, you start dying")*. When visiting other farms find out what has worked well on those farms and what has not worked well. Do not "**copy and paste**" technologies from other farms. *"Unfortunately, while copy and paste has a lot of benefits, sometimes it simply can't do everything for you. The copy function will only copy exactly what you select and the paste function will follow a set of rules that might not produce a result that is exactly what you were hoping for – so if you don't take a little extra care when using copy and paste you can run into problems"*. Keep in mind that, *"Just because something worked well on one farm does not mean it will produce similar results on your farm"*. In addition to farmers, talk to veterinarians, nutritionists and others that can provide different perspectives on management of your dairy.

10. Education and Community Engagement

Engage with your local community to educate neighbours about urban dairy cattle farming practices and address any concerns they may have. Demonstrating improved farming practices, transparency, and willingness to address issues can foster goodwill and support for your urban dairy operation.

11. Feeds and Feeding Management

Inadequate supply of feed both in quantity and quality is the single most important problem for low productivity of dairy cows in urban areas of Uganda. Maintaining a balanced diet is crucial for the health and productivity of dairy cows. Due to limited grazing opportunities, most dairy farmers in urban areas rely on purchased feeds (hay and/ or silage and pastures from roadsides). Work with a livestock nutritionist to formulate diets tailored to meet the specific nutritional needs of your cows based on their age, lactation stage (if applicable), and health requirements.

- Dairy cows have high nutritional requirements compared to animals raised for meat. Improper nutrition leads to low milk (quality and quantity), loss in body weight and long calving intervals.
- Cows require fresh/green fodder, hay, silage, agricultural and agro-industrial by-product feeds; concentrates, mineral supplements and water. Chop fodder for easy chewing.
- Conserve surplus fodder for periods of feed scarcity.
- You can cut down feeding costs by renting land to produce some of the feeds.
- A farmer in an urban area should make use of agricultural and agro-industrial by products as long as they are not mouldy or dirty.
- Mouldy feeds or feeds stored in the same area as pesticides and other contaminants can transfer dangerous toxins to the milk.

12. Veterinary Care

Maintaining good health is paramount for dairy cows. Establish a relationship with a veterinarian experienced in dairy cow care to provide routine check-ups, vaccinations, and timely medical treatment when needed. Monitor cows closely for signs of illness or stress, and implement preventive measures to safeguard their well-being.

13. Manage Manure , Odour and Flies

Effective manure management is essential in urban settings to minimize odour, flies and environmental impact. The stench and flies associated with manure that is not properly disposed of is a serious environmental concern for residents in the same neighbourhood. Concentrating high population of cows in one place means millions of litres of slurry to dispose of, enormous amounts of greenhouse gases contributing to climate change, water pollution, disease spread and ammonia damage to wildlife. Cattle are known to produce methane, one of the greenhouse gases with adverse environmental effects owing to their role in global warming. Every farm will need a manure management plan, but depending on the size of your farm a nutrient management plan may also be required.

14. Cow Comfort

Cow comfort refers to the overall well-being and living conditions of dairy cows, focusing on their physical and mental health. It encompasses various aspects of their environment, management, and care to ensure they are comfortable, stress-free, and able to perform optimally.

15. Consider Noise Mitigation

Addressing potential concerns such as noise is crucial for maintaining positive relationship with neighbours in urban areas. Implement soundproofing measures if feasible, especially around milking or feeding times.

16. Record Keeping

Proper records help you plan ahead, calculate the worth of your business and profit. You should always keep good records of finances, feeding, milk yield, breeding, disease control, calving, vaccinations, purchases, sales, assets, liabilities and everything else in your operation. Financial records are the most important records, because these records determine whether your operations and enterprise are economically viable and environmentally sustainable *("He who writes things down stays in business").*

17. You are a Manager First

In order to succeed you will need to combine each aspect of management into a whole farm plan. *"The footstep of a farmer is the best fertilizer"* and *"Telephone farming does not pay* (The closer you are to your animals each day, the easier it is to observe and respond to their needs). Work with trusted consultants to help you build a plan, and stick with your strengths. Consider creating a farm management team or profit team that engages your consultants to be active participants in the farm's progress. *"Together Each one Achieves More,* **TEAM** *work".*

18. .Motivate and Train Farm Workers

Many farm-workers face extreme occupational risks and exposures, suffer poorer-than-average health and have a life expectancy significantly shorter than average. Despite these challenges, some farm-workers are incredibly resilient. They work hard and strive to make a better life for themselves and their communities. Treat your workers well and incentive them whenever you can. Learn to forgive them when minor mistakes are committed, they are humans. Train and develop friendship with them but do not shout at them. If you harass your farm workers who do the hustle it will be to your own inconvenience and may even steer to expensive and terminal animal health issues and death. Some farm workers have been reported to mistreat animals as a sign of revenge for being mistreated by their bosses.

19. Diversify Revenue Streams

The primary advantage of diversification is risk mitigation. Relying solely on a single

product can leave your farm vulnerable to fluctuations in the market, weather-related challenges and other unforeseen issues. Multiple income streams can provide a buffer to help your farm weather financial uncertainties.

20. Boost Your Dairy Farm's Brand and Create Your Corporate Identity

In the dairy farming industry, where competition is fierce and consumer preferences are constantly evolving, establishing a distinct brand identity is crucial for the success of the dairy enterprise. By creating a strong, memorable brand, the business can differentiate itself from the competition, build customer loyalty, and effectively communicate its values and unique offerings to the target market.

Examples of Branding a Business

- Cultivate a distinct brand identity that resonates with your target audience.
- Optimize your online presence for improved local search visibility.
- Social media marketing is a powerful tool for dairy farming businesses to build brand awareness and connect with their target audience.
- Collaborate with influential community members to amplify your brand's reach.
- Implement sustainable packaging design to showcase your commitment to the environment.
- Offer transparent farm tours ("Agri-tourism") to provide consumers with a behind-the-scenes experience.
- Participate in local farmers' markets to build direct relationships with customers.
- Encourage employees to share their personal experiences and perspectives, further humanizing the brand and fostering a sense of authenticity.
- Develop a loyalty program to foster long-term customer engagement and retention.

21. Good Customer Service Always Helps Retain Your Customers

Very few customers will let a company know of their dissatisfaction after using their products or service. Others simply walk away and seek services from their competitors. Unfortunately, there are those who will share their bad experience with their friends, family, colleagues, and so on. And in this era of social media, others will publish their frustrations online thereby fast-tracking the spread of the bad experience they had to other customers and potential clients. Therefore, *good customer service is the backbone of an organization and companies should strive to offer the best experience possible to each customer it handles.* Customer service can be summed up simply as "*being prompt in relaying replies to queries, polite in our interactions with the customers, being professional with how we handle the complaints, and adding a personal touch along with that experience. Nothing can buy you a brand but your character".*

Benefits from Good Customer Care

(a) Business Growth

By providing outstanding customer service you make more money. When they experience great service, your customers are able to build trust in your organization thus they easily become repeat customers. Your customer service representatives and employees need to be friendly. You can also offer discount coupons and thank-you notes which go a long way toward cementing lasting relationships.

(b) Spend Less on Marketing

When your customers are satisfied they become your promoters and advocates. You in turn benefit by getting free, positive word-of-mouth marketing. This is considered the most effective and authentic form of brand-building.

(c) Happy Customers Spend More

You need to focus on the quality that your support team offers, to ensure they make customers feel happy and valued, which will directly impact sales. Research shows a customer's emotional experience during their interaction with your business affects how much they are willing to spend.

(d) Farm Reputation

A good reputation could be the difference between an average business and a very successful one. Bad news travels fast and far and is remembered more than good news. In fact, twice the people hear about a bad customer service experience than a good one. Therefore, you are better off taking time to address the issues that your customers have because this will enhance your company's reputation thereby leading to more customers in the future.

22. Embrace Sustainability Practices

Urban dairy cattle farming provides opportunities to integrate sustainable practices into your operations. Explore options such as rainwater harvesting for irrigation, solar energy for powering facilities, or composting, processing cow dung into products like shampoo, hand sanitizer and others to reduce waste. Emphasizing sustainability not only benefits the environment but also enhances the resilience and efficiency of your farm.

23. A Good Succession Plan Ensures Dairy Cattle Business Continuity

The term **succession planning** refers to a business strategy farmers use to pass leadership roles down to another family member, employee or group of employees. Succession planning ensures that farm activities continue to run smoothly and without interruption, after the farm owner **retires, in the event of unexpected events such as illness or death**.

Key Points to Consider

For this planning it is important to invite all family members who may be involved in the succession, be honest and open about your expectations and concerns and be willing to make compromises to reach an agreement in which everyone can help.

(a) Start Early: Time is of the Essence

The succession plan is a journey that must begin early in the life of the dairy farm, so that the transfer of responsibilities is gradual, making it a smoother transition. Family succession on dairy farms is a complex and multifaceted process, requiring meticulous planning and open communication between generations. Time, in this context, plays a crucial role, as negligence in starting the process sufficiently in advance can lead to serious consequences for the viability and future of the property.

(b) Open Communication and Family Dynamics

It is important to advise dairy farm owners to promote open and transparent dialogue between family members and key stakeholders. Therefore, communication must be clear and transparent in order to manage expectations, address concerns and align everyone's goals for the future of exploration. In a scenario where family succession plays a fundamental role in the perpetuation of dairy farms, open communication and family dynamics emerge as an essential pillar for the success of the process. This communication goes beyond the simple exchange of information, establishing a channel for transparent, respectful and constructive dialogue between the different generations involved.

(c) Talent Identification and Development

The farmer owner must begin to identify potential successors based on skills, knowledge and passion for raising dairy cows. Furthermore, it should encourage the next generation

to obtain education and experience by creating training programs to ensure that the next generation is well prepared to assume the succession.

(d) Financial Planning and Legal Considerations

Dairy cattle farmers must work with financial advisors to assess the current financial health of the farm and develop strategies to finance the transition must be emphasized. This includes considerations about tax implications, estate planning and potential sources of financing. Legal considerations are equally vital. Financial and legal professionals with experience in agricultural law should be recommended to draft and review documents such as wills, purchase and sale agreements and contracts, ensuring the legality and enforceability of these documents to protect the interests of all parties involved in the succession process.

Overall, urban dairy cattle farming has the potential to contribute significantly to the food security and economic development of Uganda. By adopting innovative technologies and practices, urban dairy farmers can overcome the challenges they face and improve their productivity and profitability.

CHAPTER 3: CLIMATE SMART DAIRY CATTLE FEED RESOURCES INNOVATIONS FOR ENHANCED PRODUCTIVITY AND ENVIRONMENTAL SUSTAINABILITY IN URBAN AREAS OF UGANDA

Due to population pressure in urban areas, land has been fragmented into small pieces, leading to low availability of grazing land. Zero grazing production system requires the cut and carry method of feeding where the recommended high yielding Napier grass *(Pennisetum purpureum)*, commonly known as elephant grass is an important fodder in Uganda and has been increasingly associated with stall-feeding/zero grazing production system. However, Napier grass fodder is expensive to get and also less available in urban areas due to limited land. As a result, dairy cattle are often underfed especially during the dry season when only poor quality forages and crop residues are available.

3.1. Dairy Cattle Nutrition Basics

The biggest cost on any dairy enterprise is the feed bill. The most important management tool of the dairy farmer is to feed his/her animals correctly. The following is a very basic outline of the nutritional requirements of dairy animals.

Calf: A poorly grown calf will never be a top-producing cow, no matter how good the breeding. It is essential that the calf receives colostrum within 6 hours (preferably 2 hours) of birth at a rate of 10-15% of birth weight. She should get colostrum for the first 5 days of life; 2-4 litres/day depending on breed and birth weight.

At one week of age, the calf should be introduced to calf starter meal. One kg of calf starter meal is nutritionally equivalent to 2-2.5 litres of milk at a fraction of the cost, so the sooner the calf starts eating meal the better. At 2 weeks, good quality roughage is introduced. The calf can be weaned once she is eating the roughage and 1.5kgs of calf starter/day.

From weaning until 6-8 months of age, the calf should be fed on calf grower meal offered *ad libitum* (as much and as often as desired). She should have good quality roughage available at all times. At about 8 months, the calf becomes a true ruminant and is able to make better use of roughage.

Heifer: The heifer must be adequately fed to reach 85% of mature mass at 14–18 months of age, depending on breed when she should reach breeding mass and height and be ready for first service. For this stage she should have constant access to good grazing or roughage and be fed heifer meal at a rate of 2–6 kgs/day, depending on age size and condition of grazing.

Cow: The cow requires energy and protein for:
- Maintenance (breathing, walking, rumination etc)
- Growth (1st lactation cows are still growing)
- Milk production
- Reproduction

If the cow's nutritional needs are not met, these functions cannot be carried out. As food is with-held the animal will: stop cycling or not reconceive; reduction in milk yield; growth is stunted; and in extreme cases – die.

A very basic rule of thumb is to **feed 2 kg of a lactating cow ration for maintenance plus an additional 0.5kg for every kg of milk produced per day**. First calvers and cows in early lactation will require more. In addition, the cow requires good quality roughage, whether it be silage, grass hay, grazing, forage legumes. A cow cannot eat

enough poor quality roughage to meet her needs, as it takes too long to digest. The better the quality of the roughage, the more she can eat, the more milk she will produce.

Dry Cow: The dry cow has different nutritional requirements to the cow in milk. The dairy farmer should aim to dry the cow off at a body condition score of 3.5 and maintain this body condition through-out the dry period. A specialized dry cow meal should be fed at a rate of 2-4kgs/day dependent on body condition and value of roughage. The cow should have access to good grazing or roughage.

3.2. Essential Nutrients in Dairy Cattle Feed

Dairy cattle feed must provide a balanced mix of essential nutrients. These nutrients include proteins, carbohydrates, fats, vitamins, and minerals.

Energy: It is fundamental for the synthesis of milk fat, protein and lactose. However, a cow can mobilize energy reserves to support milk production if energy intake is deficient, although excessive mobilization of reserves is detrimental to reproduction and health. The most common energy feeds available to cattle are based on high-starch grains (maize, sorghum, barley, wheat), fibrous by-products (soybean hulls, wheat middlings and beet pulp), or fat sources (oilseeds, animal and vegetable oils) and other grain crops, molasses.

Protein: Proteins are required by the dairy cow for many metabolic functions e.g. growth, lactation, reproduction and overall growth. The protein content in feed is commonly reported as crude protein (CP). High-quality protein sources, such as soybean meal and alfalfa, concentrate feeds, young grasses, oilseeds, fodder trees and shrubs and forage legumes should be integral to the dairy cattle feed.

Minerals and Vitamins: Dairy cattle require at least 17 minerals and three vitamins in their diet for optimal milk production, reproductive performance, and herd health. For the dairy cow, the major minerals (macro-minerals) required are calcium, phosphorus, magnesium, potassium, sodium, chlorine, and sulphur. Minerals required in much smaller, trace amounts (micro-minerals) include iodine, iron, cobalt, copper, manganese, zinc, and selenium.

Vitamin A, D, and E, are fat soluble vitamins that are required in a properly balanced feeding program; Vitamin A is important for bone development, sight, and soft tissue maintenance. Deficiencies can cause reduced fertility (longer to first cycle and lower first service conception rates). Vitamin D aids calcium absorption into your bones, thus helping strengthen them.

Generally, the two sources of minerals include natural feeds (forages and grains) and mineral supplements to balance the minerals present in the forages and grains. Minerals and vitamins are supplied in the concentrate feed. It is essential that the lactating cow is fed the correct dairy concentrate feed, whether purchased or home mixed.

Fibre: Fibre plays an important role in ruminant digestion by providing structural carbohydrates for fibre-digesting bacteria in the rumen. Key sources of fibre for ruminants include wheat bran, cottonseeds, and soy hulls.

Fats: Adding fat to diets for lactating cows increases milk yield (if energy is limiting in the diet) and increases milk protein yield but decreases milk protein concentration by 0.1 to 0.2% units. Fats offer concentrated energy and are essential for maintaining body condition, especially in high-yielding cows. A balanced combination of these nutrients ensures that your dairy cattle feed supports peak production levels. Oilseeds, such as whole cottonseed or whole soybeans, or animal fats, are common sources of fat in a cow's diet.

Water: A lactating cow requires 50-100 litres of water/day. Clean water should be available at all times. The animal body derives water from drinking water, water present

as part of feeds (moisture), or those liberated during several metabolic reactions. The importance of these different sources varies among species, habitat, and diet.

3.3. Dairy Cattle Feed Resources Innovations for Enhanced Productivity and Environmental Sustainability in Urban Areas of Uganda

The increased demand for milk and milk products among the urban population has been a driving force behind the establishment of urban dairy cattle farms. The feed costs represent over 70% of the total cost of production in a profitable enterprise. One of the dilemmas in dairy cattle production in urban areas is to feed animals with low-cost, good nutritional quality, and readily available feed in a suitable manner without altering their productivity and compromising their well-being. Proper dairy cattle feed is the cornerstone of a successful dairy operation. Dairy cows' nutritional needs are specific and demanding, as they directly influence milk production, herd health, and overall farm profitability.

Lack of appropriate nutritional management indicates that inadequacy of feed in terms of quality and quantity. Dairy cattle feed resources in urban areas of Uganda are mainly derived from natural pasture/grasslands, agricultural wastes, improved pasture, forage crops, agro-industrial by-products and non-conventional feeds. The contribution of these feed resources, however, depends up on the agro-ecology, the types of crop produced, and accessibility and production system.

Climate-Smart Agriculture (CSA) in Dairy Farming

Climate-Smart Agriculture (CSA) in dairy farming provides strategies and practices to enhance productivity, resilience, and sustainability while mitigating the impact of climate change. By adopting CSA principles, farmers can improve their livelihoods, reduce environmental impact, and contribute to a more resilient and sustainable dairy sector. This section reviews some of the climate smart feed improvement technologies and intervention options for urban dairy cattle farmers in Uganda.

3.3.1. Agricultural Wastes /Crop Residues

Agricultural waste is *'unwanted or unsalable materials produced from agricultural operations directly related to the growing of crops or raising of animals'.* All agricultural products are having edible and non-edible portions. The increasing human population has resulted in shrinkage of agricultural land for cultivation of feed for livestock and food to the human beings. This situation has forced farmers to search for utilizing the agricultural by-products and value addition of the same to meet out the requirement of both human and livestock needs.

The bulk of the agricultural food in Uganda is transported from rural areas to towns and cities in its raw form, thus compounding the net effect on large deposits of waste in urban markets, around homes and in slums as well as in various dumping grounds. In Kampala, about 2,000 tons of solid waste is collected and delivered to landfills every month. Kampala Capital City Authority (KCCA) records show that this represents approximately 40% of solid waste generated in the city. The composition of household solid generated in Kampala city are mainly vegetable/organic matter (83.6%), consisting mainly of agricultural residues such as banana and cassava peels, sweetpotato vines. cereal by-products, fruit and vegetable residues and chicken waste. The remaining uncollected waste is normally dumped in unauthorized sites, causing health and environmental problems. However, the organic fraction of domestic waste can provide an opportunity to improve livelihoods and incomes through dairy cattle feed production.

Nutrient Composition of Agricultural By-Products

Studies conducted by the National Agricultural Research Organization (NARO) and Makerere University show that most of the agricultural wastes in urban areas of Uganda and on farms contain high levels of protein and minerals such as Potassium, and Phosphorus

(Annex 1). Such agricultural wastes can be processed into high quality dairy cattle feeds. This calls for a greater awareness of urban dairy cattle farmers of the benefits of proper management and utilization of market, farm and agricultural wastes usually referred to as "garbage". A 4-year study conducted at Kyakuwa farm, Wakiso district has shown that feeding dairy cows on processed agricultural wastes such as sweetpotato vines and supplemented with energy, protein and minerals improves milk yield and household income and maintains a clean environment. Processing agricultural wastes into dairy cattle feeds could also help to prevent tragedies similar to that struck the KCCA garbage landfill at Kiteezi in Wakiso district. On 9th August 2024, a significant landslide struck the Kiteezi garbage dump in Kampala where over 30 people died. Kampala is often been struck by heavy rainfall, but poor practice in waste management is often a factor in garbage dump failures.

Common Agricultural Wastes/Crop Residues Available in Urban Areas and On-Farms

1. **Cassava Crop Wastes**

Cassava crop wastes (roots, peels, and leaves) are valuable feed resources for dairy cattle.

Cassava Roots: Moisture (6.09-10.49%), protein (1.12-1.57%), ash (0.87-1.39%), fat (0.20-0.51%), total sugars (1.43-1.80%) and cyanide contents (3.33-10.00 mg HCN/kg) of fermented flours were low, while starch (72.79-84.23%), total carbohydrate (93.67-96.45%) and energy (384.53-393.50 kcal/100 g) contents were high. Cassava roots constitute an excellent energy additive when they are chopped and ensiled with other feed resources, such as cassava leaves, bananas pseudo-stems, brewery spent grain, poultry litter and others. Cassava roots can be offered to cows up to 25% of total dry matter intake, but protein and mineral supplements must be fed in order to balance the ration.

Cassava Peels contain about 42.6% carbohydrate, 1.6% protein, 12.1% ether extract, 5.0% total ash and 22.5% crude fibre. Transforming cassava peel into nutritious animal feed has the potential to partially replace maize in animal feed while reducing environmental pollution and minimising post-harvest losses. This crop-waste by-product could be a valuable feed alternative. The key innovation is to grate the peels, and then squash them in a hydraulic press to rapidly remove the liquid. The process produces a kind of 'cassava peel cake', which is then grated again, forming particles of uniform size, which dry out in a matter of hours.

Cassava Leaves contain 16.7 to 39.9% crude protein. This wide variability is related to differences in cultivars, stage of maturity, sampling procedure, soil fertility and climate. The leaves contain minerals, vitamins B1, B2, C and carotenes, but lower in methionine and lysine compared to soybean meal. However, the presence of antinutrients and cyanogenic glucosides are the major drawbacks in cassava leaves which limit its human consumption. Dairy cows can easily eat 5 kg chopped cassava leaves per day.

Processing Cassava Leaves for Dairy Cattle Feeding

Ensiling Cassava Leaves: For ensiling, chop cassava leaves into small pieces (about 5 cm diameter), mix with molasses (5%) and salt (5%) (on fresh weight basis) and store in airtight containers. Ensiling cassava leaves reduces toxic substances (*Cyanogenic glucosides*) concentrations to safe levels. This conservation process also makes cassava leaves more appetizing.

Cassava Leaf Meal: Cassava leaf meals are leaves and twigs dried, ground, and used as feed. They are an important management tool during the dry months when fresh fodder is in limited supply.

Preparing Cassava Leaf Meal

Step 1: Sun-dry cassava leaves and browseable twigs for seven hours or air-dried under a roof for five days.

Step 2: Mill/ground the dry leaves and twigs,

Step 3: Store in sacks. For proper storage and to avoid spoilage, the leaves and twigs should be dried to 10-13% moisture content.

The crude protein content of the leaf meals derived from legumes and cassava (16.7–39.9%) are higher than the recommended 11% dietary crude protein required for favourable microbial synthesis and activity in the rumen and therefore should not be fed at 100. Research has shown that feeding non-ruminants fed 60% cassava leaf protein concentrate has no adverse effects on growth

Use of Cassava Residues in Cattle Rations

Cassava-based rations should be supplemented with molasses to reduce the powdering of the feed because cassava contains mostly starch and sugars which have a chemical structure that are not complicated. Moreover, cassava contains little oil; therefore, when cassava is milled there is a lot of powder dust formation, which is dangerous for the health of people in the cassava milling area. When the milled cassava is used as cattle feed in large quantities and given in powdered form, this can cause irritation. The cows will sneeze and will eat less. Mixing cassava powder with molasses can reduce the powdering of the feed until the animal will eat again normally. If the feed is pelleted there will be no dust problem and there is no need to add molasses.

Because cassava consists of starch and sugars which are easily digested in the rumen it is possible that you get acid conditions in the cow's rumen. When cattle use an energy source consisting of starch and sugars, which are easily digested in large quantities, the microbes in the rumen produce lactic acid. Other types of microbes will then transform lactic acid into propionic acid. The formation and accumulation of lactic and propionic acid will result in "acidosis conditions" in the fermentation stomach.

2. Sweetpotato Crop Residues

Uganda is now the leading producer of sweetpotatoes in Africa, as the east of the country has soil and weather particularly well suited to growing this crop. The orange-fleshed sweet potato is rich in vitamin A and a vital tool in the fight against vitamin A deficiency, which remains a leading cause of preventable blindness among women and children in Uganda.

Sweetpotato is the fourth most important crop in Uganda in terms of production volumes (1.8 million metric tonnes) after maize, cassava and bananas. Sweetpotato residues comprise of over 60 percent of the agricultural residues (vines, non-marketable roots and peels) in urban food markets and on farms. Sweetpotato residues are some of the most widely used dairy cattle feed in urban areas of Uganda. Farmers feed sweetpotato vines, small roots and peels to livestock but they face two challenges: (a) the vines and roots are highly perishable and, (b) they are not available two months after the harvest during the dry season, when other forages are scarce. Moreover, non-livestock farmers have no use for the vines, which become an environmental hazard.

Benefits of Feeding Sweetpotato Vines to Dairy Cows

- High protein content (16-20% crude protein, depending on the variety, soil fertility, and soil moisture and management practices).
- Rich in fibre, vitamins, and minerals.
- Improves milk yield and quality.
- Enhances digestibility and reduces feed costs.
- Environmentally friendly, utilizing a typically discarded by-product.

Feeding Sweetpotato Vines to Dairy Cows

- Fresh, ensiled or dried sweetpotato vines can be fed to dairy cows.
- Recommended inclusion rate: 10-20% of total feed.
- Mix with other feeds to prevent overconsumption and diarrhoea.
- Ensure proper drying to prevent mould growth.
- Avoid feeding mouldy or spoiled sweetpotato vines.
- Balance with other nutrients to prevent over-reliance

Sweetpotato Vines for Income Generation

In urban areas of Uganda, sweetpotato residues create a disposal problem as they are dumped within the markets after sale of roots. This causes environmental hazards. Many livestock farmers collect or buy crop residues from the food markets to feed their animals. Kyakuwa Farm located in Makindye Ssabagabo Municipal Council has contracted Mr. Enock Karangwa, a youth selling sweetpotato roots in Owino market to supply sweetpotato vines.

Sweetpotato vines delivered at Kyakuwa Farm

At the farm, sweetpotato vines are chopped, wilted and mixed with grass hay and other feeds, supplemented with sources of energy and minerals and offered to dairy cows. Sweetpotato vines have high moisture content, if not pre-wilted, they result in low dry matter intake and can cause diarrhoea. Excess sweetpotato vines are preserved as **silage** for use during periods of feed scarcity.

Sweetpotato Vine Silage Technology

Silage is *"fodder made from green foliage crops, preserved by fermentation and stored under airtight conditions".* The resultant feed is very nutritious for animals, often more attractive than unfermented material. It improves nutrition both by being more digestible and as a result of the fermentation. Silage can be stored using several methods such as: plastic tube silos, stack silo, trench/pit silos and, bunker silo, largely dependent on available technology, local tradition, or prevailing climate.

The "**Sweetpotato Vine Silage Technology"** was developed by the International Potato Centre in collaboration with Makerere University; Sight Farm, Namulonge; Kyakuwa Farm; National Livestock Resources Research Institute and; International Livestock Research Institute.

Requirements for Making Sweetpotato Silage Using a Plastic Tube Silo

For small-scale urban dairy cattle farmers, silage can be made in large plastic tubes or plastic drums, which have no holes to ensure no air enters. This is referred to as "**tube silage**".

(1) **Sweetpotatoes vines:** They are more commonly used, but the roots can be included for added nutrition.

(2) **Fodder choppers or "chaff cutters"** are machines that chop fresh forages such as sweetpotato vines and dry fodder crops such as maize and sorghum stover with minimal problems. The ideal chop size is 2-3 cm length to ensure compacting and minimize air pockets.

(3) **A large tarpaulin:** Used when chopping and wilting the sweetpotato vines and roots.

(4) **A weighing scale:** Used to weigh chopped materials to be mixed in the right proportions.

(5) **Silage bags, plastic drums or pit:** You need airtight containers like silage bags, plastic drums or a properly lined silage pit to store silage.

(6) **Aflatoxin Binder:** Aflatoxins are amongst the most poisonous mycotoxins and are produced by certain molds *(Aspergillus flavus and Aspergillus parasiticus)* which grow in soil, decaying vegetation, hay, *maize grain, silage and other grains. Animals that eat feed containing unsafe levels of aflatoxins can develop aflatoxin poisoning.*

Molds in maize grain

Humans can be exposed to aflatoxins by eating contaminated plant products or by consuming meat or dairy products from animals that consume contaminated feed such as silage. Aflatoxin toxicity may result in nausea, vomiting, abdominal pain, convulsions, and other signs of acute liver injury. Long-term exposure also leads to various complications like growth retardation, cirrhosis, and hepatocellular carcinoma. Aflatoxin binders such as Diatomaceous earth or Calcium bentonite have been especially recommended for use in animal feeds.

Importance of Diatomaceous Earth Grade

Diatomaceous earth (DE), also known as Diatomite is the remains of microscopic one-celled plants (phytoplankton) called diatoms that lived in the oceans. These deposits are mined from underwater beds or from ancient dried lake bottoms thousands of years old. This means, diatomaceous earth has an unlimited shelf life provided you keep it dry. Diatomaceous earth, has been recognized as an organic product for animal health and nutrition. Diatomaceous earth contains high levels of silica and 15 essential trace minerals including phosphorous, selenium, calcium, sodium, potassium, magnesium, copper, zinc, chromium, titanium, aluminium, chlorine and iron. This product has been further fortified with enzymes, probiotics for holistic performances in all stocks. Trace minerals act as catalyst to increase surface area for ruminal microbial activities. This increases microbial proteins which are absorbed by animals.

The Role of Diatomaceous Earth Grade in Dairy Cattle Feeding

- **Afltoxin Binder:** Studies have shown that diatomaceous earth has the potential *in vitro* to bind aflatoxins. Livestock feed toxin binders are a great

way to reduce mycotoxicosis and improve livestock health and productivity.

Diatomaceous earth feed additive produced by Capital Feeds
*(**Source**: +256 787117707/753476876)*

- **Internal Parasite Control:** Diatomaceous earth makes a very effective natural insecticide. The insecticidal quality of diatomaceous earth is due to the razor sharp edges of the diatom remains. When diatomaceous earth comes in contact with the insects, the sharp edges lacerate the bugs waxy exoskeleton and then the powdery diatomaceous earth absorbs the body fluids causing death from dehydration. To be most effective, food grade diatomaceous earth must be fed long enough to catch all newly hatching eggs or cycling of the worms through the lungs and back to the stomach. A minimum of 60 days is suggested by many, 90 days is advised for lungworms. 1% to 2% feed grade diatomaceous earth has been recommended to add to cattle feed to reduce internal and external worm or parasites.
- **Fly Control:** Used daily, Diatomaceous earth helps eliminate fly population. Sprinkle Diatomaceous earth on livestock when flies are present. Dust barns, coops, after mucking and throw on top of manure/compost piles. Feed it daily to livestock, so it comes out in the manure of each animal as well and prevents flies from growing in the manures. Diatomaceous earth can be put in a backpack sprayer mixed with water to spray your dairy cattle unit.
- **Prevents Bad Smell:** Diatomaceous earth is popular in natural deodorants, as it works as an odour blocker and eliminator, protecting against body odour even if you have very sensitive skin. Diatomaceous earth is composed mostly of silica, which is a highly absorbent material that takes away bad smells.
- **Grain Storage and Protection:** Add diatomaceous earth to seeds such as wheat, maize, beans and barley to prevent spoilage. It keeps food dry, prevents mould and protects against insects. While protecting your food against insects and pests, diatomaceous earth can also be used as a natural pest control in your garden. But, make sure to keep in mind that many insects are beneficial to your plants and don't cause any harm.

Usage: Mix 2-5 kgs of diatomaceous earth powder in 100 kgs of feed. There is no withdrawal period when given to milking or feed animals.

Caution: Make sure you use diatomaceous earth powder responsibly as it is an abrasive material, and overuse and inhalation could have adverse effects.

(7) **Additives:** Ferment starter (microbes, maize bran and/or molasses) improves the process of fermentation and nutrient content. One of the most significant benefits of MolaPlus Livestock Microbes is its ability to transform agricultural crop residues

into valuable feed for dairy cows. These residues, such as cereal stovers, barley, rice, and wheat straws, are often discarded as waste. However, MolaPlus Livestock Microbes can be used to predigest/ferment these residues, converting them into nutritious and palatable silage and or haylage that can be used to feed dairy cows**.**

The Role of MolaPlus in Dairy Cow Digestion

- **Enhancing Feed Utilization**: MolaPlus livestock microbes break down complex carbohydrates and fibres found in feed, this they do by unlocking the tied up nutrients ligno-cellulose rich feed materials making these nutrients more readily available to the cow during digestion; this in its case leads to improved nutrient extraction from the feed and so increased nutrient absorption and therefore improved feed efficiency.
- **Increasing Protein Synthesis:** MolaPlus promotes the growth of beneficial bacteria in the rumen, which are responsible for synthesizing microbial protein and besides this the microbes in MolaPlus livestock microbes form after fermentation form part of the microbial protein thereby providing extra protein to the cow. This additional protein adds to the digested protein which can be used for maintenance, growth milk production and also animal health.
- **Improving Ruminant Stability:** The microbes in MolaPlus assist in maintaining a healthy rumen environment by controlling the population of harmful bacteria facilitating the growth of beneficial microbes. This act of ensuring a conducive environment that promotes the development and rapid multiplication of beneficial bacteria in the rumen ensures improved digestion as well as reduced incidences of digestion-related issues/disorders.
- **Increasing Feed Palatability:** MolaPlus Livestock Microbes when used in treating/predigesting crop residues like cereal stovers and straws greatly improve their taste, flavour and scent which makes the resultant feed more appealing for dairy cows. This in a sense creates numerous opportunities for the urban dairy farmer to convert most of the would-be neglected crop residues/agricultural waste into more palatable feed for the animals.
- **Reduced Feed Costs:** MolaPlus Livestock Microbes promotes sustainable and cost-effective dairy farming, contributing to the future of the industry.
- **Sustainable Waste Management:** This practice promotes sustainable farming by reducing waste and utilizing readily available resources to make nutritious feeds for cows.
- **Improved Animal Health:** The nutritious silage produced with MolaPlus contributes to improved animal health and milk production.

By embracing MolaPlus Livestock Microbes technology, urban dairy farmers can easily overcome the challenges presented by the limited grazing land, rising feed costs, and waste management, paving the way for a more profitable and sustainable dairy enterprise.

Making Sweetpotato Vine Silage in a Polythene Tube Silo

Sweetpotato silage can be made with only chopped vines or mixed with roots (ratio of 70:30).

Step 1: Collect sweetpotato vines after harvesting the roots. You can buy the vines from farms or food markets.

Step 2: Chop the vines 1-3 cm lengths. The shorter the chop length, the better the

compaction, hence less air is trapped in the forage, resulting in better silage quality.

Step 3: Wilt chopped vines for about 3 hours under the sun to reduce moisture content by 40-45% and to ensure quality silage. Weigh the material and record the weight

Chopping sweetpotato vines in Kweme, Tanzania (Source: Lutwama Vincent)

Step 4: Mix 10 kg of maize bran, 0.5% salt and 5% Diatomaceous earth (aflatoxin binder) in 100 kg of chopped vines. You can use diluted molasses (ratio of 1 molasses to 2 water) instead of maize bran. The maize bran produces better silage because it reduces the effluent from the silage. It is important to note that 1 litre of MolaPlus Livestock Microbes mixed with 2litres of molasses and 20litres of fresh water is sufficient to make 500-1000 kgs of silage which will be ready for feeding to livestock in 3 days making it the most cost effective way of preserving feed nutritious feed for cows.

Wilt chopped sweetpotato vines

Mix maize bran with chopped vines

Sweetpotato vines can be fermented with 15% processed (sieve, dry and mill into powder) chicken manure, resulting in a higher crude protein, dry matter and ash content than in the other silages.

Step 5: Make a Plastic Tube Silo

(a) Open up a black polythene tubing (1.5m long, gauge of 600-800 mm for every 70 kg of silage) and pleat the tube lengthwise. Tie firmly with a sisal twine, 30cm from the cut edge. You can buy the black polythene tubing from Hardware shops. Turn the bag inside-out and fold back the edge to produce a silage bag.

Make a plastic tube silo *(Source: CIP Silage production Manual, 2017)*

Step 6: Place the silo bag into a-100kg synthetic sac to protect the silo bag from being damaged by rats and hot weather. Start by placing chopped vines into the silo bag. As you fill the bag or plastic drum, compact the material tightly to expel as much air as possible. The absence of air is critical for proper fermentation.

Place the silo bag into a-100kg synthetic sac (left), fill the bag with the materials and compact to remove the air(right)

Step 7: **Seal the Silo Bag** tightly once it is full and tie the opening securely.

Sealed silo bags and plastic drums

Silage can be stored in plastic tanks of re-usable silo bags

Re-usable plastic silage bags
***(Source:** Fadal Agri Farms Ltd, +256 772852569)*

Step 8: **Allow The Mixture to Ferment:** If you do not add microbes to the mixture, the silage matures in 21 to 30 days. With microbes added, the silage is ready for feeding livestock in 3 days. During this period, anaerobic bacteria will ferment the sugars in the sweet potatoes, preserving the feed. Silage in well-sealed silo bags that prevent the entry of air or water will maintain its quality for much longer than will silage in poorly sealed storages. To ensure a tight seal, the neck should be twisted and then tied or taped.

It is important to store silage bags in a suitable location. Silage bags attract rodents which damage the bags. Children and animals can do the same. This lets air in the bag and can result in spoilage of silage. Stacking the bags carefully in a room can protect them against rats, mice and other pests.

The surface area selected for storage of silage bags has a large impact on silage quality and ease of feeding from the bag. Concrete floor provides excellent surface for silage bag, easy removal of feed with little or no damage, can achieve exceptional drainage of water away from bags, discourages pests and makes inspection for damaged bags very easy.

Step 9: **Monitor the Silage Bags** on a regular basis for any rodent, bird or livestock damage.

Under anaerobic conditions, sweet potato vine silage can be stored for up to 3 years.

Characteristics of Good Silage

- **Odour**: Pleasant fruity odour/ an acceptable aroma.
- **Taste:** Liked very much by animals because of mild-acidic taste and pleasant aroma.
- **Texture**: Free flowing and non-sticky texture.
- **Absence of mould and rot**: there is no visible mould, and it is not musty or slimy.
- **Uniformity**: It is uniform in moisture and colour. Generally green or brownish silage is good. Tobacco brown or dark brown silage indicates excessive heat, and black silage is rotten and should not be fed to animals.

Sweetpotato Vine Silage as a Protein Supplement to Lactating Dairy Cows

A study was conducted at Sight Farm, Namulonge, Wakiso district to evaluate the effects of sweetpotato vine silage supplementation on the performance of lactating crossbred (Ankole × Friesian) dairy cattle fed a basal diet of Rhodes grass (*Chloris gayana*) hay supplemented with 4 kg/cow/day of dairy pellets (concentrate) and four graded levels of sweetpotato vines silage (0, 100, 200 and 300 g/kg of the daily ration). The study

was funded by the International Potato Center (CIP) and implemented by Bavubuka Twekembe Group, Kyakuwa Farm, Makerere University and the National Livestock Resources Research Institute.

Highlights of the Study Results

Dry matter intake (DMI) improved with addition of sweetpotato vine silage to Rhodes grass hay, with average intake being highest (11.9 kg/cow/day) in cows that were fed the highest (300 g/kg of the daily ration) sweetpotato vine silage level and lowest in cows that were not given sweetpotato vines silage (6.8 kg/cow/day) (Table 2). Sweetpotato vine silage as a supplement to low quality forages has a great potential for improving milk yield by 15-20%. The best use of sweetpotato vine silage is during the dry season as it helps to maintain good milk and meat production levels.

Considering profit margins, supplementing dairy cows with sweetpotato vine silage at a level of 100 g/kg (10 percent) of daily ration was the most profitable at Uganda shillings 1,290 (USD 0.344) per cow per day.

Table 2. Ingredients and chemical composition of commercial concentrate, Rhodes grass hay and sweetpotato vine silage used in the experiment (g/kg dry matter basis)

Item	Concentrate	Rhodes grass hay	Sweetpotato Vine Silage
Ingredients, g/kg			
Maize bran	520	0	100
Cotton seedcake	180	0	0
Mineral premix	20	0	0
Calliandra calothyrsus leaf hay	90	0	0
Molasses	190	0	0
Chemical composition (g/kg Dry Matter)			
Dry matter	675	830	266
Ash	74	104	85
Crude protein	148	75	194
Metabolisable Energy (Mega Joules/kg dry matter)	795	198	772

***Source**: Galla et al. (2020)*

Sweetpotato vine silage offer dairy cattle crude protein of up to 18 percent. This is significantly higher than common Napier grass fodder (Table 3).

Table 3: Nutrient value of sweetpotato vines and silage compared to Napier grass

Feed resource	Moisture content (%)	Crude protein content (%)	Neutral Detergent Fibre (%)	Metabolizable energy (Mega Joules/kg)	Digestibility (%)
Sweetpotato vines (fresh)	87	16.0	46	8.3	60
Sweetpotato silage (vines and roots)	72	16.2	20	13.3	69
Napier grass (fresh)	82	10	60	8.5	57
Napier grass (silage)	80	9.5	56	7.8	66

***Source**: Lutwama et al. (2016)*

Based on the study results, it was concluded that sweetpotato vine silage is a good source of supplement that improves efficiently on digestibility, dry matter intake, milk yield and quality in lactating crossbred dairy cows. It is most profitable to supplement lactating crossbred dairy cows with 100 g/kg (10% of total daily intake) sweetpotato vine silage inclusion level. However, overall effects of sweetpotato vine silage in the diet depend on many other dietary and non-dietary factors. To prevent tainting the milk (off-flavour), do not feed sweetpotato vines silage to lactating dairy cows within 30 minutes of milking.

Benefits of Sweetpotato Vine Silage as a Supplement for Lactating Dairy Cows

- Sweetpotato roots are high in protein (about 18%) and carbohydrates, providing excellent energy for livestock.
- Making sweetpotato vine silage is a practical way to preserve and make use of sweetpotato residues efficiently. You can ensure a high-quality, nutritious feed source for your dairy cattle year-round.
- Utilizing sweetpotato vines and roots, which might otherwise go to waste, makes this a cost-efficient feeding option.
- Silage production reduces waste in urban markets, on farms and at household level.
- Sweetpotato vine silage production opens up business opportunities for women, men and youth. Making silage for sale and/or offering silage-making as a service provides a source of income.

Sweetpotato Vine Silage Production as a Business

In Uganda, individual farmers and youth have adopted sweetpotato vine silage production as a source of income. Members of youth groups have demonstrated silage production as a source of income to farmers, at schools and during agricultural shows. With the help of motorized vine choppers provided they are able to offer a silage-making service to farmers.

Mrs. Martha Matovu (+256774112810), Director MADCO Investments Limited; Mr. Vincent Lutwama, Director, Austin Farm (Tel; +256 774550349); Mr. Aloysius Male, Director, Kiweebwa Mixed Farm (Tel: +256 751627759) and others are some of the youth who produce sweetpotato vine silage the foundation of a new family-run business.


Mrs. Martha Matovu, Director, MADCO Enterprises produces sweetpotato vine silage

Martha says, "*We have given young people opportunities to work all along the value chain: from planting sweetpotato as a food and cash crop to silage making, packaging and delivery. This has generated income for everyone involved.*" *Martha says, "The profit depends on the source of the vines. If the vines are free, from one's own field, for example, or very nearby so that transport costs are minimal, then the profits are larger. But even if one has to buy the vines, it is possible to make a profit on selling the silage".*

There is also a networking effect, with satisfied customers leading to increased business. *"As we disseminate this new sweetpotato silage vine technology,"* she said, *"we have got more clients."* So far, Martha has produced over 500 tons of sweetpotato vine silage. Her major challenge now, apart from farmers whose fields are inaccessible, is finding labour to process the silage. Martha produces and sells microbes that enhance fermentation during silage production. Table 4 shows estimated cost-benefit analysis of producing sweetpotato vine silage from one acre/season.

Table 4: Estimated cost-benefit analysis of producing sweetpotato vines silage from one acre/season

Activity (per season)	Units	Quantity	Unit Cost (Ugshs)	Total Cost (Ugshs)
1. **Land preparation**				
Land Hire	per acre	1	150,000	150,000
Land clearing	per acre	1	200,000	200,000
1st ploughing	per acre	1	140,000	140,000
2nd ploughing	per acre	1	120,000	120,000
2. **Planting and fertilizer application**				
Creating mounds/ridges	per acre	1	200,000	200,000
Sweet potato planting materials	1 bag/ acre	1	25,000	25,000
Fertilizers	100 kg bag	1	150,000	150,000
Labour for planting	per acre	1	80,000	80,000
Fertilizer application	per acre	1	50,000	50,000
3. **Weeding**				
1st weeding	per acre	1	120,000	120,000
2nd weeding	per acre	1	120,000	120,000
Sub-total				**1,355,000**
4. **Variable costs**				
Harvesting of vines	per acre	1	150,000	150,000
Labour costs for chopping and ensiling	per day	2	200,000	400,000
Silo bags (100 kg bags)	Pcs	100	8,000	800,000
Sisal strings	1 roll	1	6,000	6,000
Tarpaulins	1 pc	1	150,000	150,000
Hiring forage choppers	per days	2	150,000	300,000
Fuel	Litres	20	6,500	130,000
Purchase of cereal bran	Kg	1000	800	800,000
Sub-total				**2,736,000**
TOTAL (1)				**4,091,000**
5. **Income**				
Silage	Kgs	11000	500	5,500,000
Sweet potato tubers	Bags	30	80,000	2,400,000
TOTAL (2)				**7,900,000**
NET INCOME (Ushs) {(2)-(1)}				**3,809,000**

Source: *(Lutwama, 2023)*

3. Cereal Stovers and Straws

Cereal crops are a staple food source for humans and animals. **Cereal stovers** are the leaves and stalks of field crops, such as maize and sorghum that are commonly left in a field after harvesting the grain. **Cereal straws** are the dry stalks of cereal plants such as rice, millet and wheat after their grain and chaff have been removed.

After harvesting the grain, many farmers burn cereal stovers and straws. This is a big waste that should be avoided in all seasons considering the high cost of feeding cows in urban areas. Cereal stover sand straws are some of the maor roughages available during the dry season.

Maize stover can yield between 6 to 13 tons dry matter/ha (depending on the variety, climate, soil fertility and other agronomic management practices), but about only 40-60% is harvestable. Maize stover and rice straw can be stored as silage or as dry straw.

Maize stover

Nutritional Value (approximate) of Cereal Crop Residues

Cereal crop residues are potentially rich sources of energy because up to 80 percent of their dry matter (DM) consists of polysaccharides. Cereal crop residues have very low protein content (3-5 percent) and Metabolizable energy (6-8 Mega Joules/kg DM).

Benefits of Cereal Crop Residues for Dairy Cows

Cereal crop residues are readily available and inexpensive in cereal crop-producing districts of Uganda than other feed options, making it an attractive choice for dairy farmers. The stovers and straws are high in fibre, which can help maintain rumen health and promote digestive efficiency.

Challenges of Feeding Cereal Crop Residues to Dairy Cows

Cereal stovers and straws are low in protein (less than 5%), energy, and other essential nutrients. They have high lignin content of plant cell walls, can reduce digestibility and nutrient availability. They can be prone to mold growth, which can affect cow health.

Methods of Harvesting Cereal Crop

Cereals are traditionally harvested manually. There are three main types of harvesting equipment for the small scale producer: manual, animal powered and engine powered. A range of mechanised harvesting equipment suitable for the small-scale farmer has been developed.

Methods to Improve the Feeding Value of Cereal Crop Residues

(a) Physical Treatment

Chopping: Chopping is the most common physical treatment of cereal crop residues widely used by smallholder farmers. It is important for crop residues with thick stems like maize, sorghum, and pearl millet. The advantages of chopping cereal crop residues are: it minimizes wastage of feed, avoids selective feeding and maximizes their utilization. Animals usually select the most nutritious parts like leaves compared to stems. Chopping also increases intake of roughages, and improves the overall feed use efficiency to increase animal productivity.

Grinding: Grinding/milling machines are used to crush and sieve residues into small sizes of 0.6 to 0.8 mm, which can be mixed with other feeds that are given to animals directly or made into pellets. Chopping and grinding increase cereal crop residues intake by animals by more than 25%. It has also been reported that these practices increase feed passage rate and overall efficiency of feed utilization. Farmers mix chopped / threshed straws or stover with legume haulms to improve intake and quality.

(b) Biological Treatment of Crop Residues

Urea Treatment of Crop Residues: Urea treatment is suitable in Uganda due to its ease of access and use. The main benefits for smallholder farmers are that the urea treatment procedures are simple. The inputs and facilities required for treatment of crop residues are:

- Chopped (2-4 cm length) cereal straws and stover or poor-quality hay,
- Plastic sheets for mixing,
- Fertilizer grade urea,
- Molasses (optional),
- Weighing scale,
- Clean water,
- Silos of different types or other containers like plastic bags, plastic drums and sealing materials such as airtight plastic sheets, and
- Watering cans and weighing balance machine.

Steps for Urea Treatment of Cereal Crop Residues

Step 1: Prepare a pit silo, silage bags, or large volume plastic drums and the chopped and weighed crop residues to be treated.

Step 2: Prepare 5 kg of fertilizer grade urea to treat 100 kg of crop residue.

Step 3: To improve palatability and digestibility of treated crop residues it is advisable to add about 10 kg of molasses for 100 kg of crop residue (but this is optional). The recommended moisture content of the treated product is about 30%.

Step 4: Based on this, depending on the level of moisture in the crop residue and weather conditions, 60– 80 litres of water is enough to treat 100 kg of crop residue.

Step 6: Mix 5 kg of urea with 60–80 litres of water and then add 10 kgs of molasses and stir to mix uniformly.

Step 7: Spread the 100 kg chopped crop residue on a plastic sheet and spray with the mixed solution.

Step 8: Spray the solution uniformly. For uniform distribution, spray slowly with a watering can and turn up the residues continuously while spraying the crop residue and weather conditions, 60– 80 litres of water is enough to treat 100 kg of crop residue.

Step 9: Pack the material into a silo, plastic bag or any airtight container. The filling

need to be done slowly and should be compacted to take out the air inside the silo or container to create an anaerobic environment. The top should be covered and sealed with an airtight plastic sheet or similar material. In addition, it is recommended to place heavy materials like stones, old tyres or any similar heavy object on top to help to take out the remaining air inside the silo or storage container.

Step 10: The sealed material should be kept for 21 days before use. The treated cereal crop residues will have a pungent smell when it is opened. The treated crop residue should be taken out and ventilated by spreading it on a plastic sheet or canvas overnight before it is fed to animals.

(c) Effective Microorganisms of Crop Residues

Effective microbes are a mixture of lactic acid bacteria, yeast and photosynthetic bacteria. They help to increase digestibility of fibrous feeds like crop residues by directly producing enzymes, organic acids, amino acids, hormones, and other chemicals inside the digestive system of the animals. In Uganda, effective microbes are commercially available from MADCO Investments Limited.

Procedures for Preparing the Effective Microbes Solution

Step1: Mix 1 litre of molasses (if molasses is not available use 30 to 50 g of sugar) with 20litres of warm water (35–40°C).

Step2: Stir until it is completely dissolved. In this solution add 1 litre of microbe solution and stir so that the solution is properly mixed. Pour the solution into a 20-litre jerrican and tightly close or seal to create anaerobic conditions. The sealed solution should be put in a warm shed/room to ferment for 10–14 days. Occasionally remove the gas by slowly loosening the cap for short time and closing it again tightly.

Using Microbes to Improve Feeding Values of Cereal Crop Residues

Step1: Spray the microbe solution on cereal crop residues at the rate of 20 litres of microbe solution per about 15 kg crop residues and keep it for about 4 hours before feeding it to animals.

Step2: Treat crop residues using the microbe solution to make a silage. The procedures are described in detail below:

- After the treatment, the silage will be ready for use in 4–6 weeks.
- Microbes can be included in drinking water of ruminant animals (100 ml solution to 50 litres of water).
- Properly mix and allow animals to drink ad libitum.
- Microbes can also be used to treat concentrate feeds like wheat, rice and maize bran, poultry litter and other organic concentrates feeds.

Microbes are also used to avoid or reduce bad odour of barns and poultry houses when sprayed on barn floors.

(d) Ensiling Cereal Crop Stover or Straw with Processed Poultry Waste

Poultry waste (droppings) has a potential use as a feed resource for dairy cows because of its high (about 25%) protein content. In addition to offering an economic advantage, using poultry manure/litter as animal feed is environmentally friendly.

Chopping and fermenting cereal crop stover or straw with 15% processed poultry manure, microbes and molasses enhance protein and mineral content, increases dry matter digestibility and protein degradability of haylage.

Maize crop residues in Owino market (left) and chopped maize stover (right)

The use of low cost processed chicken manure, rice straw or maize stover as dairy cattle feed in urban areas presents a great nutritional potential to urban dairy cattle farmers.

Ensiling maize stover **Maize stover haylage**

(e) Improving Nutritive Value of Cereal Crop Residues Through Supplementation

Supplementing cereal crop residues with high protein and energy feeds is one of the best methods of maximizing the efficiency of their utilization. Crop residues (even treated crop residues) need to be supplemented with high-quality feeds such as green fodder and concentrate feeds. The level of supplementation, however, is lower for treated straws relative to the untreated crop residues. Many smallholder dairy cattle farmers may have limitations to afford concentrate feeds. Under such condition cultivation of forages, especially those with high crude protein content and higher biomass yields such as alfalfa, vetches, Mexican sunflower, cowpea, lablab, tree lucerne and elephant grass are alternative options.

4. Forage Legume Haulms and Hulls

Pulses are important crops belonging to the Leguminosae family. They comprise of annual and perennial leguminous crops such as beans, cow peas, groundnuts, chickpeas, pigeon peas and forages such as lablab with edible seeds that are used for both food and/or fodder/feed. The potential of pulses and their by-products as animal feed is governed by mainly two factors: (a) the contribution of nutrients to the diet, and (b) the presence of anti-nutritional factors.

There are three main by-products obtained from the preparation of bean legume seeds for human consumption which are marketed as supplemental animal feeds, namely, the seed-coats (testa) which are removed from beans, peas and lentils. They are known commercially by various names, “skins,” “shells,” “husks,” “hulls” and as “offals.” Pulse seeds

are sources of energy, fibre, amino acids, minerals, vitamins and essential fatty acids. However, their contribution of energy and amino acids is what confers on them the greatest economic potential in animal feeding.

By-products of pulses are valuable sources of protein and energy. They do not compete with human food, but contribute to decreasing cereals and soybean levels in the diets of livestock in intensive livestock production systems. They are used by smallholder farmers in Uganda, in extensive or mixed crop-livestock production systems to extenuate the feed shortage. Also their feeding provides important economic, social and environmental benefits by saving grains used for feeding for animals. For cows legume husks are milled into powder and mixed with oil cakes and bran with good results.

Groundnut/Peanut Haulm are a major industrial waste in peanut-producing countries. Their utilisation by livestock helps alleviate their environmental burden. They consist of an external hull (or shell) (21-29%) surrounding the nut (79-71%). Studies have shown that that average haulm yield ranges from 551 to 1,364 kg/ha while the average pod yield varies from 1,208 to 1,580 kg/ha. Peanut hulls are mostly comprised of fibre, with a crude fibre content that often exceeds 60% of DM, and a lignin content in the 6-45% DM range. Due to the presence of kernel fragments, peanut hulls contain small, but significant, variable amounts of protein (average 7% of DM) and oil (2% of DM).

Peanut by-products supply substantial quantities of feedstuffs to cattle grown in the same region where peanuts are produced. Concentrate feed sources especially grains and most by-products are expensive and not readily available to farmers. Residual peanut hay is by far the most widely used peanut by-product fed to cattle, and if it is properly harvested with minimal leaf shatter, it is comparable to good-quality grass hays in nutrient content. Peanut skins are often included in small quantities in cattle and pet foods, supplying both protein and energy. High tannin content of peanut skins can cause severe performance depressions in beef cattle if peanut skins are included at levels higher than 10% of the diet, unless diets contain relatively high CP (above 15% CP), or additional N sources are added such as ammonia or urea. Because dairy cattle diets are often above 16% CP in the total dietary DM, peanut skins may increase milk production when added at levels up to 16% of the dry matter. Peanut hulls are economically priced because of their quantity, their inherent high fibre, and low CP content, and they should not be fed as a primary feedstuffs for cattle.

Soybean Hulls: Soybean hulls are a by-product of soybean processing and are an excellent supplemental feed for dairy cattle. They provide excellent source of protein (9.4-19.2 percent), energy and digestible fibre to the dairy cattle ration. Soybean hulls have been used to replace forage and to replace cereals in concentrates. While soybean hulls ferment differently than starchy concentrate feeds, they cannot replace fibrous forages completely because they do not have sufficient structural fibre to stimulate rumination and maintain rumen pH. Conversely, excessive replacement of starch with soybean hulls may limit production of microbial protein and milk components. Urban dairy cattle farmers can mix milled soybean hulls with other forages.

Processing Soybean Hulls

Soybean hulls have to be heat-treated and milled to reduce their bulkiness and lower their urease activity. After cracking of soybeans, the hulls first pass through a sieve which separates fines and meats from the true hulls. The hulls are then toasted in order to destroy the urease enzyme. After heat treatment soybean hulls are referred to as soybean mill run, soybean flakes, or soybran flakes. Since soybean hulls have a very low density, they can be milled and pelleted to lower bulkiness.

Common Beans (*Phaseolus Vulgaris* L.) Residues: The common bean has a crude protein content of around 237.7 g/kg DM characterized the common bean as a product of low acceptability and digestibility, with recommendations for inclusion of up to 15% in

concentrates for fattening cattle. The inclusion of 0%, 13%, 26% and 39% in concentrates for lactating cows resulted in the reduction of milk production of the animals.

Legume grains contain 22 35% proteins, which may provide animal dietary requirements, as well as increase share of local protein sources in feed, diminishing the costs at the same time. Despite all this, the use of inappropriate proteins or amounts may cause an increase in production costs and decrease efficiency. Field beans have relatively high crude protein level and contain a considerable amount of energy in the form of starch, which makes them a unique feed that can be substituted for higher-priced protein and energy commodities like soybean meal.

5. Fruits Wastes

Due to increasing demands for horticultural produce, there is an ongoing shift in the cropping pattern from cereals to more remunerative fruit and vegetable crops, which has resulted in increased production of vegetable and fruit by-products and wastes. A lot of waste in the form of whole fruit, peels, seeds, etc. is generated daily from fruit production to the processing chain.

The fruit and vegetable industry produces millions of tons of residues, which can cause large economic losses. Fruit and vegetable by-products contain a large number of bioactive substances with functional ingredients that have antioxidant, antibacterial, and other properties. The use of these wastes could help in reducing feed cost and scarcity.

1. Pumpkin Waste

Pumpkin waste are part of the millions of tons of fruit residues produced yearly that could be used in livestock feeding. Every year discarded pumpkins release harmful methane gas into the atmosphere as they rot in urban food markets and landfills. Pumpkin waste which cannot be used in human consumption, may contribute to dairy cattle feed resource.

Pineapple waste

Nutritive Value of Pumpkin Waste

The primary health benefit for cattle is that pumpkins contain a high concentration of energy; 70 to 75% Total Digestible Nutrients on a dry matter basis. This makes them an excellent supplemental energy source. Pumpkins also contain 12 to 14% protein, a good source of vitamins A and E as well as folate and fibre that could enhance quality of milk as well animal health. Pumpkins are generally safe to feed to dairy cows. However, feeding a large amount of a new food to any animal may cause gastrointestinal upset or other digestive issues, so it's best to consider it as a seasonal snack.

Processing Pumpkin Waste for Dairy Cattle

Pumpkin Silage: Pumpkin waste can be made into silage ("Pumpkage") for use during periods of feed scarcity or dried and stored as powder for use in feed formulations. Whole pumpkins are chopped into small pieces and all components (rinds, seeds, guts, stems) are put into a heavy plastic garbage bag or plastic drums manually packed down with a weight to exclude as much air as possible, and tied closed. A lid is placed on the plastic bucket, which remain outside exposed to ambient temperatures. Chopped stover can be mixed with chopped pumpkins and the same ensiling process is used as for whole pumpkins.

Pumpkin Powder: To make the pumpkin powder, chop the pumpkins into small pieces and dry them in a solar dryer. Grind dried pumpkin into powder form. Store in an air-tight bag or container; in a dark and cool place.

Pumpkin silage

Pumpkin powder

2. Banana By-Products

Uganda is a significant banana producer, with over 10 million tons produced annually. Banana peels makes up around half of the total mass of the fruit (35%–50%) out of all by-products of the banana such as pseudo-stems, leaves, and blossoms. Banana by-products such as leaves, young plants, peels, stems, flower, rejected fruit and stems can be used as a source of dairy cattle feed. Although the volume of banana plant waste is abundant in urban, rural and peri-urban areas, its utilization is limited by several factors such as the high fibre in the stems and leaves. In addition, high water content can easily damage banana plant waste so that it is often wasted. To overcome the above constraints, further processing methods are needed to increase the nutritional value. The easiest and most low-cost method of further processing is using fermentation technology. Added value of the fermentation process is being able to preserve seasonally abundant feed for subsequent feeds during periods of feed shortages.

Banana Peels: Banana peels, which make up approximately 40% of the banana fruit, are typically wasted and contribute to a number of environmental issues, such as they may lead to the production of harmful gases namely ammonia and hydrogen sulfide in the atmosphere. Using banana peels as dairy cattle feed is a common practice in in urban areas of Uganda.


Banana peels

The use of banana peels as dairy cattle feed can support sustainable agriculture practices and enhance livestock productivity. Banana peels have numerous positive attributes, making them suitable as animal feed and as an alternative complementary feed during periods of forage shortage.

Nutritional Value of Banana Peel

The nutritional value of banana peels varies based on the cultivar and maturity stage, as the plantain peel contains less fibre than dessert banana peels, and lignin content increases with ripening (from 7 to 15% dry matter). Dried banana peels contain 6–9% protein and 20–30% fibre. Green banana peels contain 40% starch that is transformed into sugars after ripening. Green banana peels contain much less starch (about 15%) than green plantain peels, while ripe banana peels contain up to 30% free sugars. Banana peel contains phosphorus, iron, calcium, magnesium, and sodium but has low levels of zinc, copper, potassium, and manganese were found in very low concentrations as mg/100 g.

Benefits of Banana Peels for Dairy Cows

Banana peels are often readily available and inexpensive, reducing feed costs for farmers. Utilizing banana peels reduces waste and promotes sustainable agriculture practices. Studies have shown that feeding banana peels to dairy cattle can improve digestion, increase milk yield and quality and reduce feed cots.

Challenges and Limitations of Banana Peels as a Feed for Dairy Cattle

- High moisture content
- Availability and consistency
- Quality and safety concerns (mould and mycotoxins)
- Palatability and acceptance
- Competition with other feed sources

Feeding Guidelines

- Collect clean fresh banana peels from markets or farms.
- Wilt the peels to 10-15% moisture content.
- Mix peels with other feeds (e.g., hay, concentrates).
- Introduce peels gradually to prevent digestive upset.
- Banana peels can replace up to 10-15% of conventional feed.
- Combine peels with other feeds to avoid digestive issues such as diarrhoea.

Precautions

- Ensure peels are properly dried and handled to minimize risk of pathogens.
- Introduce peels gradually to prevent digestive upset.
- Ensure peels are free from contaminants and mould.
- Properly store dried peels to maintain quality.

- Accessibility: Banana peels may not be readily available in all regions.

Banana Peel Processing Technologies

Sun-Drying: Sun-drying banana peels and milling into powder is a very cost-effective option for urban dairy farmers in Uganda. The advantages of banana peel powder are long shelf-life and ease of mixing with silage or concentrate feed. Animals relish the powder compared to fresh peels. In case large quantity and rapid drying are desired, solar dryers are another option. Dehydrated, green, milled banana (banana pulp flour) has been successfully used as a source of starch in the preparation of calf feeds and specifically in the manufacture of milk replacers. Banana meal is an acceptable substitute for corn or wheat bran in concentrates for lactating cows.

Ensiling: Ensiling process is similar to the one used for making sweetpotato vine or Napier grass silage.

Ensiling Banana Peels, Maize Stover and Sweetpotato Vines

Step 1: Wilt clean (remove polythene material) banana peels.

Step 2: Chop maize stover into pieces of about 3 cm length. Maize stover (leaves and stems) can be bought from farmers' fields or from urban food markets.

Step 3: Chop sweetpotato vines into pieces of about 3 cm length and wilt them under sunshine for about 3 hours.

Step 4: Mix banana peels with chopped maize stover and sweetpotato vines in a ratio of 1 bag (about 50 kgs) of banana peels, 3 bags (about 210 kgs) of maize stover and 2 bags (about 140 kgs) of sweetpotato vines. Banana peels can be mixed with low sugar containing sugarcane tops or leafy vegetables.

Step 5: Mix molasses with water using a ratio of 1:2.

Step 6: Sprinkle the solution over a mixture of maize stover, banana peels and sweetpotato vines and mix thoroughly until the material is completely wet. Molasses improves palatability of the feed and aid fermentation during silage making.

Step 7: Store the mixture in airtight plastic drums or polythene tube silos for 30 days.

Supplement milking cows with a source of energy and minerals and provide plenty of clean water. The feed enhances milk and beef production.

Banana Residue-Based Total Mixed Ration for Dairy Cows

Ingredients

- Banana residues (dried, 20% moisture) - 15%
- Maize grain - 25%
- Soybean meal - 20%
- Wheat straw - 10%
- Mineral supplement - 5%
- Vitamin supplement - 2%
- Salt - 1%
- Calcium carbonate - 2%

Banana Leaves and Pseudostems: Banana leaves and pseudostems can be chopped and fed fresh or ensiled. Pseudostems are low in protein and mineral contents. They are efficiently used when supplemented with rich-protein ingredients, such as, cassava leaves, poultry manure and spent grain. The silage is of good quality when chopped pseudostems are properly mixed with an easily fermentable carbohydrate (such as molasses, sliced root vegetables) and protein-rich feeds (such as poultry litter, wet spent grain).

Banana Flower (Banana Blossom): The banana flower, often called banana blossom is a pendulum that forms below the last bunch of unripe bananas.


Banana flower and leaves and chopped and wilted banana flowers

The banana blossom, commonly employed as a dietary vegetable, represents one of the lesser-utilized components of the banana plant. It contains proteins, dietary fiber, vitamins, flavonoids (especially quercetin), tannin, and β-tocopherol). Banana blossoms contain significant potassium, calcium, as well as vitamins A, C, and E apart from powerful flavonoids like quercetin and catechin. They can be chopped, wilted and mixed with other feeds.

3. Pineapple Wastes

Pineapple fruit processing and consumption generates large quantities of by-products, which, in most cases are discarded as wastes. Pineapple by-products are thrown away and left at the farm sites or in urban areas until they decomposes naturally. Open dumping allows anaerobic digestion to go on releasing methane gas in the atmosphere. This huge volume of solid waste can be of substantial economic value. Out of the whole fruit, only about 30% is edible and remaining 70% (crown with leaves and peels) is non-edible for human consumption.

On a dry matter basis, the fresh pineapple waste contains 4 – 8% crude protein, 40 to 75% soluble sugars, pectin, and low amounts of minerals. There is therefore a need to add extra protein and mineral sources when formulating pineapple fruit wastes-based diets for animals. To improve the protein and mineral content of the pellets, add 15% Mexican sunflower *(Tithonia diversifolia)* leaf meal and 3% mineral premix to the pineapple residue powder.

The Pineapple Stem continues to elongate and sets down a tuft of short leaves called a 'crown. Individual fruits develop from the flowers and fuse to form one large cylindrical fruit topped by the crown. Pineapple waste in the form of **crowns** is a source of essential cellulose which will still be wasted due to lack of knowledge in processing and about its economic uses.

Pineapple crown

The high fibre contained in pineapple crown serves as an energy source in animal feed. Pineapple crowns can be chopped and mixed with other feeds. They can also be dehydrated as "bran" and fed to cattle.

Pineapple Leaves can be fed to dairy cows as fresh, dried, or conserved (silage or powder). Leaves must be chopped before use. It is recommended to ferment pineapple leaves with molasses. Although pineapple waste feed is relatively low in protein and high in fibre, this feed can be given to ruminants 15-20 kg per day either fresh or fermented plants during periods of feed scarcity. The dried leaves can be made into pellets. Because pineapple leaves have a low and poorly digestible protein content, supplementation with protein sources is needed.

Pineapple Peels and Core make 40-50% of the fresh fruit and contain mainly sucrose, fructose, glucose and other nutrients.

Pineapple peels and pineapple core

Pineapple's energy comes to it primarily from its carbohydrates, to the tune of 11.70 g per 100 g. Its carbohydrate content is higher than the average amount found in fresh fruit (11.31 g per 100 g). These are mainly sucrose (6.40 g per 100 g), fructose (2.30 g per 100 g) and glucose (1.80 g per 100 g). If fresh pineapple peels are not consumed, it often gets mouldy and sour, and therefore unlikely to be used as an animal feedstuff. Problems related with the fresh form, can be overcome by sun drying technique of pineapple peels.

Pineapple Waste Processing Innovations for Dairy Cattle Feed

Pineapple wastes can be processed by **ensiling, drying, pelleting and feed blocks** to improve their keeping quality and nutritional values for extended storage. The nutritive value of pineapple fruit wastes depends on the ratios of the different by-products contained, the cultivar, stage of ripening, and the juice extraction technology employed.

Silage Production Using Pineapple Residues

Step 1: Collect pineapple waste and sort out any contaminants.

Step 2: Chop the waste into smaller pieces of about 3 cm length.

Step 3: Mix pineapple leafy crown and fruit peels in a ratio of 4:1 ("weight by weight").

Step 4: Compact under airtight plastic drums/ plastic bags and allow natural fermentation or add microorganisms to break down the waste.

Step 5: Store the fermented mixture in airtight containers or silos.

Good quality pineapple silage is ready in a period of 21 days. The protein content of the pineapple silage on dry matter basis is 8-12%, calcium 1.5-2.5%, and phosphorus 1.2-2.0%. The protein content of pineapple residues silage can be improved by ensiling with 15% processed poultry litter

Benefits of Pineapple Waste Silage

- Pineapple waste silage is rich in fibre, protein, and minerals, making it a suitable supplement for ruminant animals like cattle, goats, and sheep.
- Utilizing pineapple waste reduces feed costs for farmers.
- Reduces waste disposal issues and methane emissions from decomposing waste.
- Silage can help reduce the risk of disease and improve animal productivity

Production of Pellets from Pineapple Leaf Waste

Feeding dairy cows with fresh pineapple wastes is difficult since the wastes are easily rotten and cannot be stored for the long-term usage. Thus, converting pineapple waste into **pellets** is a suitable method in handling such waste where the pellet form can increase the bulk density, improve the storability as well as reduce the cost of transportation. Furthermore, feed pellets are easier to control over the desired feed ration with the nutritional needs for animals. Below are steps in pineapple leaf waste pellet production:

Step 1: Remove rotten pineapples residues.

Step 2: Clean and chop pineapple fruit into small pieces of 2.5 to 5 cm length.

Step 3: Place the slices on drying trays fitted in a solar dryer for drying.

Step 4: Grind the dry pineapples waste to a size of 0.8mm to form powder.

Step 5: Sieve the powder using a sieve with size of 800 micrometre (μm) mesh.

Step 6: Add 10% molasses to improve fermentation and 5% Diatomaceous to serve as an aflatoxin binder.

Step 7: Compact pineapple leaf powder, Mexican sunflower leaf meal, mineral powder and molasses into pellets in the twin-screw extruder.

Pineapple waste pellets (Source: NET)

4. Watermelon Waste

Watermelon waste also known as watermelon pulp or rind, can be a nutritious and economical feed supplement for dairy cattle. Watermelon consists mostly of water (91%) and carbs (7.6%). It provides almost no protein or fat and is very low in calories. Not only do watermelon rinds contain all the nutrients found in the juicy fruit, but they also contain higher concentrations of certain antioxidants, minerals, vitamins and active ingredients. This hard peel has low-calorie levels, but high amounts of vitamin C, vitamin A, vitamin B6, potassium and zinc.

Watermelon rinds

Benefits of Watermelon Wastes for Dairy Cattle

- Increases dry matter intake
- Supports rumen health
- Provides essential nutrients
- May improve milk production and quality
- Cost-effective alternative to traditional feed ingredients

Precautions and Considerations

- Ensure proper drying or ensiling to prevent spoilage.
- Balance watermelon waste with other feed ingredients to avoid digestive issues.
- Limit inclusion rate (5-10% of total diet).
- Monitor for potential allergens or anti-nutritional factors.

Processing Water Melon Wastes for Dairy Cattle Feed

- Sun drying: Spread watermelon waste in thin layers, dry in sun (3-5 days)
- Mechanical drying: Use dryers or ovens (50-60°C, 2-3 hours)
- Ensiling: Mix with other feeds (e.g., hay, grains), add silage additives (e.g., molasses)

Recommended Inclusion Rates

- Lactating cows: 5-7% of total diet (DM basis)
- Dry cows: 3-5% of total diet (DM basis)
- Heifers: 5-7% of total diet (DM basis)

Potential Effects on Milk Quality and Production

- Increased milk yield (5-10%)
- Improved milk fat content (3-5%)
- Enhanced milk protein content (2-4%)
- Potential reduction in somatic cell count

Feeding Guidelines

- Introduce gradually (over 7-10 days)
- Mix with other feeds to avoid digestive upset
- Monitor cow health and adjust inclusion rate as needed

5. Jackfruit Waste

One of the unexplored vegetable by-products is Jackfruit waste on which least research has been conducted for its possibility to be included in livestock feed. Jackfruit consumption and processing leads to the generation of enormous amounts of non-edible wastes of peel, central axis, and edible by-products like seed and perianth. About, 70 to 80% of the jackfruit consists of wastes. The outer rind or peel, central core, and perianth make up about 55 to 60% of this fruit. The seed is an important by-product that constitutes around 12- 14% of a whole jackfruit.



Jackfruit waste (Source: NET)

Nearly 60 per cent of the jackfruit is discarded after the fleshy parts are taken out. Fresh jackfruits and fruit wastes are highly palatable to ruminants. They can be a good source of energy due to their valuable amount of starch and high in vitro dry matter digestibility (84-85%).

Jackfruit Seeds: There is considerable variation in the composition reported for jackfruit seeds in the literature. They are low to moderate in protein (10-18% dry matter), and low in fibre (crude fibre < 4% dry matter) and fat (< 2% dry matter). The rest of the seed consists in starch and sugars. The seeds have good nutritive value (they contain valuable amount of vitamine A, sulphur, calcium and phosphorus).

Jackfruit Leaves: Jackfruit leaves are used as fodder for cattle. The leaves are of moderate nutritional quality, with a protein content 10-19% dry matter and a large range of fibre (Neutral Detergent Fibre 28-51% dry matter) due to the variable proportion of twigs and stems included in the fodder. Jackfruit leaves can be a good source of protein

but they must be supplemented with another protein source due to the presence of tannins content and to the low protein digestibility or degradability.

Jackfruit Peel: Jackfruit peel, also known as rind or skin, is the outer protective layer of the fruit which consists about 58%. The unsystematic disposal of peel imposes a serious burden on the environment. However, proper utilization of the by-products not only increases the economic value but also reduces the cost of disposal.

Jackfruit peel is rich in cellulose, pectin, protein, and starch comprising about 27.75%, 7.52%, 6.27%, and 4%, respectively. Jackfruit peel is a rich source of bioactive antioxidants like vitamin C and beta-carotene, which protect the body against free radicals and strengthen the immune system. It is also rich in various phytonutrients such as alkaloids, lignans, isoflavones, and saponins.

Jackfruit peels are prone to rapid spoilage due to their high sugar content and moisture level. Thermal drying, grinding and fermentation with fungi and bacteria have been found effective for the inclusion of Jackfruit peel in livestock meal. Ensiling must be done promptly to prevent microbial contamination and spoilage.

Potential of Jackfruit Waste As Livestock Feed

Research has shown that jackfruit waste feed supplemented with 2% ammonium sulphate and fermented by combined yeast and LAB (*Lactobacillus acidophilus*) recorded the highest crude protein (22.34%) and crude fibre (23.37%). The developed feed from jackfruit waste in the form of dried powder contained moisture 5.42%, carbohydrate 71.40%, protein 23.81%, crude fibre 22.63%, crude fat 6.37%, and ash 6.5%.

Milk Production: Inclusion of jackfruit waste into dairy animal ration increases milk yield and other pertinent quality factors. Further, this increases the profitability of the farmer in terms of quantity and quality produced. To properly balance the diet, it may be necessary to provide an appropriate supplement of energy or protein to enhance the utilization of jackfruit leaves.

Jackfruit Leaves Silage: Jackfruit leaves can be used to make silage. In a plastic silo, the chopped jackfruit leaves are mixed with feeds such as napier grass, sweetpotato vines, cereal stovers and diluted molasses and packed into a polythene tube, which is then placed in an airtight container. Solid-state fermentation of jackfruit waste by probiotic yeast and lactic acid bacteria is advantageous for livestock feeding. Fermentation of jackfruit waste with *S. boulardii* and lactic acid bacteria *L. acidophilus* demonstrated crude protein of 9.59% and 9.32%, respectively. The increase in the protein content of jackfruit waste is possibly due to utilization of sugars and nitrogen sources by the probiotic yeast and *Lactobacillus acidophilus*. Replacing one third of concentrate feed with about 5 kg of fresh jackfruit waste in diet of crossbred lactating cattle resulted in a reduction in feed cost per kg milk production by 15% without altering feed consumption and milk yield. They estimated digestible crude protein of 4.17% in jackfruit waste.

(6) Vegetable Wastes

Feed and fodder problems could be well-addressed in urban areas using the vegetable wastes. They are highly perishable and are very prone to spoilage due to high moisture content. Vegetable wastes are left in the field or in urban areas after harvesting or selling the vegetables contributing to unhealthy/unhygienic surroundings. A number of vegetable wastes such as carrot, cucumber, peas, tomato, cabbage leaves, cauliflower trimmings, leafy greens (kale, spinach), pea vines and radish leaves, among others in ruminant diets are rich in both protein (11-20%) and energy.

Benefits of Using Vegetable Wastes as Cattle Feed

- Vegetable waste can be cheaper than traditional feed sources.
- Vegetable waste can provide essential nutrients like fibre, vitamins, and minerals.
- Reduces waste disposal issues and promotes sustainable agriculture.

Constraints in Using Vegetable Wastes as Dairy Cattle Feed

- High moisture content
- Presence of contaminants, mainly pesticides and pesticide residues.

Precautions

- Ensure waste is free from contaminants (e.g., soil, plastics, pesticides).
- Balance nutrient content to avoid digestive issues.
- Consult with a veterinarian or animal nutritionist for proper integration.

Processing Vegetable Waste for Dairy Cattle Feeding

Drying and ensiling vegetable wastes have been used for enhancing shelf life and making incorporation in animal feeds easier. There is a need to monitor pesticide and pesticide residues, mycotoxins, heavy metals and anti-nutritional factors before using vegetable products in animal diets. Full potential of these unconventional feed resources can be realized by concerted commercial efforts. These resources are yet untapped and their efficient use will enlarge feed resource base, enhance feed availability and bring the wasted food back to human food chain.

Feeding Guidelines

- Introduce vegetable waste gradually (5-10% of diet).
- Mix with other feeds to balance nutrient content.
- Ensure proper moisture content (50-60%).
- Monitor cow health and adjust feeding rates accordingly.

7. Poultry Waste

The poultry industry is one of the largest and fastest growing sectors of livestock production in urban areas of Uganda. This can be attributed to an increasing demand for poultry meat and egg. However, a major problem facing the poultry industry is the large-scale accumulation of wastes including poultry excreta, spilled feed, feathers, and material used as bedding in poultry operations which may pose disposal and pollution problems. A chicken produces 80-100 g of manure daily, corresponding to 3-4% of its body weight. This rapid expansion of the poultry industry has increased the need to find economically viable and environmentally acceptable ways of utilizing such large quantities of poultry waste.

When birds are housed on littered floor, the amount of poultry house wastes (litter) may be twice as that of droppings alone. It has also been estimated that for every kg of egg mass produced, a hen produces about 4 kg of fresh droppings or 1 kg of the dry excreta.

Chemical Composition of Poultry Waste

Fresh poultry manure is about 30% crude protein on a dry mater basis, about half of which derives from uric acid. Poultry droppings have high phosphorus (2.5 to 2.8 %), potassium (2.0 to 2.3 %), calcium (4.5 to 8.2 %), magnesium (0.5 to 0.7 %) and appreciable quantities of micronutrients like Copper, Zinc, Iron, Magnesium etc. Protein content in the dried poultry manure is 25-30%, equivalent to 75% of three grades of fish meal protein matter content.

Challenges of Feeding Processed Poultry Waste to Dairy Cows

From a hygiene perspective, unprocessed poultry waste contains pathogenic microorganisms such as Clostridium, Salmonella and Enterobacter spp. Hence proper processing to render the waste free of pathogens is required. In addition, feed additives such as antibiotics, arsenicals, and coccidiostats are added in poultry diet, which can be excreted as waste by-products. Furthermore, some of the fungal species that are indigenous to the manure or litter can result in the production of mycotoxins. Pathogenic microorganisms can be destroyed by chemical, fermentation, ensiling or heat processing. Poultry waste is a source of odour caused by the activity of anaerobic microorganisms

in the manure. It is, therefore, necessary to subject poultry manure to some treatments in order to improve its storage and handling properties and to minimize the risk of disease transmission and environmental pollution.

Processing Poultry Waste/Litter

Proper poultry manure management systems that will preserve the environment, contribute to both animal and human health and return a profit on investment to farmers need to be developed. Processing methods are helpful in detoxification, improving its feeding value, palatability and texture/colour. Good poultry waste management, including exclusion of dead birds/other extraneous materials from the litter and appropriate processing prior to feeding, such as sun drying, ensiling or roasting has been reported to prevent growth of microorganisms.

Methods Used to Process Poultry Waste/Litter

Sun-Drying:

Drying and milling poultry waste is feasible because it contains less moisture than that in pig or cattle excreta.

Step 1: Sieve poultry waste to remove foreign materials such as feathers and stones.

Step 2: Dry the manure under sunshine or in a solar dryer and store in a well-ventilated place.

Sun-drying reduces the bulk of animal wastes to 20-30% of the original volume. By drying, the rate of deterioration from chemical and biological activity is minimized and the environmental problems associated with raw manure can be prevented. Drying also removes manure stickiness and hence allows for easier handling. Savings in feed cost through nutrient recycling would be sufficient to justify the cost of sun-drying while also protecting the environment.

Drying poultry waste in a solar dryer (Task Farm, Rubaga, Tel: 0782747326)

Step 3: Roast the powder for about 10 minutes.

Step 4: Milled manure into powder using a mill hammer. The powder is stored in well ventilated store.

Processing poultry waste

Ensiling Poultry Manure (Wastelage): Wastelage is *"a material obtained after ensiling of waste material of animal origin in a suitable combination with forages and additives, under anaerobic condition through fermentation by lactic acid producing bacteria".* The steps in the preparation of **wastelage** are similar to silage production.

Processed poultry waste can be ensiled with crop residues such as sweetpotato vines, maize stover, forages and other roughages, fruit and vegetable wastes or with molasses alone provided there is sufficient moisture (40-60%) and soluble carbohydrates in the substrate to ensure good fermentation process.

Advantages of Ensiled Poultry Waste

- Ensiled poultry waste is nutritionally superior to the dried product.
- Ensiling poultry waste is a simple and low-cost option, which can preserve feeds that are seasonally abundant for later feeding during periods of feed shortage.
- Ensiling destroys pathogenic microorganism and render palatable feed to livestock by changing the chemical nature of some unusable materials.

Guidelines for Feeding Processed Poultry Waste to Dairy Cows

Research conducted on feeding processed poultry waste to dairy cows shows encouraging results with no adverse effects on milk yield or composition. **The optimum level of poultry waste in dairy cows' ration has been worked out to be 15%** in high yielding animals to prevent excessive intake of Calcium which may otherwise cause serious metabolic disorders. Dairy cows fed ensiled poultry manure consisting of chopped rice straw or maize stover, poultry manure and maize bran in a 5:2:3 ratios performed well. Cows usually adapt themselves rapidly from fresh green forage or pasture to the poultry litter and cassava silage without any adverse effect on milk production.

Suggested Rations

The two deficiencies associated with litter and grain mixes are vitamin A and fibre. Add vitamin A to litter and grain mixes or inject individual cattle. Provide hay, pasture, maize stover or some other roughage to meet fibre needs. To obtain the desired animal performance, adjust litter to grain ratios and feed consumption. Maize is usually the preferred grain to mix with litter. However, other high-energy/low-protein concentrates, when properly processed, may be used, such as soybean hulls.

- **Ration 1: For Dry Beef Cows until 3 to 4 Weeks Before Calving**. A-450kg/ dry cow requires 8 to 10 kgs of Ration 1 during the dry months. Provide roughage source to maintain normal rumen function. Broiler litter: maize bran ratio is 80:20
- **Ration 2: Formulated For Dry Beef Cows With Average Milking Ability**. Feed approximately 10 kgs daily. This ration furnishes adequate nutrients during the dry months. Provide hay or other roughage. Broiler litter: maize bran ratio is 70:30.
- **Ration 3**: **Formulated For Superior Milking Cows and First Calf Heifers**. Feed

about 12 kgs daily to 450 kgs cows and 4 daily to 400 kg first calf heifers. Provide hay or other roughage source. Broiler litter: maize bran ratio is 65:35.

- **Ration 4**: **Formulated For Growing Stocker Cattle.** Stocker cattle weighing 500 pounds will consume about 3 percent of their body weight of this ration. Healthy stocker cattle that have been dewormed, vaccinated, implanted and otherwise managed as recommended should gain an average of 1 kg daily when fed this ration. Provide at hay or other roughage source. Broiler litter: maize bran ratio is 50:50.

Note: To successfully formulate a balanced diet, the chemical composition of the litter and other ingredients and nutrient requirements of the animal must be known.

Hardware Precaution

Farmers who intend to utilize litter as a feedstuff should use precaution to avoid **hardware disease**. A **magnet** installed in mixing equipment can help capture metals; however, copper wire or glass from broken light bulbs will not be collected by magnets.

3.3.2. CONSERVED FEEDS (SILAGE AND HAY PRODUCTION)

Herbage availability during the wet season often exceeds animal requirements; however the accumulated forage becomes coarse and loses most of its nutritive value with maturity. The excess herbage harvested at optimum nutritive value (when about 10% of the plants have flowered) could be conserved as silage for dry season feeding when pasture is very scarce so as to sustain milk production.

Feeding strategies based on conserved fodder include feeding of dry fodder (hay or haylage) and fresh material (silage). Forage conservation permits a better supply of quality feed when forage production is low.

Silage is made from green, leafy plants that have been fermented. This fermentation process helps to preserve the nutrients in the plants and make them more digestible for cows. Silage can be made from a variety of plants, including pasture grasses such as napier grass, maize, sweetpotato vines, sorghum, and leguminous forages.

Hay is made from dry grasses and forage legumes. Hay is dried to contain less than 20% moisture, whereas pasture typically has around 80% moisture. Due to its reduced water content, hay can be stored for longer periods without spoiling or becoming mouldy.

Haylage is ensiled dry forages such as cereal stover, straw or grass hay. Haylage is part-way between hay and silage.

Benefits of Feeding Conserved Forages to Dairy Cows

- In urban areas of Uganda good quality silage, haylage and hay provide dairy cows with some of the nutrients they need to stay healthy and productive. Good quality silage, haylage and hay are high in nutrients, including protein, energy, and fibre. In addition, silage and hay can help to reduce the cost of feeding dairy cows and contribute to a clean environment.
- Silage, haylage and hay can help to improve the quality of milk produced by dairy cows by increasing the milk's protein and fat content.
- Silage, haylage and hay can help to reduce the amount of land that is needed to produce feed for dairy cows.

Pasture Hays (Grasses and Legumes)

Pasture Grass Hay: Pasture grass hay is produced from a variety of grasses including *Brachiaria ruziziensis* (Congo grass) and *Brachiaria brizantha* (Common signal grass); *Chloris gayana* (Rhodes grass) and other grass species. Pasture grass hay contains

lower levels of carbohydrates, protein (about 10 percent), vitamins and minerals than legume hay. However, pasture grass hay is very high in fibre. Because pasture grass hay contains low feeding value, it is necessary to supplement dairy cows with high protein and energy supplements to ensure its nutritional needs are being met. Many farmers in peri-urban and rural areas are producing pasture grass hay for sale to dairy cattle farmers with no land to produce feeds.

Pasture Legume Hay: Pasture legume hay can be made from a wide variety of forage legumes and fodder trees and shrubs including *Lablab purpureus* (Lablab), *Centrosema pubescens* (Centrosema), *Macroptilium atropurpureus* (siratro), *Medicago sativa* (alfalfa); *Calliandra calothrysus* (Calliandra), *Gliricidia sepium* (Gliricidia) and *Tithonia diversifolia* (Mexican sunflower). Pasture legume hay has high protein (over 15 percent) and calcium levels, as well as being rich in vitamins and minerals. It is more palatable than other grass hay. Cattle perform well on legume hay and benefit from the high energy and protein content. Dairy cows require the highest quality legume hay to keep up with milk production.

Legume/Grass Blended Hay: A mixture of pasture grass and forage legume hay help to improve nutritional value of grass hay. Not only do these mixtures provide a more well-rounded diet, but growing them together often produces more forage than growing a legume or grass alone.

Grass Cut from Compounds and Conserved as Hay

Many schools, residential areas and church compounds in urban, rural and peri-urban areas of Uganda are very large and keeping them clean is almost a mystery. However, grass cut from these compounds can be turned into dairy cattle feeds and a source of income. This grass can be collected and stored for use during periods of feed shortage.

Paspalum grass *(Paspalum notatum)*: Paspalum also known as Caterpillar grass, Millet grass, common paspalum is a long-lived tufted grass growing up to 1.5 m tall. The live leaf bases at the terminus of each rhizome usually have a purplish hue. However, in mown situations, the plant can be prostrate (growing close to the ground) with only the flowering heads produced above mowing height.

Paspalum grass (Source: NET)

Paspalum Grass Hay Production

Step 1: Spread Paspalum grass cut from compounds and leave it under sunshine for one day. For quick drying, turn the grass 2-3 times during the day using a rake while still in the compound. Remove polythene materials that could be dangerous to cows.

Step 2: Collect the grass in the afternoon and transfer it to store to complete the drying under a shade. This enables the grass to maintain the green colour. Bale the dry grass using locally made baling boxes.

Dry Paspalum grass cut from a compound

Feeding Pasture Grass Hay to Dairy Cows

Step 1: Chop grass hay into small pieces of about 3 cm length using a forage chopper. You can mill it into powder.

Milled Rhodes grass hay (Source: Kiweebwa Mixed Farm (Tel:+256 751627759)

Step 2: Mix chopped or milled grass hay with 30% wilted leguminous forages such Mexican sunflower foliage or dry forage legumes such as lablab to improve the protein content of grass hay.

Step 3: Soak the mixture in diluted molasses (molasses mixed with water in a ratio of 1:2) for about 4 hours. Molasses improves energy content and palatability of the hay.

Step 4: Provide the cows with plenty of clean water and mineral supplements. Lactating dairy cows must be supplemented with a source of energy.

Silage Production

Types of Silos (For Small-Scale Operation with About 10 Animals)

Stack Silo: A plastic sheet (about 0.1 mm thick) is spread over the ground, and similarly chopped silage materials on the sheet are entirely covered with a plastic sheet. The size can be determined according to the number of animals. Proper tread pressure has to be applied, and complete sealing is required. It is necessary to prevent damages on the plastic sheet by field mice or birds

Bunker Silo: A bunker silo is built on the ground, but there are other building methods to build a silo using the configuration of the ground (slope) or a semi underground type, which is half below from the ground level.

Bunker silo at The Green Elephant Limited, Kajjansi, Wakiso district

Side walls made of wood and concrete are needed, and the interior is preferably sealed by plastic sheets. Proper tread pressure has to be applied, and complete sealing is required. Supports are needed so that the side walls do not fall toward the outside. The width of the front should be such that the total amount of silage per day can be taken out with a thickness of 20-30 cm to prevent aerobic deterioration.

Trench/Pit Silo: A trench silo can be built by simply digging the ground, but it is better to place plastic sheets inside to prevent loss. Proper tread pressure also has to be applied, and complete sealing is required. A trench silo whose interior is coated with concrete can be used for a long time. The width of the front should be such that the total amount of silage per day can be taken out with a thickness of 20-30 cm to prevent aerobic deterioration.

Plastic Silo Bag and Drums: Silage is packed and stored in a plastic bags with the thickness of about 0.1 mm or plastic drums.

Plastic silos

Advantages of Using Plastic Bag Silos

- Plastics silage bags or drums are an economical alternative to traditional silage storage systems, such as pits and silos when related, harvest and storage losses are considered.
- It is an effective way for preserving feed with minimum nutrient loss. (The anaerobic environment that is created eliminates spoilage from the growth of yeasts, moulds and adverse bacteria while maintaining essential proteins and nutrients).
- Allows farmers to store silage anywhere they need it. A well graded and well drained ground surface is all that is necessary.
- The silage is completely sealed in the bag or drums. This means that all the acid is retained in the silage, unlike that in pit silage when it seeps out through the

bottom of the pit as effluent. This compensates for the longer pieces of forage and poorer compaction than that found with silage machinery, so that the quality of the silage is just as good.

- Ensiling in a bag or drum avoids the hard work of having to remove silage, as it has to be from a pit, when it has to be dug out every day.
- Because the whole bag is fed out to the animal, it means the rest of the silage which is in the other bags is not exposed to air at removal and is therefore unspoiled. Much of the silage in pits has been found to be spoiled due to poor sealing and exposure to air every day when the silage is removed for feeding.
- The bag is easily stored and easily portable so that any member of the family can carry it to the feed trough for the cow.

Disadvantages of Using Plastic Silos

- Correct bag size must be used
- Can result in significant losses of dry matter (DM) if bags are not routinely monitored for holes and tears
- Occasionally bags split open, usually due to inadequate venting of fermentation gases
- Plastic from silage bags needs to be disposed of properly
- Ensiling forage with large variations in DM from load to load can result in variability in silage DM at feedout

Maize Crop Silage Production for Dairy Cattle Farmers in Urban Areas

Maize silage is made out of whole ensiled maize plants. It is one of the most valuable forages for dairy cattle. Maize silage is popular because:

- It is a consistent source of palatable and high-energy forage for all classes of ruminants, including dairy cattle, beef cattle, sheep and goats.
- It is one of the most high-yielding (10 -20 ton/ha/season of maize fodder depending on the variety) forage crops, requires less labour (since it is harvested in a single operation) and is generally less costly (per ton dry matter) to produce than other forage crops.
- Maize silage is a good way to secure the crops as it is possible to turn a maize grain crop damaged by frost, rain or drought into maize silage.
- Silage made from maize is very tasty, and average yields are 10 -20 ton/ha of maize fodder depending on the variety

Though relatively easy to produce, maize silage requires good crop and harvest management as well as careful ensiling practices.

Nutritive Value of Maize Silage

Maize silage contains 25-35% dry matter (DM). Nutritionally, maize silage has high protein content (12-15 percent, depending on the variety and other agronomic conditions) and rich in fibre (15-27% of DM), with a highly variable starch content (18-37% of DM). It differs from other forages in that quality does not decline with advancing maturity. This is because the increasing amount of grain in the crop offsets the decline in digestibility normally associated with structural tissues (in the case of maize, stem). Compared to many forage crops, maize is relatively easy to ensile. It is however a high-cost crop to grow, ensile and feed.

The Size of a Silo

The silo size is determined by a herd size, the amount of daily feed, the number of feeding days and packed density of the raw materials. An example of calculation in case of 10 dairy cows is as follows:

- Ten dairy cows (a herd size) x 20 kg/cow/day x 180 days (number of feeding days) = 36 tons
- The capacity of the silo is: 36,000 kg = 700 kg/cubic metres (m^3) = 51.4 cubic metres (m^3).

- 10% is added to account for packing loss in the silo: 51.4 m^3 (1 – 0.1) = 57.1 m^3
- 20% is added to account for loss during storage. The resulting calculated silo capacity is: 57.1 m^3 (1 – 0.2) = 71.4 m^3

Key Steps in Making Maize Crop Silage Using a Plastic Tube Silo

Step 1: **Harvesting Time**: Maize plants are cut at "**milk stage "** (the stage when the grains are being filled. It begins after flowering and lasts for about 2 weeks. Starch produced primarily by the flag leaf and second leaf move into the grain)". This occurs 50-55 days after cob silking. This can be correlated with two visual indicators in the grain, the milk line (limit between the dent part and the liquid part of the grain), and the black layer (that is visible at the base of the kernel once complete maturity has occurred). Delaying harvest can reduce both the fibre and starch digestibility as the stover gets more lignified and the over mature kernels become harder and less digestible if left unbroken after ensiling. Maize needs to be cut at 15 cm from the ground and chopped into pieces of around 1 cm length.

Maize crop ready for harvesting for silage production (Source: NET)

The kernels are the primary source of starch in maize silage, and they must be cracked before being placed in the silo. Newly made maize silage contains about 10%, which can cause acidosis, where too much acid forms in the stomach, so it is best to wait at least two months before using the maize silage as feed.

Maize plant residues are available in peri-urban and rural areas after harvesting the maize grain. Dairy cattle farmers can buy the residues and make silage.

Stage 2: Wilt the maize fodder by leaving it in the field for at least 12 hours, to remove excess water.

Step 3: Chop maize fodder into small pieces, about 2.5 cm length. The smaller the pieces the easier it is to compact the fodder. Longer chop lengths are more difficult to compact and displace the air within the crop especially the stems, which are harder and hence more difficult to compress resulting in losses in the silage making process. Livestock especially young ones consume more forages with shorter length as compared to longer ones. More consumption of good quality forages results in higher milk production. It is important to time the cutting of the forage so that the cut forage is not sitting for more than a day waiting to be chopped and ensiled, otherwise it will become mouldy or to dry.

Step 4: Spread 50–70 kg (1 gunny bag well compacted) ensilage on a canvas or polythene sheet.

Step 5: In order to improve the ensiling process, various types of additives such as microbes and diatomaceous feed grade (aflatoxin binder) are recommended. The biological additives are advantageous because they are safe and easy to use, noncorrosive to machinery, do not pollute the environment, and are natural products. Inoculants/microbes are added to silage in order to stimulate lactic

acid fermentation and to accelerate the drop in pH. *Lactobacillus buchneri* is used as a silage inoculant to enhance the aerobic stability in a variety of silages via the anaerobic degradation of lactic acid to acetic acid. The maize grain provides fermentable sugar to favour the development of the correct bacteria and speed up the fermentation process.

Step 6: Pack the silage in a plastic silo. It is important that once the forage has been chopped it is placed in the silos and compacted as much as possible to get the air out before the silo is sealed. Air should not be allowed to enter the silo as oxygen will cause oxidation of sugars in the forage. If too much air is present, the silage becomes too hot and the overheating causes the silage to become dark brown. Good silage is sweet smelling and green to light brown in colour.

Step 7: Store silage in bags can result in significant losses in DM if bags are not routinely monitored for holes and tears. It may be necessary to limit the access of birds and wildlife to the storage area with fences, bird netting and other pest control measures.

Advantages of Maize Silage

- High fodder yield (10-25 tons/acre, depending on maize variety, soil fertility, climate and overall management).
- High energy feed forage to meet the requirement of milking cows.
- An efficient way to store high quality feed for feeding during the dry season.

Disadvantages of Maize Silage

- Requires very careful preservation to give a good product.
- Added cost of plastic and molasses for storage.
- Must be able to chop relatively large volumes at one time.

Effects of Feeding Maize Silage on Dairy Cattle Performance

- Maize silage will supply the necessary energy to produce higher levels of milk.
- Cows with adequate energy in their feed will show heat and get in calf earlier than cows that are fed less energy.
- Cows will maintain their weight while milking well and not get skinny.
- Cows will give higher volumes of milk longer and will have good weight when they are dried off for the next calf.

Feeding Maize Silage to Dry Cows, In-calf-Heifers and Calves

- Silage should be fed as soon as possible, preferably within a few hours.
- After feeding, the feed troughs must be cleaned out to prevent any remaining silage, which will spoil, contaminating the next feed out.
- Silage can be provided to animals in number of different recipes based on its composition and the breed and use of the animals.
- In general silage should be used up to 25 kg per day for 550 kg cow.
- To avoid off-flavour in milk, silage should be fed to lactating cows after milking the animals.
- The easiest way to get a cow's weight is using a heartgirth tape measure and a conversion table (Table 5). Suggested quantities for feeding maize silage to different types of stock are shown in Tables 6.

Table 5: Table of girth circumference (cm) to estimate weight (kg) (Source: NET)

(cm)	(kg)	(cm)	(kg)	(cm)	(kg)	(cm)	(kg)	(cm)	(kg)
68	30	115	136	162	351	209	732	256	1202
69	31	116	140	163	358	210	742	257	1211
70	32	117	143	164	366	211	752	258	1221
71	34	118	147	165	373	212	762	259	1231
72	35	119	150	166	381	213	772	260	1240
73	36	120	153	167	388	214	782	261	1250
74	37	121	157	168	396	215	792	262	1260
75	38	122	161	169	403	216	803	263	1270
76	40	123	164	170	410	217	814	264	1279
77	42	124	168	171	418	218	825	265	1289
78	43	125	172	172	426	219	836	266	1299
79	45	126	176	173	433	220	847	267	1308
80	46	127	180	174	441	221	858	268	1318
81	48	128	184	175	448	222	869	269	1328
82	50	129	188	176	456	223	880	270	1338
83	52	130	192	177	463	224	891	271	1347
84	54	131	196	178	471	225	900	272	1357
85	56	132	201	179	478	226	910	273	1367
86	58	133	205	180	485	227	920	274	1376
87	60	134	210	181	492	228	930	275	1386
88	62	135	214	182	500	229	939	276	1396
89	65	136	219	183	508	230	949	277	1405
90	67	137	223	184	516	231	959		
91	69	138	228	185	524	232	968		
92	72	139	232	186	532	233	978		
93	74	140	236	187	540	234	988		
94	77	141	241	188	548	235	998		
95	79	142	246	189	556	236	1007		
96	82	143	250	190	564	237	1017		
97	84	144	255	191	572	238	1027		
98	87	145	260	192	580	239	1036		
99	90	146	265	193	588	240	1046		

(cm)	(kg)	(cm)	(kg)	(cm)	(kg)	(cm)	(kg)	(cm)	(kg)
100	93	147	270	194	596	241	1056		
101	96	148	275	195	604	242	1066		
102	98	149	280	196	613	243	1075		
103	101	150	285	197	622	244	1085		
104	103	151	290	198	631	245	1095		
105	106	152	295	199	640	246	1104		
106	109	153	300	200	649	247	1114		
107	112	154	305	201	658	248	1124		
108	115	155	310	202	667	249	1134		
109	118	156	316	203	676	250	1143		
110	121	157	321	204	685	251	1153		
111	124	158	327	205	694	252	1163		

Source: *NET*

Table 6: Utilization of silage for different types of stock

Stock	**Quantity (kg)**
Lactating dairy cow	10-20
Dry cows	10-15
Dairy heifers	5-8
Beef breeding cows	12-20

Source: *Mellish et al. (2016)*

Silage Business Opportunities in Uganda

Dairy farming is turning out to be a profitable venture for both small and large-scale farmers in Uganda. As more farmers venture into the practice, the need to have quality feeds is also pushing many farmers to take to silage as a feed for their animals for more milk production. For many years, Uganda has been known as a basket for maize where farmers grow maize for food and income generation. The trend is today slowly changing with many farmers taking to maize growing as a feed for animals. The advantage of such ventures is the vast land in the country where some residents own large acreage of land. The need for silage making has been necessitated by the urge by Ugandans to venture into dairy farming. Indeed, the key to unlocking the potential of dairy farming in the country lies with the improvement of feeds and low costs of milk production. Technology has made it easier for quality silage and individuals and companies have ventured into the practice to boost dairy farming besides making profits. Enterprising farmers and youth can look at maize, napier grass and other forages for silage production as an alternative source of livelihood. Dairy cattle farmers in urban areas can hire land in peri-urban and rural areas to produce silage for sale. Table 7 shows estimated costs and income from producing maize silage as a business.

Table 7: Estimated income from growing one acre per season of maize crop

Operation (Ushs/acre)	Maize grain and maize stove haylage production	Maize silage production
Seed rate (kg/acre)	10	20
Hiring land (Ushs/acre)	150,000	150,000
Cost of hybrid maize seed (Ushs 6,000 @ kg)	6,000	12,000
Land preparation and planting (Ushs)	250,000	250,000
Weeding (Ushs)	300,000	200,000
Labour for harvesting and drying grain (Ushs)	250,000	-
Labour for harvesting and making maize silage (Ushs)	-	300,000
Labour for making maize stover haylage (Ushs)	200,000	
Transport cost (Ushs)	100,000	100,000
Sisal strings (4 rolls @ shs 4000)	16,000	16,000
Polythene sheets	360,000	360,000
Total cost of production (Ugshs)	1,632,000	1,388,000
Yield (kg/acre)		
Average quantity of maize silage produced (kgs/acre)	0	15,000
Average quantity of grain produced (kgs/acre)	2,500	-
Average quantity of maize stover haylage produced	5,000	-
Income (Ushs/acre)		
Income from sale of maize grain @ shs 900 per kg	2,250,000	-
Income from sale of maize silage (shs 500 per kg)	0	7,500,000
Income from sale of maize stover haylage @shs 500 per kg	2,500,000	-
Total income (Ushs)	4,750,000	7,500,000
Profit (Ushs per acre)	3,118,000	6,112,000

(a) Napier Grass Silage

Napier grass fodder is recommended as a basal diet for dairy cows under zero grazing system. Limited land in urban areas makes it difficult for farmers to grow napier grass fodder. Some dairy cattle farmers in urban areas hire land in peri-urban and rural areas

to grow napier grass varieties such as: Pakchong 1 Super, Juncao Giant and Sugar napier. The major challenge is the cost of transporting the fodder and the high cost involved in planting and managing the fodder fields. Some farmers in rural areas plant napier grass as a source of income through sale of silage to urban dairy cattle farmers.

Pakchong 1 Super Napier Grass Variety

The Super Napier grass also known as Pakchong or Hybrid Napier is an interspecific hybrid of two species native to Southeast Asia. It was first developed in Thailand in the late 1960s by culturing the tissue of the pearl buckwheat tree with the African Napier grass. The resulting hybrid has a number of advantages over its parent species, including higher yields, better resistance to pests and diseases, and greater tolerance of drought and flooding. Super Napier grass was introduced into Uganda by The Green Elephant Uganda.

Once planted, the grass can provide high yield for 7-8 years continuously with a harvest of 100-150 metric tons of green succulent grass per acre annually (depending on soil fertility, climate and management) which can be harvested 7-8 times a year. The yield is twice that of ordinary Napier grass. Besides high fodder yield, Super Napier has crude protein ranging from 17 to 18 percent. The grass is very palatable to livestock, making it an ideal choice for animal feed. In addition, this hybrid grass is more tolerant of both drought and flooding than either of its parent species, making it well suited for cultivation in areas prone to extreme weather conditions. The leaves of Super Napier grass are wider, smoother and greener than ordinary Napier grass. Its stems are long, juicy and thick.

Dairy cattle farmers in urban areas of Uganda have recorded a significant increase of over 20 percent in milk yield as a result of feeding Super Napier fodder or silage supplemented with forage legumes, minerals, vitamins and a concentrate. The major challenge to Pakchong 1 Super napier grass production are pests and diseases such as fruits flies, stem borers and army worms and napier stunt disease.

Giant Juncao Napier Grass Variety

The Giant Juncao grass technology originates from China, and Kenya is now among the 108 countries with the grass species thanks to Liu, who introduced it in 2021. "**Jun**" means fungi or mushroom and "**Cao**" means grass.

Pakchong 1 Super Napier grass (Source: DAFAN)

Juncao Giant napier grass variety (Source: NET)

Giant Juncao grass is a hybrid of the African elephant grass and the bamboo plant (*Pennisetum purpureum x P. typhoideum*). The outcome of these crossing is new hybrid varieties that has deep rooted system that supports fast growth, drought resistance and high nutrient content. It is a tall growing (3 m +) grass with a strong, fibrous root system. The succulent, fast-growing green plant thrives under heat and drought. It can resist the most common diseases and pests while packing up to 18% digestible protein in its soft, juicy stems. Research conducted in Kenya shows that the variety is drought tolerant.

Napier Grass Silage Production

Step 1: Harvest napier grass fodder when the plants are about 1 metre high (depending on soil fertility, soil moisture, variety and other management factors). Wilt the plants for about 4 hours to reduce moisture content. Chop the plants into pieces of about 5 cm length.

Step 2: Dilute molasses (1 litre of molasses with 2 litres of water) **OR** mix 1kg of maize bran for every 10 kg of chopped napier grass fodder and mix thoroughly. You can add molasses and microbes to provide fermentable sugar to favour the development of the correct bacteria and speed up the fermentation process. Maize bran produces better silage because it reduces the effluent from the silage.

Step 3: Sprinkle diluted molasses (preferably using a watering can) or maize bran onto the chopped forage as evenly as possible. Mix the forage repeatedly to ensure an even spread.

Step 4: Sprinkle a mixture of microbes and molasses (use recommended rate indicated on the container) on the fodder.

Step 5: Turn/mix the forage repeatedly to ensure an even spread of additives. Silage can be stored in form of bales.

Pakchong 1 Super Napier grass silage bales produced by The Green Elephant, Kajjansi, Wakiso district (Tel: 0759752339)

Feeding Napier Grass Silage to Dairy Cows

- Remove enough silage to feed your cows for the whole day.
- After removing the silage, tie the bag again to ensure air or water does not get in.
- Feed the same quantity of silage as you would feed fresh material and supplement with dairy meal and minerals as required.
- A 300-kg cow eats about 25–30 kg of silage per day.

Napier Grass Leaf Meal (Powder)

Young leaves and stems of napier grass fodder can be cut, chopped, dried under shade, milled into leaf meal (powder) and added to animal feed rations. This type of feed is highly palatable and nutritious, providing high levels of protein, energy, minerals, and

vitamin to livestock. For pigs, poultry, rabbits and fish use, 45-day old growth, chopped or shredded. For larger ruminants like dairy cattle, beef cattle, give 60-70 day-old growth, also chopped or shredded.

Napier Grass Pellets for Livestock Feeding

Compared to grass fodder, grass pellets are convenient for storage and transportation. They contain less dust and debris, are easier to digest for the animals than common grass. The grass pellets are an excellent choice for **feed**.

Napier grass pellets (Source: NET)

In Taiwan, Napier grass is used for the production of dehydrated grass pellets used as a supplementary stock feed. Farmers can make Napier grass pellets and feed them to cattle, goats, rabbits and poultry or sell them to livestock farmers. By combining with other high quality ingredients, Napier grass feed pellets are healthier and with more nutrients and will remain edible for a long time. Turning elephant grass into pellets requires several processes and professional equipment. Below are stages of elephant grass pelletizing process.

Napier Grass Pelletizing Process

Step 1: **Chopping**: Chop wilted Napier grass fodder into pieces of about 5 cm length using a motorized forage chopper.

Step 2: **Drying:** The moisture content of freshly harvest elephant grass is high as 70%-75% which needs to be reduced to around 10% to get ready for the pelletizing and ensure a better quality. In this process, a solar dryer can be used to dry chopped elephant grass.

Step 3: **Crushing:** Crush into small pieces with the size no longer than the diameter of the die holes of biomass pellet mills. The widely used crushing machine is a hammer mill. It is noted if your target product is feed pellet, in this process, you can add some other nutrients, such as leguminous forages, molasses, processed poultry litter and proteins etc. depending on your requirement. Mix them up with mixer.

Step 4: **Pelletizing:** Pelletizing directly influence the quality of pellets. Given the same raw material conditions, better quality pellets can be produced by high quality pellet mills. The most popular and cost-effective elephant grass pellet making machine is Flat Die Pellet Mill or Ring Die Pellet Mill. If you don't know which type suit you most,

Step 5: **Drying:** The wet pellets can be dried in a simple solar dryer.

Step 6: **Packing:** After drying the pellets are packed according your requirement..

Benefits of Feeding Napier Grass Pellets to Dairy Cattle

- **High Transform Rate:** Feeding the livestock and poultry with the grass feed pellets in dry season results in more meat, egg and milk with less forage.
- **Small Volume:** Grass pellet made by grass pellet mill is only around 1/4 of the raw materials in volume in favourable for storage and transportation. In addition, less dust is beneficial to the health of human and animals.
- **Increase Palatability and Improve the Quality of Forage**. For instance, sweet clover possesses a flavour of coumarin which livestock more or less don't like. However, it becomes another forage with a strong palatability and high nutritional value.

Intake of napier fodder for the young calves may cause indigestion due to the glucose content in stem. To prevent this it can be mixed with dry fodder.

3.4. AGRO-INDUSTRIAL BY-PRODUCTS

Agro-industrial by-products are "*waste products arising from the processing of crop or animal products*". Agro-industrial by products which can be of tremendous use for feeding dairy cows are molasses, brewery spent grain, yeast solution, cotton seed cake, soybean meal, sunflower cake, brans and others. Agro-industrial by-products play an important role in urban dairy cattle production systems for supply of energy and protein which are key components in feeding dairy cattle for optimum productivity.

Classification of Agro-industrial By-products

(a) Energy sources are rich in fermentable carbohydrates and low in protein (containing less than 20% crude protein). The best example is molasses traditionally used as a carrier for urea in ruminant feeding.

(b) Protein sources/supplements refer generally to ingredients that contain more than 20% crude protein. Agro-industrial by-products such as cotton seed cake, soybean meal and sunflower cake serve as protein sources.

(c) Miscellaneous by-products supplying both energy and protein considered under this category are from cereal (wheat bran and other brans from traditional grains like sorghum, millet, rice and maize), brewers' grains and others.

(d) Mineral sources primarily supply minerals and are commonly from animal by-products example is bone meal, and oyster shell.

1. Breweries Left Overs

Most cereal grains go into the production of alcoholic beverages. The production of alcohol from these grains involves grinding, cooking and addition of enzymes to hydrolyze starch to simple sugars and then yeast to cause fermentation.

(a) Brewers Wet Grains

Brewery spent grains is the solid residue left after the processing of germinated and dried cereal grains (malt) for the production of beer and other malt products (malt extracts and malt vinegar). Brewery spent grains is a readily available at Uganda Brewery's Luzira, Kampala and Nile Breweries in Jinja, high volume low cost by-product of brewing and is a potentially valuable resource for industrial exploitation.

Nutritive Value of Brewery Spent Grains

Brewery spent grains have low dry matter content and a high content of energy due to the digestibility of the available fibre. Wet brewery grains is a good source of protein with a crude protein content that ranges from 25 to 34%. The concentration of rumen degradable protein ranges from 28 to 43% with a mean of 35%, indicating that brewery spent grains is good sources of rumen undegradable or "bypass protein." Brewery spent grains are low in calcium and potassium, similar to other cereal grains. Therefore, more phosphorus is supplied relative to calcium from brewery spent grains. A well-balanced mineral supplement should be supplied when using wet brewery grains in cattle diets to avoid the negative effects of decreased growth performance experienced when this

ratio is not properly balanced. Brewery spent grains from sorghum contains high levels of anti-nutrients such as tannins which are very dangerous to animals if consumed in high quantitates (over 10 kgs/day).

Desirable Features of Brewery Spent Grains

- Very palatable
- Highly digestible fibre
- Good by-pass protein
- Can be ensiled
- Brewery spent grain stimulates milk production. A supplement of 8 to 10 kg/cow/day of wet spent grain is usually adequate to cover the frequent nitrogen deficiency of cows feeding on crop residues and pastures.

Undesirable Features of Brewery Spent Grains

- Wet, nutrient loss through spillage and run-off
- Short storage life
- Low in starch (carbohydrates)
- May suppress intake of hay
- Price changes with local demand
- High transport cost
- Feeding large quantity of brewery spent grains is very dangerous to animals.
- Spent grain from sorghum contains high levels of antinutrients which might be dangerous to animals.

Techniques for Brewery Spent Grains Preservation and Storage

Wet spent grain spoils rather quickly and should be used fresh. Keep away from direct sunlight and moisture. For longer storage, it may be dried or ensiled in an airtight trench silo, tightly tied plastic bag silos or plastic drums.

Ensiling Wet Brewery Spent Grains: Silage is a good method for storing wet brewery spent grains for a long period, particularly since ensiling does not alter their nutritive value.

Trench/pit silo containing brewery spent grains

Wet spent grain can be ensiled alone or in association with other feeding ingredients, for example, with 2 to 3% molasses (to ensure proper fermentation), chopped banana by-products (pseudostems, fruit, skin); 2% Diatomaceous earth grade (aflatoxin binder), chopped root vegetables or leaves, napier grass fodder and others. The silo (pit/trench or plastic silage bags) should be protected from rain and tightly packed.

The silo should have proper drainage to collect runoff. Storage time can be improved by storing in a shaded or cool place, and by covering the surface with plastic or some other covering material that minimizes surface spoilage. Brewery spent grains silage is ready within 3 weeks and can be used during 6 months, and even more if a silage additive is used. Adding carbohydrates accelerates fermentation, releasing more acids and resulting in stable silage.

Drying Wet Brewery Spent Grains: Preservation of wet brewery spent grains by drying method has the advantage of reducing the product volume, and decreases transport and storage costs. Spent grain can be dried under sunshine or in a solar dryer. Conservation of brewery spent grains in a simple solar-dryer reduces the bulk of the product and does not change its chemical composition. Dried spent grains levels can replace up to 75% of soybean meal and can be used to feed lactating cows since it provides improvements in digestibility, milk production efficiency, and economic return without affecting microbial efficiency.

Feeding Brewery Spent Grain to Dairy Cows

Milking cows benefit from brewery spent grains when offered as a supplement (3 to 4 kg per cow) during milking time. This increases milk production by over 20 percent. The major challenge is a cow getting used to brewery spent grains and if there is a shortage, a dairy farmer faces a problem of a reduction in milk yield of over 40 percent.

Dried brewers grains are an excellent source of high quality by-pass protein and digestible fibre. Dried brewers grains have a good amino acid, mineral and B-vitamin content. This feed ingredient is known for putting "**milk in the pail**". Dried brewery spent grains levels can replace up to 75% of soybean meal and can be used to feed lactating cows, since it provides improvements in digestibility, milk production efficiency, and economic return without affecting microbial efficiency. Suggested feeding levels of brewery spent grains are 30-40% of the ration for dairy cows

Sample Rations Based on Spent Grain

Dairy Cow Ration

- Spent grain: 20-25% of total ration
- Hay (e.g., alfalfa): 30-40%
- Concentrate (e.g., maize bran, soybean meal): 30-40%
- Calcium and phosphorus supplements as needed

Beef Cattle Ration

- Spent grain: 15-20% of total ration
- Hay (e.g., grass hay): 40-50%
- Concentrate (e.g., maize bran, soybean meal): 20-30%
- Vitamin and mineral supplements as needed.

Calves (0-6 months)

- Spent grain: 10-15% of total ration
- Calves can be fed 2 to 4 kg/calf/day. Brewery spent grain must be offered to animals as a supplement NOT as a basal diet. It can be offered during milking time.
- Milk replacer or whole milk
- Starter feed (e.g., grain mix)
- Hay (e.g., alfalfa)

Heifers (6-24 months)

- Spent grain: 15-20% of total ration
- Hay (e.g., grass hay)
- Concentrate (e.g., corn, soybean meal)
- Vitamin and mineral supplements

Lactating Cows

- Spent grain: 20-25% of total ration
- Hay (e.g., alfalfa)
- Concentrate (e.g., corn, soybean meal)
- Calcium and phosphorus supplements

Feeding Guidelines

- Introduce spent grain gradually (5-10% increments).
- Limit spent grain to 1-2 kg per 100 kg body weight per day.
- Ensure adequate moisture (50-60%) in the total ration.
- Balance rations for protein, minerals, vitamins, energy, and fibre.
- Provide access to clean water.
- Consult with a veterinarian or animal nutritionist for personalized recommendations

Benefits of Spent Grain

- Can reduce feed costs.
- Supports sustainable agriculture.
- Increased milk production (5-10%).
- Improved cow health.

Precautions

Spent grains from breweries can have negative effects on animals if not stored properly or introduced to their diet gradually:

- **Mold:** If not stored in a cool, dry place, brewery waste can develop mold, which can be harmful to animals.
- **Digestive Issues:** Introducing brewery spent grains to an animal's diet too quickly can cause digestive issues.
- Performance Losses: It can negatively impact an animal's performance, feed intake, and energy digestibility.
- **Food Poisoning:** Cattle can become ill from eating spent grains that contain *Clostridium botulinum,* which can cause anorexia, regurgitation, profuse salivation, and dehydration. Sorghum spent grain contains anti-nutrients that can be very dangerous to cows if it is offered in large quantities.
- **Ethanol Poisoning**: If used incorrectly or stored improperly, brewery by-products can cause ethanol poisoning in cattle.
- **Neurotoxicosis:** *Aspergillus clavatus*, a fungus, can cause neurotoxicosis in cattle that eat brewery by-products.
- Ruminal Acidosis: Cattle can develop ruminal acidosis from eating brewery by-products.

(b) Spent Grain Yeast Solution

Spent grain yeast solution typically refers to utilizing the leftover yeast and grain residue from brewing or distillation processes.

Brewery spent grain yeast solution

It is high in proteins, vitamins and minerals. Protein accounts for 35–60 % of yeast dry weight and contains a well-balanced amino acids profile.

Benefits Spent Grain Yeast Solution

- Utilizing spent grain reduces waste disposal costs and environmental impact.
- Spent grain can replace or supplement commercial feed or fertilizer.
- Spent grain contains proteins, fibre, and micronutrients.
- Closed-loop systems promote resource efficiency and recycling.

Nutritional Content

- Crude Protein: 20-30%
- Crude Fibre: 40-60%
- Dry Matter: 80-90%
- Ash: 5-10%
- Calcium: 1-2%
- Phosphorus: 1-2%

Feeding Yeast Solution to Dairy Cattle

The standard recommendation is to introduce yeast solution to the cow's diet at least 3 weeks before calving to get the beneficial effects of yeast when they are most needed, during transition and during early lactation. Then to continue feeding throughout the lactation. For dairy cows, an inclusion rate of about 0.5% of the total diet is effective. This proportion ensures that cows receive enough yeast to enhance their rumen function and overall health without overloading their system. Yeast may boost digestion, reduce health risks for dairy cows on high starch diets. Spent grain yeast solution can be mixed with molasses and water (ratio: 1:1:2 to make high quality maize stover or sugarcane bagasse haylage.

2. Oil Seed Cake and Meals

Oil seed cakes and meals are the residues remaining after removal of the greater part of the oil from oil seeds. The residues are rich in protein (over 30% protein content) and most are valuable feeds for farm animals. They often serve as protein supplements. They include cottonseed, soybeans and palm kernel.

Soybean Cake: Soybean is by far the most widely used oil seed protein and as such is assigned the standard against which other plant proteins are compared. The commonest form in which soybean is fed is as soybean meal after oil extraction by solvent or hydraulic method. Soybean meal has 40 - 48% protein depending on the efficiency of oil extraction and whether or not the beans were dehulled.

Cotton Seed Cake: Cotton seed cake is the product obtained by finely grinding the flakes which remain after removal of most of the oil from cottonseed by a solvent extraction process (solvent-extracted meal) or by finely grinding the cake which remains after removal of most of the oil from cottonseed by a mechanical extraction process It has a protein content of 41- 45% depending on the efficiency of oil extraction. It is high in fibre containing about 10-13%. It is deficient in lysine, methionine, leucine and isoleucine. Cotton seed cake contains several anti-nutritional factors including gossypol. The nutritional value of Cotton seed cake can be improved by: (i) decorticating and dehulling and, (ii) removal of gossypol by extracting the meal with a mixture of hexane, acetone and water,

Palm Kernel Cake (PKC): Palm Kernel Cake is a product of oil palm processing. It is obtained after oil extraction from Palm kernel. Protein content is 18 - 25%. Palm kernel cake is deficient in lysine, methionine, histidine and threonine. PKC is gritty and high in fibre content (at least 9%).

Sunflower Meal: Sunflower meal is obtained by grinding the residue remaining after extraction of most of the oil from either whole or dehulled sunflower seed by either solvent. The protein content ranges from 41- 47%. It is deficient in lysine, tyrosine, methionine and

cystine. It is high in fibre (11 - 13%). While decorticated sunflower meal can be fed to all classes of livestock, the use of undecorticated meal should be restricted to ruminants. Sunflower meal is high in calcium and phosphorus.

Cereal Bran: Cereal bran is the outer covering of grains separated during processing. Bran is present in cereal grain, including rice, maize, wheat, oats, barley, rye, and millet. Bran is highly nutritious (about 12 percent protein), but is difficult to digest due to its high fibre content; its high fat content also reduces its shelf life as the oils/fats are prone to becoming rancid. Usually, the amino-acid profile of bran protein is superior to that of the whole grain. They are high in phosphorus but low in calcium.

3. Sugar Industry By-products

The by-products of the sugar industry can be grouped according to source; those that originate from harvesting: tops, leaves and straw, and those that are obtained from the industrial process: bagasse and molasses. The residues can be used directly as forage, especially during dry periods when pastures are limited. These by-products are concentrated in specific areas, i.e. the sugar cane producing regions. In addition to residues obtained from harvesting and by-products from processing of sugar, cane juice may be used as a substitute for grains, as well as high-test molasses, which is a concentrated form of partially inverted cane juice which avoids crystallization of sucrose, and the use of sugar cane itself in ruminant feeding.

Molasses: Molasses is a sticky dark by-product of processing sugar cane into sugar. Molasses has been used for many years as a cheap source of energy in the ration of farm animals. Molasses contain about 3.25% crude protein.

Molasses

It can be a source of energy, calcium, sodium, potassium, magnesium and sulphur for dairy cows. Molasses has been used in animal feeding at levels of 5-10%. These levels are mostly used as (i) a carrier for urea impregnation of poor quality roughages (ii) a binder for commercial pelleted feeds for the convenient and economic feeding of livestock and as (iii) a sweetener for increasing the voluntary intake of compounded feeds.

Soaking poor quality chopped pasture grass hay or cereal crop residues in a mixture of diluted molasses, brewery yeast solution and water (ratio: 1:1.2) improves digestion of pastures/hay; increases milk production, improves body weight; strengthen the overall bone structure of dairy cows; and help maintain body condition and appetite and result in less feed waste. Molasses can reduce the dusty powdery nature of some finely ground feeds. In this role, it makes a feed mixture more palatable and edible to dairy cows.

Sugarcane Bagasse: This is the dry pulpy fibrous residue that remains after sugarcane or sorghum stalks are crushed to extract their juice. Raw bagasse is a poor, fibrous roughage mostly used for ruminants. It has low protein content (about 3.0%) and low digestibility (about 30%). Improvements in dairy cattle performance have been reported where sugarcane bagasse haylage is supplemented with protein and energy sources or it is ensiled with processed poultry waste and/or leguminous forages.

Sugarcane bagasse

Sugarcane Tops: Sugarcane tops is a major by-product of the sugarcane industry which is left in the field after cane harvest. Sugarcane tops consist of 3 distinct parts - the green leaves (blades), the bundle leaf sheath and variable amounts of immature cane.

Constraints Limiting the Use of Sugarcane Tops

- Seasonal availability
- Relatively low nutritive value (about 6% protein content.
- Lack of knowledge on the best ways to use sugarcane tops.
- Labour intensive: cutting, collection, transporting and chopping of the cane tops in the field.
- The restricted access to cane fields. Although sugarcane tops is considered free (at present), large scale collection on private lands requires the permission of the land owners.
- Transport of sugarcane tops over long distances involves additional costs and is accentuated by the bulkiness of the collected material (half the weight of cane a lorry normally carries) and competition with the priority of carrying cane for sugar production.
- The increasing use of burning practised to ease harvest, especially with cane having trashing problems.
- The construction of silos for preserving sugarcane tops.

Improving the Nutritive Value of Sugarcane Tops for Dairy Cattle Feeding

- Supplementation of sugarcane top-based diets with leguminous forages, minerals, vitamins and concentrates.
- Ensiling chopped sugarcane tops with leguminous forages.

Practical Aspects to Ensiling Sugarcane Forage

- Ensiling young cane (e.g. 6 months of age) with high moisture content (e.g. 22 % DM) can potentially lead to clostridial fermentation and significant levels of butyric acid.
- Sugarcane is difficult (but quite possible) to harvest using conventional harvesters which would typically be used for maize or sorghum. Difficulties are encountered because sugarcane is a high yielding crop, has tough stalks, tends to lodge easily and can have broad stooling characteristics.

- Alcoholic fermentation due to yeast growth can be a negative result of ensiling sugarcane. To ensure this effect is minimised, additives such as microbes should be used during the ensiling process. Options include the use of lactobacillus inoculants.
- Due to the high concentration of fibre in sugarcane forage, it is sometimes difficult to successfully compact this material to remove air. To assist with this, avoid ensiling frosted material. A short chop length should also be used. Using a short chop length also improves the intake of sugarcane forages. To minimise aerobic spoilage, sugarcane silage should also be sealed quickly at the completion of ensiling.

Factors Affecting the Performance of Dairy Cows Fed Sugarcane Silage

- The low energy content of sugarcane forage limits milk production per cow and hence its inclusion rate in lactating cow diets. Maximum feeding levels of sugarcane silage range from 5 - 8 kg dry matter per cow per day.
- Studies have shown that sugarcane leaf silage performs poorly in comparison to other forages fed to lactating cows.
- Intake of sugarcane silage by lactating cows is less than other forages.

3. Mineral and Vitamin Supplements

Deficiencies of many minerals and vitamins required by cattle can result in metabolic disorders that impair animal health. The transition period, from 3 weeks before to 3 weeks after parturition, is a stressful time for dairy cows. During the transition period the immune response is suppressed and cows exhibit greater susceptibility to a number of diseases. Assuring adequate trace mineral and vitamin status is critical for optimizing the immune response during the transition period.

Two major sources of minerals are (a) natural feeds (forages and grains) and (b) mineral supplements to balance the minerals present in the forages and grains. A dairy cow requires calcium, phosphorus, magnesium, potassium, sodium, chlorine, and sulphur. Minerals required in much smaller, trace amounts (micro-minerals) include iodine, iron, cobalt, copper, manganese, zinc, and selenium.

Calcium and Phosphorus: Two macro-minerals are of particular importance in dairy cattle production. These are calcium and phosphorus and special attention needs to be given to them when formulating rations. They primarily contribute to bones' structure and strength, but they also play important roles in other processes, like muscle and nerve function. Calcium and phosphorus are naturally found in grasses, legumes, cereals and concentrates and are added to commercially produced dairy meals, but:

- Most tropical soils are deficient in phosphorus and forages grown on them will also be low in phosphorus.
- Pastures grown on acid, sandy or peaty soils in humid areas tend to be low in calcium.
- During prolonged dry seasons, when there is a shortage of green leafy material, the amount of phosphorus in forages decrease.
- Legumes tend to have more calcium and phosphorus than grasses.
- Cereal grains are low in calcium.
- Calcium deficiency is most likely to occur in early lactation (milk fever).
- Young, dark green forage tends to contain more minerals than old, dry, yellowing forage.

Extra calcium and phosphorus usually need to be provided in the ration over and above that naturally present in the feed and mineral mix, especially for high yielding animals.

Calcium and phosphorus requirements for the mature dairy cow depend on bodyweight, milk yield and composition, and stage of pregnancy. Calcium and phosphorus

requirements need to be balanced for the complete lactation cycle. It is important to monitor calcium and phosphorus levels during the late dry period (last four weeks) to reduce the incidence of milk fever. Good sources of calcium and phosphorous include: steamed bone meal, mono calcium phosphate and calcium chloride.

Other Macro-Minerals: Common salt (sodium chloride) should also be given to provide sodium and chlorine. Magnesium is also required in relatively large quantities by high yielding dairy cows. Good sources of magnesium include magnesium oxide and magnesium sulphate. Forages will usually supply enough potassium.

Koudijs Mineral Lick Block

- Koudijs Mineral Lick Block has all the essential minerals and elements needed by a dairy cow.

Koudijs Mineral Lick Block *(Source: NET)*

- These blocks also play a crucial role in bone growth, immune system support, and reproductive health. By ensuring your cattle have access to the necessary minerals, you can improve their overall health and well-being.
- Prevents poor udder development
- Supports skeleton development
- Improves appetite
- Increases disease resistance

Untapped Feed Resources for Urban Dairy Cattle Farmers

Untapped feed resources are valuable for urban dairy cattle farmers but they are not yet used or taken advantage of.

3.5.1. Hydroponic Fodder Production

Green fodder is an essential component of the dairy cattle rations. Feeding green fodder improves productive and reproductive performance of the animals. Conventional growing of fodder crops in soil involves large land area, more man power and huge quantity of water. Moreover, in urban areas, land is not available for fodder cultivation. Another serious problem is the high cost of labour for conventional agriculture. The alternative technology to increase green fodder production in urban areas is by **vertical farming** through "**Hydroponic green fodder production**".

What is Hydroponic Farming?

Hydroponic also known as "**Soilless**" farming is a method of growing plants without soil. Only moisture and nutrients are provided to the growing plants. Hydroponic fodder is an alternative solution to provide the sustainability of quality forage for livestock. Hydroponics can include several crops such as barley, oats, wheat, sorghum, maize or legumes, such as alfalfa, clover, or cow peas. Maize and barley are the most commonly grown fodder, because they give the best yield of nutrients. The fodder can be produced in a short

duration (8-10 days) and all year around.

Production of Hydroponic Green Maize Fodder

A simple hydroponic fodder unit consists of a framework of shelves on which perforated (with holes) trays are stacked.

Low cost hydroponic green fodder unit (greenhouse) at Kyakuwa Farm, Seguku Cell 4, Makindye Ssabagabo Municipal Council

They are supplied with moisture and (sometimes) nutrients, usually via drip or spray irrigation. While it is possible to grow hydroponic fodder in any building, including a garage or basement, a greenhouse is ideal because temperature, light, and humidity can be precisely controlled.

Seed Quality and Seed Rate

- Use good quality, clean and not insect infested seeds. Do not use broken seeds as these will not germinate and grow properly. Do not use seed treated with chemicals because it the seed is dangerous to animals.
- The seed rate (quantity of seeds loaded per unit surface area) affects the yield of hydroponic fodder, which varies with the type of seeds and size of a tray. Hydroponic maize fodder can be produced with seed rate of 6.5-8 kg per square meter. If seed density is high, there is more chance of microbial contamination in the root mat, which affects the growth of the fodder.

Steps in the Production of Hydroponic Green Maize Fodder

Step 1: Select good quality and viable maize seeds (not treated with chemicals).

Step 2: Remove broken seeds.

Step 3: Immerse maize seeds in clean water (e.g. 10 kgs of maize seed in 20 litres of water). Add 2 tablespoons of diatomaceous powder to 20 litres of water to control pests, improve growth and provide a source of minerals.

Step 4: Remove the floating seeds and dirt.

Step 5: After 5 minutes, drain the water from the seeds, wash and rinse the seed for 2 to 3 minutes

Step 6: Soak the seed again in water for 12 hours. (Preferably in the evening)

Step 7: In the morning, remove the seeds from the water.

Step 8: Spread the seeds out on perforated (holed) plastic or lightweight metallic trays up to a depth of 1 cm.

Tray with a base made of plastic sheet

Plastic tray

Metallic tray with holes

The amount of seeds loaded per unit surface area, or seed rate, varies based on the kind of seeds and size of the tray and might impact the amount of fodder produced. Holes in the trays facilitate drainage and the waste water is collected in a tank. After soaking overnight, a layer of seeds is spread over the base of the trays.

Step 10: Irrigate the seed on the trays 3 times a day to keep it and roots moist all the time. Nutrient solutions or fresh tap water can be used to irrigate seeds that have germinated. Dripping irrigation is a good way to keep the seeds moist during growth. During the growing period, the seeds are kept moist, but not saturated.

Germination of Seed and Maintenance

- The starting of germination and visibility of roots varies with the type of seeds. In case of maize, germination starts on the second day and the roots are clearly visible from third day onwards.
- Maintenance of clean hygiene is very important in the production of hydroponic fodder as greenhouse is highly susceptible to microbial contamination, particularly of mould growth due to high humidity. Inside the greenhouse, the grains are allowed to sprout for seven days and on day eight, these are fed to the dairy animals.

Tray-Shifting and Harvesting

To advance in the growth cycle, trays need to be moved to the next level every day. It is important to shield hydroponic trays from harsh sunshine, gusts of wind, and persistent rain. The trays need to be turned to the right and *vice versa* if the tray on the left side exhibits more growth. The fodder mat is removed from the tray on the ninth day so that the animals can eat it. Before being reused for the following cycle, the trays are cleaned with a cleaning solution.

Mature hydroponic green fodder

Benefits from Hydroponic Green Fodder

- **Feed Resource:** For sustainable urban dairy cattle production, quality green fodder should be fed regularly to animals. Hydroponic green fodder is a promising feed supplement for cattle. It is effective in improving, growth performance, digestibility, milk production, reduces the feeding cost.
- **Water and Nutrient Saving:** The hydroponic system requires 2 to 3 litres of water to grow 1 kg of quality green fodder compared to 55 to 75 litres of water used in conventional. The plants also have less root and nutrient competition than those grown in soil, and they have significantly fewer pests, so individuals can be planted more closely together.
- **Utilization of Minimal Land:** Hydroponic greenhouse requires marginal land to cover an area of 10 meters x 5 meters for 1000 kg of green fodder per day per unit. In traditional it requires about one hectare land.
- **Less Labour Requirement:** In hydroponic system, the labour required for green fodder production is less than 1 hour a day whereas conventional fodder production system requires continuous intensive labour for land preparation, planting, weeding to harvesting of the grass. No need of weeding and storage facilities and no post-harvest losses in hydroponic system as fodder is produce at the demand rate of livestock.
- **Dry and Drought-Prone Areas:** The farm is guaranteed of a consistent supply of quality fodder throughout the year irrespective of climate conditions. A farmer normally has to wait for at least 3 months before the fodder can be harvested and fed to the animals. The sprouting system produces feed within 7-10 days.
- **Hydroponic Systems Can Be Set up Indoors in Places** that would not normally be available for the growing of plants, such as in densely populated areas, and have even been studied as a potential method of crop production aboard spacecraft. Climate is not a factor, and hydroponic systems use dramatically less water compared with conventionally grown plants.
- **Small-Scale Dairy Cattle Farmers:** Requiring smaller amounts of fodder, dairy cattle farmers in urban areas are able to build their own fodder systems. When the investment is low, the cost of hydroponic fodder is considerably less.
- **Fodder Yield:** Hydroponic fodder production is accelerated by as much as 25% by

bringing the nutrients directly to the plants, without developing large root systems to seek out food. Plants mature faster and more evenly under a hydroponic system than a conventional soil based system. One kg of un-sprouted seed yields 8-10 kg green forage in 8-10 days when they are about 20 to 30 centimetre in height. The biomass conversion ratio is as high as 6-7 times that of the conventional green fodder grown for 65 to 80 days. About 300-400kgs/day of green fodder can be obtained from a space of 25 square metres. Only 1 person is needed to produce 400kgs/day of fodder.

- **Organic Fodder:** Traditional outdoor farming must rely on herbicides, fungicides and/or insecticides for optimum production. Hydroponic fodder is grown in a controlled environment without soil and, therefore, is not susceptible to soil-borne diseases, pests or fungi, thereby minimizing use of pesticides, insecticides and herbicides.
- **Fodder Quality:** Hydroponic green fodder is highly palatable, easily digestible and of better quality as compared to traditional fodder production. Hydroponic green fodder contains more crude protein (13.6%) and less crude fibre (14.1%) as compared to some traditional fodder species (10.7% crude protein and 25.9% crude fibre, respectively). Hydroponic fodder is a rich source of vitamins A, E and C, thiamin, riboflavin, niacin, biotin, free folic acid, anti-oxidants like □-carotene, minerals, bioactive enzymes, with the highest activities in sprouts being generally between germination and 7 days of age.
- **Reduced Carbon Footprints:** Hydroponic green fodder is more environmentally friendly than traditional agriculture, because fertilizers are rarely used. This reduces greenhouse gas emissions considerably. In traditional farming, run-off can lead to the degradation of the surrounding environment. Hydroponic systems help in reducing the fuel consumption for transportation of product from distant agricultural farms and carbon emissions in turn.

Feeding Hydroponic Green Fodder to Dairy Cows

- Sprouted hydroponic fodder is ready to be harvested within 7 to 10 days. The interlaced roots form a dense mat, which can be cut into serving portions with a sharp knife.
- Avoid keeping the fodder more than 10 days in the trays because after 10 days the nutrient value of fodder start to decrease slowly and fibre start to develop.
- Take out fodder slabs form the tray and cut into small pieces and wilt it under sunshine for about 1 hour before feeding it to the animals, so it is easier for them eat the fodder properly. Fresh hydroponic green maize fodder contains high moisture content which makes.

Feeding hydroponic green maize fodder to a dairy cow *(Source: DAFAN Group)*

- It is important to note that cows cannot be fed on hydroponic fodder alone because of its low dry matter content. They still require roughages such as pasture hay, maize stover, green fodder or straw plus mineral, protein and energy supplements.

Feed about 25 kgs/cow/day of hydroponic green maize fodder to dairy cows as a supplement. Provide plenty of clean water.

Effect of Hydroponic Fodder on Livestock Production

The addition of sprouted grains improves milk yield by up to 8.7 percent in dairy cows. The increase in milk yield is mainly due to hydroponic fodder, which leads to a longer lactation period, improved fat percentage and general herd health.

Economics of Hydroponic Fodder Production

Traditional fodder production requires a major investment for the purchase of land, in addition to investment in agricultural machinery, equipment, infrastructure required for pre- and post-harvesting, including handling, transportation and conservation of fodder. It also requires labour, fuel, lubricants, fertilizers, insecticides, pesticides, and weedicides. On the other hand, hydroponic fodder production requires only seed and water as production inputs with modest labour inputs. Hydroponic minimises post-harvest losses, with no fuel required for harvesting and post harvesting processes. Moreover, in hydroponic systems it takes only 78-10 days to develop from seed to fodder while it takes 45-60 days under traditional systems.

Disadvantages of Imported Hydroponic Units

- High installation costs and the need to test the solution frequently (for imported hydroponic units).
- The systems are very vulnerable to equipment failure or power outage, which can kill the plants within a few hours.

3.5.2. Mexican Sunflower *(Tithonia Diversifolia)*

Low cost protein source is the most limiting nutrient for cattle fed poor to moderate quality harvested forages as well as for mature cows and growing cattle grazing dormant grass pastures and crop residues. Protein is needed to support a healthy, active population of fibre-digesting microorganisms in the stomach. Consequently, when dietary protein is limiting, fibre digestion is not optimal. Poor digestion results in inefficient energy use, and often decreases feed intake too. The combined effect of these factors is a significant decrease in overall energy balance for the animal. This can limit growth rate of young animals or lead to poor body condition scores in reproducing cows and heifers.

The last four decades have seen vigorous promotion of exotic or foreign species of fodder trees and shrubs, e.g. *Calliandra calothyrsus* (calliandra), *Leucaena leucocephola* (leucaena), *Sesbania sesban* (Sesbania) and *Gliricidia sepium* (gliricidia) for fodder. These trees are easy to propagate, are ready for harvest within one year after planting and, unlike grasses, maintain their green foliage and protein content during the dry season and contain high levels of protein (over 20%). However, there are two important issues to consider:

- Farmers need to diversify the tree species they use, both to enrich dairy cattle diets and to reduce the risk of a tree species succumbing to pests or disease. For example, Leucaena succumbed to the physillid *(Heteropsylla cuban)* pest; Sesbania is affected by nematodes while calliandra, now being widely promoted in Uganda, is being threatened by a die-back disease that reduces biomass yield by over 60 percent.
- There is a need to use the many indigenous fodder species that are now being promoted as livestock feed.

Plants regarded as "**weeds**" provide a source of protein. **Mexican sunflower** *(Tithonia diversifolia)* or tree marigold, is a perennial shrub found growing on abandoned/waste lands, along major roads and waterways and on cultivated farmlands in all districts of Uganda.

Mexican sunflower

Chemical Composition of Mexican Sunflower

Compared to other tropical forages commonly used for milk production, Mexican sunflower foliage has greater protein (about 18%) and phosphorus content.. Additionally, studies have shown that the nutritive value of Mexican sunflower remains relatively constant throughout the dry season, while the nutritional quality of most pasture grasses markedly decreases under water limited conditions. Furthermore, Mexican sunflower has previously showed potential as a methane reducing feed additive in ruminants thus, it has been suggested that Mexican sunflower could be used as an alternative protein forage source in Uganda. With increasing pressure from the global community to reduce methane emissions and the inverse correlation between energy utilization and methane production, the supplementation of ruminant diets with Mexican sunflower has been suggested as a promising dietary strategy. Anti-nutrients such as tannins and saponins have been shown to decrease methane production due to their inhibitory effects on rumen ciliate protozoa

A- 500 kg dairy cow would require about 15 kg dry matter (intake is about 3% of its body weight). Mexican sunflower should therefore comprise of less than 30% of the daily intake. Therefore, 30% of 15 kg is 4.5 kg dry matter (DM). To produce 4.5 kg DM of Mexican sunflower foliage, you would require about 23 kg /cow/day of fresh Mexican sunflower tender shoots.

Processing Mexican Sunflower for Dairy Cattle Feeding

Making Mexican Sunflower Leaf Meal: Mexican Sunflower foliage (leaves and tender shoots) can be collected from waste land at the sides of the highway or from established fields, chopped and dried in the sun for 3 to 5 days. It is then milled and packed into polythene bags and stored for use in feed formulations. Mexican sunflower leaf meal is a valuable supplement in dairy cattle diets. Mexican sunflower leaf meal has about 18.9 percent crude protein. The leaf meal can be used in the production of dairy meal or dairy pellets.

Production of Mexican Sunflower Dairy Pellets

Step 1: Harvest Mexican sunflower young leaves and tender shoots and chop into pieces of about 3 cm length.

Step 2: Spread the leaves and tender shoots on a concrete slab or tarpaulin and air dry them under shade for 5-7 days and then mill the dry foliage into leaf meal.

Step 3: Pack the leaf meal in polythene bags and store for use in feed formulations.

Step 4: The leaf meal can be used in the production of dairy meal or dairy pellets.

Mexican Sunflower Leaf Meal as a Protein Supplement for Lactating Dairy Cows

A study conducted in Gulu district by the National Livestock Resources Research Institute (NaLIRRI) showed that, dairy cow pellet supplements based on a mixture of milled sorghum stover, maize bran, cotton seed cake, molasses and Mexican sunflower leaf meal increased milk yield (10-16%) of crossbred dairy cows fed a basal diet of Guinea grass hay. These findings indicate the potential of Mexican sunflower leaf hay or pellets as a supplementary forage for dairy cattle fed low quality roughages.

Mexican sunflower leaf hay and dairy pellets

Mexican sunflower has a number of anti-nutrients such as tannins. However, all major anti-nutrients in fresh Mexican sunflower leaves can gradually decrease with lengthening duration of ensiling or drying.

Ensiling Mexican Sunflower With Low Quality Forages: Mexican sunflower is prepared by harvesting daily, the fresh and mature leaves of plants of different ages before flowering. The leaves are chopped into pieces of about 2-3 cm and ensiled in a plastic container using sugarcane molasses as the silage additive in a percentage of 4% to the total weight (wet basis) of the chopped leaves in the container. The plastic container holding the ensiled leaves of Mexican sunflower must be properly sealed and carefully closed to prevent any air contamination and kept in a safe environment to prevent physical damages or alterations. The ensiling process is carried out for a period of 21 days. The ensiled Mexican sunflower is used as a protein supplement to dairy cattle. Mexican sunflower (30 percent) can also be ensiled with Napier grass or chopped maize stover to improve the quality of silage.

Anti-Nutrients in Mexican Sunflower

Mexican sunflower has a number of anti-nutrients such as tannins. However, all major anti-nutrients in fresh Mexican sunflower leaves can gradually decrease with lengthening duration of ensiling or drying.

3.5.3. Azolla (*Azolla pinnata x Anabaena azollae*)

Azolla, also known as water velvet, mosquito fern, duckweed fern or red water fern, is a small, floating fern that's rich in protein, fibre, and nutrients. Azolla plants are visible as clusters of small leaf floating in ponds, wet fields, rice field and drains. While their fibrous roots floats underneath of the water. It is used as a nutritious feed supplement for dairy cows.

Azolla (Source: Dr. Gumisiriza Ssentambi, 2024; Tel: + 256 752912127)

Advantages of Azolla

- High protein content (25-35%): Excellent for dairy cow feed supplement. It improves milk production and quality.
- Rich in essential amino acids, vitamins, and minerals.
- May reduce feed costs.
- Can help reduce nitrogen and phosphorus excretion.
- Azolla is very rich in Beta Carotene vitamins A, B12 proteins, amino acids, and minerals including, iron, magnesium, phosphorous, calcium, potassium, phosphorus, manganese, ferrous, magnesium copper, on a dry weight basis. Azolla has mineral content of 10-15%, and 7-10% comprising a combination of amino acids, bio-active substances, and biopolymers. Azolla's carbohydrate and oil content are very low. Azolla has low lignin content, animals easily digest.

Cultivation Methods

- Pond-based system: Create shallow ponds with adequate water flow and nutrient supply.
- Tank-based system: Use large tanks or containers with controlled water parameters.
- Floating mats: Use floating mats or nets to cultivate Azolla in existing water bodies.

Azolla Cultivation Techniques

Step 1: Clear the pond of debris, and fertilize with nitrogen-rich materials.
Step 2: Introduce Azolla spores or plants into the pond.
Step 3: Maintain optimal water temperature, pH, and nutrient levels.
Step 4: Remove Azolla biomass every 7-10 days.

Optimal Growth Conditions

- Temperature: 20-30°C
- pH: 5.5-7.5
- Nitrogen: 1-2 mg/Litre
- Phosphorus: 0.5-1 mg/Litre
- Light: Partial shade

Harvesting Azolla

- Harvest Azolla every 7-10 days to maintain optimal growth.

- Harvest Azolla and wash thoroughly to remove dirt and smell of cow dung and then feeds them to animals.
- Dry or ensile Azolla to preserve nutrients.

Common Challenges

- Algae blooms
- Pest infestations (e.g., snails, insects)
- Disease outbreaks (e.g., fungal infections)
- Competition with other aquatic plants

Economic Considerations

- Initial investment: Pond construction, equipment, and initial Azolla inoculation.
- Ongoing costs: Fertilizers, labour, and maintenance.
- Revenue: Sale of Azolla biomass as animal feed.

Feeding Azolla to Dairy Cattle

Azolla is a very nutritive and cheap organic feed substitute for dairy cattle. Dairy cattle can easily digest Azolla due to its high protein content and low lignin content. Azolla can be fed to cattle either in **fresh** or **dried** form. It can be given directly or mixed with concentrates. Fresh Azolla can be mixed with commercial feed in the ratio 1:1. Studies have shown an increase (15–20%) of milk yield when 1.5–2kg of Azolla was combined with regular feed. Azolla feeding improves the quality of milk and animal health.

3.6. Concentrates for Boosting Dairy Cattle Productivity

Concentrates are energy-dense ingredients added to dairy cattle feeds to enhance milk production. They include grains like maize and wheat and protein supplements like soybean meal. Concentrates supply the extra energy that high-producing cows need, especially during peak lactation periods. Balancing the ratio of forage to concentrate in dairy cattle feed is crucial. While concentrates increase milk yield, too much can lead to metabolic disorders such as acidosis. Therefore, it is essential to carefully monitor the feed mix to avoid imbalances.

High production and transport costs mean that concentrates are usually far more expensive per unit of feed value than grazed grass or grass silage produced on the farm. To maximise profit, animals should achieve as much of their growth from forage, preferably grazed grass, as possible. Nonetheless, concentrates are essential at key times in the animal's life

Advantages of Concentrate Feeding

- Concentrates promote the growth of heifers and cows.
- They increase dry matter intake and milk production of dairy cows in current and future lactations.
- Cows fed concentrate supplements maintain better body condition score when pasture availability is low. This increases their ability to reach their milk yield potential and helps reduce the time of their first oestrus after calving.
- Appropriate supplementation can increase milk protein content when the energy intake from pasture is low.

Nutritive Quality of Concentrates

A concentrate contains all required micro-ingredients including vitamins, minerals, amino acids, phosphates, additives and proteins. Concentrates also contain more than 20% crude protein on the basis of dry matter. The ratios are determined by the nutritional needs of your animals and by the composition of the main raw materials that you have available. The energy is in the form of starch, high in phosphorus but low in both crude fibre and calcium.

Challenges to Use of Commercial Dairy Concentrates

Although commercial concentrates improve milk yield, dairy cattle farmers in Uganda frequently complain that they are too expensive, not readily available and are sometimes sub-standard. Commercial concentrates are estimated to cost about 20% of the total cost of milk production hence reducing the farmer's profits. Making dairy cattle supplements using locally available and less expensive feeds can help farmers to realize higher milk yields at a lower cost of production. For the concentrate to be useful to the cow it must contain balanced proportions of energy, protein and minerals.

Home-made Dairy Cattle Concentrates: In order to reduce the cost of commercial concentrates, farmers supplement their cows with homemade dairy concentrates based on maize bran, mineral premix, cotton seed cake, and other ingredients because the ingredients are readily availability and affordable. Generally, a cow will eat from 2.5 to 3 % of its body weight in feed daily. For top performance, about 70 to 80 % of this feed should be a concentrate mix and the remainder good quality roughage. On good pasture, concentrate mix can be reduced 50 to 70 %, but more concentrates produce faster gains.

The use of local feed resources to reduce production cost should be more a primary concern for dairy farmers. Most of farmers use home-made concentrates comprising of local feed resources. Fodder tree leaf meals such as Calliandra leaf meal, Mexican Sunflower or herbaceous forage legumes such as alfalfa can save over 30% of the total cost by mixing your own concentrate. Tables 8, 9, 10 and 11) show some of the ingredients used to formulate homemade dairy concentrates.

Table 8: Examples of Ingredients Used to Formulate Homemade Dairy Concentrates

High Energy Feed	High Protein Feeds	Sources of Minerals
• Maize germ • Wheat pollard • Molasses • Maize bran • Wheat bran	• Lucerne hay • Alfalfa leaf meal • Cotton seed cake • Soya bean meal • Sunflower seed cake • Fodder trees and shrubs • Azolla	• Di-calcium Phosphate • Limestone • Rock phosphate • Mineral Premix.

Calliandra leaf meal

Table 9: How to Mix the Dairy Supplement

1. **Ordinary Supplement** To make 100 kg of the supplement use: **Example 1.1:** • 75 kg energy feeds • 23 kg protein feed • 2 kg minerals. **Example 1.2:** • 57 kg Maize germ • 18 kg Wheat pollard • 17kg Lucerne hay • 6 kg Soya meal • 2 kg Dicalcium phosphate.	2. **High Yielder Dairy Supplement** To make 100 kg of the supplement use: **Example 2.1:** • 68 kg energy feeds • 30 kg protein feed • 2 kg minerals **Example 2.2:** • 50 kg maize germ • 16 kg wheat pollard • 2 kg molasses • 14 kg cotton seed cake • 12 kg lucerne hay • 4 kg fish meal.

***Source**: (Cowsoko Kenya, 2022)*

Table 10: Simple homemade dairy concentrate

Ingredient	**Quantity (kg)**
Maize germ	43
Wheat pollard	16
Wheat bran	26
Sunflower meal	5.5
Cotton meal	6.75
Lime	0.5
Diatomaceous powder	1
Rock salt	1
Premix	0.25
Total	**100**

***Source**: (Cowsoko Kenya, 2022)*

Table 11: Homemade dairy meal using fodder trees leaf meal

Ingredient	**Quantity (Kg)**
Maize bran or wheat bran	48.5
Sunflower or cotton seed cake	16
Yellow gram (chickpea)	20
Fodder tree, herbaceous legume meal	10
Limestone	4
Maclick super salt	0.5
Common salt	1
Total mix	**100**
Crude protein (%)	18.6

***Source**: (Cowsoko Kenya, 2022)*

Key Steps to Make Concentrates at Home

Step 1: Have a list of all available feed ingredients.

Step 2: Group the ingredients according to availability of the macronutrients (energy, protein, minerals). The general rule where a weighing scale is not available is to mix the energy (the cereals) and the protein feeds (the oilseed cakes + leaf meals) at the proportion of 3 to 2. Use minerals and premixes such as lysine in small amounts (about 1%).

Step 3: Identify a good, clean mixing area. Farmers with a herd of 5 or more milking cows can acquire feed mixers with outputs as little as 500 kg per hour.

Step 4: If you are mixing manually, start mixing the ingredients being used in small proportion—for example, mix the salt + premix then add the yeast. Mix thoroughly, using a clean shovel.

Step 5: Continue mixing with the shovel to ensure that all ingredients are distributed well throughout. Ensure you properly mix the materials using a mixer or a spade.

Step 6: Store your mixed feed well. Gunny bags are commonly used.

How Much Concentrate to Feed a Dairy Cow

The amount of concentrate supplement offered to a dairy cow depends mainly on:

- Quality of the basal forage,
- Milk production level of the cow,
- Weight of the cow and,
- Availability of either forages or the concentrate.

A general rule on feeding concentrate suggests 1 kg of concentrate for every increase in milk yield above 8 litres of milk.

Advantages of Homemade Dairy Meal

- Increase in dairy cattle production in remote areas where commercial concentrates are not available.
- Increase in farm efficiency by using on-farm by-products.
- Reduction in the cost of production where homemade rations are cheaper than commercial rations.
- Homemade concentrates are fed fresh and are of good quality.

Disadvantages of Homemade Concentrates

- It is not easy to maintain quality control and balance the ration because some ingredients may not be available.
- Due to variability in quality it is difficult to determine feeding rates.
- It is difficult to mix homogenously, especially the ingredients used in small amounts, because mixing is done manually,
- It is difficult to observe recommended limitations for some ingredients, which can be toxic or have negative effects.

3.6.1. Koudijs Dairy Concentrates

Using Koudijs dairy concentrates gives you the highest revenue based on feed efficiency and milk quality. These easy-to-use feed concentrates include all the essential nutrients for excellent performance and persistent milk production.

Koudijs Dairy Meal: A nutritious balanced meal, with sufficient energy and protein is required to prevent the negative energy balance and produce more milk with less problems. Fresh roughage should be available all day. The nutritional requirements depend on the genetic potential, the lactation phase and the available nutrients from the roughage.

Koudijs Dairy Meal is an additional feed beside roughage. Koudijs-Kaffika dairy meal ration (Table 12 and Table 13) is a mixture of several ingredients to give right balance of energy, proteins minerals to meet the needs of cow.

Table 12: Koudijs-Kaffika Dairy Meal Ration

Ingredient	Quantity (kgs)
Koudijs dairy concentrate 10%	17.5
Wheat pollard	40
Maize broken	20
Maize bran	12.5
Cotton seed cake	10
Total	**100**

***Source**: (Koudijs-Kaffika, 2024)*

Table 13: Koudijs Dairy Meal Feeding Regime

Days in lactation	Cow weight 350 kg	Cow weight 450 kg	Cow weight 550 kg
0	1,50	2,00	2 , 50
7	4,00	6,00	6 , 50
28	5,00	7,00	7 , 50
49	5,00	7,00	8 , 00
70	5,00	7,00	8,00
91	4,50	6,50	7 , 50
112	4,00	6,00	7 , 00
133	4,00	5,50	6 , 50
154	3,50	5,00	6 , 00
175	3,00	4,50	5 , 50
196	3,50	4,00	5 , 00
217	3,00	3,50	4 , 50
238	2,50	3,00	4 , 00
259	2,00	2,50	3 , 50
280	1,50	2,00	2 , 50
301	1,00	1,00	1 , 50

***Source:** (Koudijs-Kaffika, 2024)*

Koudijs Dairy Feed: After 305 days or 60 days before calving, provide the cow with rest. Stop milking and prepare her for the next lactation. Approximately 14 days before calving, the cow should be provided with maize bran to increase the rumen function and prevent ketosis. Right after calving the cycle starts all over. The amount of dairy meal and the kind of dairy meal always depends on the production, the weight of the cow, the lactation stage, other available nutrients. This is why it is important that you check with our local representative.

Koudijs Milk Replacer: Rearing a calf is investing in your future. The rearing period determines the vitality of the calf. Before puberty, the calf will grow in size and body capacity. Using a balanced diet will stimulate the right development of the calf and provide vitality. This is exactly what a modern farmer wants. The Milk Replacer Koudijs offers supports you in creating strong vital calves which are ready for a long lasting and high productive life.

Instructions for Milk Preparation

- Rinse and clean the buckets and teat buckets before use.
- Check on the Feeding Table 14 how much milk to prepare.
- Weigh the correct quantity of Milk Replacer (150 gram per litre of water. Look on the bag's label for more details).
- Warm up the water to 45-50°C, but never over 70°C (use a thermometer).
- Add, little by little, the powdered Milk Replacer until the correct concentration is attained. Mix the milk thoroughly (stir at least 30 seconds).
- Pour the milk in the bucket at least at 42°C, so the temperature of the milk is correct.

Table 14: Feeding plan for rearing a calf using Koudijs milk replacer

Period of 8 weeks (days)	Period of 10 weeks (days)	Period of 12 weeks (days)	Milk 2 times a day (Litres) Milk 2 times a day (see instructions above)	Remarks
0-3	0-3	0-3		Colostrum
4 – 8	4 – 10	4 – 12	2	Calf rearing meal + hay
9 – 6	11 – 20	13 – 23	2.5	Calf rearing meal + hay
17 – 42	21 – 50	24 – 55	3	Calf rearing meal + hay
43 – 46	51 – 60	56 – 64	2.5	Calf rearing meal + hay
47 – 51	61 – 66	65 – 75	2	Calf rearing meal + hay
52 – 56	67 – 70	76 – 84	1.5	Calf rearing meal + hay

Koudijs Milk Replacer gives me strong well developed calves. During the first 3 days provide the calf with colostrum from its own mother (if the quality is good}. After that, you can switch to artificial milk. Lt is important for the calf to drink a minimum of 2 litres of colostrum (40°C)

as soon as possible after he is barn. The inclusion of antibodies from the colostrum mostly takes place during the first 12 hours of a calf's life. Give the calves 3 times a day 1 .5 - 2 litter

Nutrafol Pellets

The intake of Nutrafol Calf Pellets is a very important factor in the development of the calf rumen, which is very small and undeveloped at birth. Nutrafol Calf Pellets intake is important in ensuring a smooth transition from milk feeding to an adult diet at weaning without setbacks to growth. In general, calves are fed a 'calf starter' ration up to 12-16 weeks of age. From there they are switched to a 'calf grower' ration.

Nutrafol calf pellets

Benefits of Nutrafol Calf Pellets

- High levels of starch that promote rumen development and drive growth rates.
- High levels of quality protein promote frame development.
- Contain vitamin E, selenium and zinc to support the calf's immune system thus strong and healthy.
- Enables easy and early weaning.
- Average weight gain of 300 grams per day is attained.

Table 15: Feeding regime of Nutrafol calf pellets at different stages of calf growth

Period	Quantity of milk (litres/calf)		Quantity of pellets per calf	
	Morning	Evening	Morning	Evening
1-7 days	3 litres of colostrum	3 litres colostrum	0	0
8 days to 4 weeks	3 litres of milk	3 litres of milk	250gms	250gms
5-8 weeks	2 litres of milk	2 litres of milk	750 gms	750gms
9-12 weeks	2 litres of milk	2 litres of milk	1 kgm	1 kgm

3.6.2. Can Climate Smart Forages Replace Concentrates in Dairy Milk Production?

A study conducted in Kenya showed that on many dairy farms, the quantity of feed offered to cows is an insignificant factor in milk productivity and this indicates gaps in the quality of fodder. To increase dairy productivity, farmers increased the quantities of concentrate used. This turned out to be not only costly and unprofitable but made the enterprise less technically efficient. Thus, initiatives that promote adoption, utilisation and commercialisation of fodder varieties that have a higher nutrient density and are more resilient to climate change than the commonly available feed resources would be a pliable pathway that would ensure all year-round feed supply, reduce quantity of forage used and need for concentrate feeding. Such fodder that can meet the nutritional requirements of improved dairy animals would reduce the cost of production and increase returns on investment. Furthermore, lowering concentrates is expected to avoid nutrition based metabolic disorders of the dairy cows which in turn result to positive outcomes regarding food quality and ecology. Farmers therefore need access to key agricultural resources to increase the local availability of reliable climate-resilient forage for dairy cattle.

3.7. Multi-Nutrient Feed Blocks

Multi-nutrient feed blocks are lick blocks containing energy, protein, vitamins, minerals and other nutrients. Multi-nutrient feed blocks comprise of forages, concentrate and other supplementary nutrients in desired proportion capable to fulfil nutrient requirements of animals. Multi-nutrient blocks are supplements for ruminants (goats, sheep and cattle) fed on low-quality pastures. Strategic ruminant supplementation is one of the technologies to reduce methane gas which is also responsible for global warming.

Advantages of Multi-nutrient Blocks

- Simple and efficient technique for long term conservation of crop residues which are available abundantly in one season and scarce in another season.
- Easy to transport and feeding to stall-fed and free grazing animals.
- Reduces use of conventional concentrate feeds, thereby feeding cost would be alleviated.
- Allows a synchronous and fractionated supply of essential nutrients for ruminants fed on low quality roughages.
- Environment pollution may be reduced, because farmers do not have sufficient time between harvesting of matured crop and sowing of next seasonal crop. As a result, crop residues suitable for feeding are being burnt in the field per se. The burning of crop residues pollutes the environment.
- Dry matter intake of the nutrients is increased in block form of complete diet,

The main **justification** for using blocks, to provide deficient nutrients is, therefore, their convenience for packaging, storage, transport and ease of feeding.

Basic Feed Ingredients of the Blocks and Nutrients They Provide

(a) Minerals: The block contains minerals such as calcium, phosphorous that are not naturally found in grass. These minerals are important for growth, reproduction and milk production. Mineral premix can be sourced from the different mineral powders on the market. Wheat, maize or rice bran provides some key nutrients including fat, protein and phosphorus. They also serve as an absorbent for the moisture contained in molasses and give structure to the block.

(b) Protein: The block gives up to 50% protein needed by animals for growth. Leaf meal from forage legumes such as alfalfa; fodder trees and shrubs such as Calliandra and Mexican sunflower and processed poultry waste provide protein required by the animal. Oilseed meals such as cotton seed cake, sunflower cake or soybean cake provide both soluble and insoluble proteins and are a good source of phosphorous. It is appropriate to add such ingredients when blocks are given to animals in production.

(c) Energy: The block gives about 45% energy needed by animals to increase meat and milk production. Molasses provides fermentable substrate and various minerals and trace elements (but low amounts of phosphorous). Because of its pleasant taste and smell, it makes the block very attractive and palatable to animals.

(d) Salt: The salt in the mixture is ordinary table salt or mineral salts, depending on their availability and price. Even though the salt is not toxic it is better to prevent lumps in the mixture.

(e) Roughage-Based Ingredients: Milled crop residues such as cereal stovers (maize and sorghum); milled pasture grass hay or straws (rice and wheat) can be included in the block depending on their availability. Some crop residues and by-products will provide more nutrients than others.

(f) Binder-Based Ingredients: A binder such as Calcium bentonite, Diatomaceous feed additive or cement is necessary in order to solidify the blocks. Calcium

bentonite or Diatomaceous feed additive help to bind aflatoxins and reduce mycotoxin (poisonous substances produced by a fungus and especially a mould) from contaminated feeds in the animal's gut. Large doses of aflatoxins can lead to acute poisoning and can be life threatening to humans and animals, usually through damage to the liver.

(g) Bran: Apart from its nutritive value, bran serves as an absorbent and to give structure to the blocks. All kinds of bran (maize, wheat or rice) can be used. If there is no bran available, or if it can be used more economically elsewhere, it can be replaced by other fibre sources such as ground straw, bagasse or peanut hulls.

The formulae can be changed according to results and specific needs in a given situation. If, for example, the blocks are too hard a reduction in the amount of gelling agent and an appropriate increase of molasses can change the consistency of the block. The opposite is done if the blocks are not hard enough. The percentage of the absorbent (e.g. wheat, rice bran or bagasse) can also be changed. It is essential to bear in mind that any changes in the formula can lead to modifications in the solidification process and the hardness of the blocks. Table 17 shows an example of ingredients used to make a Multinutrient feed block.

Table 17: Example of ingredients used to make a Multinutrient feed block.

Ingredients	**Quantity (kgs) (a)**	**Crude protein content (percent) (b)**	**Total contribution to crude protein (percent) (c)**	**Cost per kg (Ushs) (e)**	**Total cost (Ushs) (f)**
Milled cereal straw, grass hay and other dry feeds	10	5	0.5	500	5,000
Maize bran	35	10	3.5	600	21,000
Soybean cake	30	40	12	3,700	111,000
Mineral premix	2	0	0	4,000	8,000
Calliandra leaf hay	10	20	2	500	5,000
Molasses	10		0	2,000	20,000
Cement	1	0	0	600	600
Diatomaceous binder)	2	0	0	3,000	9,000
Total	**100**		**18**		**179,000**

NB: The protein content of the block is about 18 percent

Calculations

- Average crude protein content (percent): obtained from chemical analysis tables
- Total contribution to crude protein (percent) (c): Quantity (a) x Crude protein content (percent) (b)
- Cost per kg (Ushs) (e): based on current market prices.
- Total cost (Ushs) (f): Quantity (kgs) (a) x Cost per kg (Ushs) (e)
- US dollars (g): Total cost (Ushs) (f) divided by Ushs 3,700 (1 dollar = Ushs 3,700)

Steps in the Production of Multi-nutrient Feed Blocks

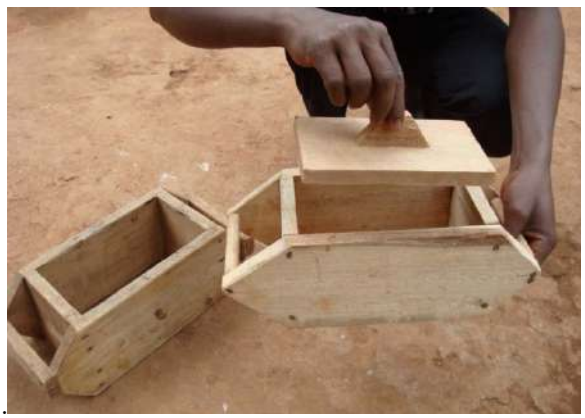
Step 1: **Prepare and Weight Feed Ingredients:** A standard volume or weight can be adopted for each component which would correspond with the weight of the block desired. For example, if each block is to weigh 5 kg and at each mixing 50 blocks are to be produced (a total of 250 kg), then assuming that the feed ingredients available are molasses, maize, forage legume leaf hay, bran, soybean meal, salt, cement and mineral mixture, then the following formula can be used to prepare the components for mixing. Double the quantity if each ingredient will be required for 100 blocks.

Step 2: Introduction of the Components: Ihas been found that the order of introduction of the components plays an important role in the mixing process. The recommended order is as follows:

- Milled cereal straw, grass hay and other dry feeds
- Maize bran
- Soybean cake
- Mineral premix
- Salt
- Legume leaf hay
- Cement
- Diatomaceous
- Molasses

Step 3: **Mix the Ingredients Thoroughly:** According to the rate of production foreseen and the level of investment different types of mixers can be used. If adequate labour is available and only few blocks (say 50-150) are needed then manual mixing is possible. With 3 labourers and one supervisor, approximately 150 blocks of 5 kg each could be made over a period of 8 hours (a working day). However, for producing larger numbers of blocks (over 150 blocks/day) a concrete mixer is recommended. The cylinder of this concrete mixer should turn horizontally and as slowly as possible, to avoid the molasses, which is highly viscous, sticking to the side of the mixer. Spillage of the mixture should also be avoided. For bigger units it is recommended that a horizontal paddle mixer is installed (the ribbon mixer used in feed manufacture is not suitable) with one or two axles and a discharge valve.

Step 4: **Moulding**: Moulds are necessary to set the blocks in an acceptable shape. Once set the frame can be removed for reuse and to allow the drying process to continue. Moulds can be of different types. The size of the mould(s) will depend on the preferred size of the block(s) with slots sawn in order to be able to assemble the frame easily. The most appropriate for small scale manufacture of blocks are frames made out of a number of wooden planks with slots cut out to enable easy assembly and removal. Each compartment measures 25 x 15 x 10 cm and can hold a urea-molasses block weighing 4.5-5.0 kg



Wooden frame

Step 5: Drying: After removal of the moulds and cutting up, blocks can be dried in a solar dryer. After 24 to 72 hours the blocks are dry enough to be transported.

How to Utilize the Blocks

The aim of the block is to improve the utilisation of low quality roughages, especially during and at the end of the dry season, when livestock are often dependent on crop residues or low quality dry season grazing, which are both low in crude protein and high in fibre. Therefore, the production and distribution of blocks should be limited to these critical periods. There is no advantage in offering blocks when green forage is available, as during the wet and early dry seasons. To avoid wasting resources they should not be made available at these times.

3.8. Total Mixed Rations (TMR)

A Total Mixed Ration is a method of feeding cows with a complete mixture of all forages, grains, protein feeds, minerals, vitamins and feed additives formulated to a specified nutrient concentration into a single feed mix. This is an excellent concept to improve the dry matter intake and maintain healthy rumen environment

Advantages of TMR

- **Nutritional Homogeneity:** One of the biggest advantages of TMR is the ability to provide uniform nutrition for all cows. This helps prevent competition for feed, ensuring each cow receives the nutrients needed for consistent milk production.
- **Improved Feeding Efficiency:** With TMR, less time is spent with feeding cows, since the feed is prepared in advance, which saves labour that can be applied to other tasks. As the mixed ration is formulated to meet the nutritional needs of cows, this results in better use of nutrients and consequently increases productivity.
- **Precise Nutritional Control:** TMR allows precise control of nutrients, which is vital to meet the specific needs of each cow at different stages of lactation, allowing to optimize milk production, weight gain and overall cow health.
- **Waste Reduction:** All ingredients are mixed homogeneously, there is no waste, for example when the cow selects only the components of her preference.
- **Improves Milk Quality:** A balanced and homogeneous diet, such as mixed feed, allows to obtain milk with higher levels of fat and protein.
- The incidence of digestive and metabolic problems often decreases when a TMR is fed, and milk production has been shown to be up to 5% higher with a TMR compared to conventional feeds due to these benefits.
- Mixing all foods in a TMR can mask the flavour of less palatable foods. However, through mixing, they can be added to the TMR in reasonable amounts, with little or no reduction in feed consumption.

Disadvantages of TMR

- **Cost**: Mixed feed is more expensive than feeding separate concentrated and roughage foods. Mixer wagons are expensive.
- **Complexity**: TMR formulation and preparation is complex and requires the support of an animal nutritionist.

How to Formulate the TMR Feed Ration

Rations for dairy cows are formulated on a dry matter basis and then the amounts of each feed are on “as fed basis.” Knowing the correct dry matter of ensiled forages, and all other wet grains and feeds fed in the TMR is critical to the mixing. Rations should be balanced for slightly higher nutrient intake than what the average milk production of the group is. The dry matter intake used to formulate the ration to the desired nutrient concentrations should be the same as the actual DM intake of the group.

A general guide for lactating cow rations is to formulate them for milk productions about 20% above the average production of the group. By formulating rations slightly above the

average milk production, cows are challenged to produce more and if they do not, the extra nutrition generally can be used for growth or added body condition. First lactation cow ration can be formulated for 25% above actual milk production of the group to provide nutrients for growth of these cows. Consult an animal nutritionist.

Key Point before the Formulation of TMR

- Conduct a laboratory analysis to find out the nutritive quality of each ingredient.
- Determine average body weight, milk production, and fat test of the group. Determine the realistic, desired amount of milk production to balance the ration.
- Estimate dry matter intake (DMI) and determine the amounts of individual forages to be fed on a dry matter basis (based on quality and inventory).
- Work out the quantity of grain and mineral supplements required to meet the nutrient needs of the cow beyond the nutrients supplied by forages.
- Know the correct number of cows in the group every day and feed for that number. Daily counts of the number of cows in a group before feeding is necessary so the correct amount of feed fed per cow is provided.
- Cow diet is based on forages, protein, liquid, energy, and vitamins. Farmers should calculate how much of each nutrient cows need and formulate TMR according to them.

Factors Effecting TMR Feeding System

- Particle size: Check particle size of the TMR. Every two to four weeks, the particle size of the TMR should be 2 to 3 cm (fibre length).
- Proper order of ingredients in the TMR
- It is important to maintain length of forage fibre in TMR. There are ingredients for TMR preparation: (Table 18).

Table 18: Guideline for limits of various feed ingredient for making Total Mixed Ration

Ingredient used	Quantity of ingredient (kg/day/cow)
Hay/wheat straw	4-6 kg
Maize silage (DM-35%)	10-12 kg
Maize grain	4-5 kg
Deoiled rice bran	0.2-0.3 kg
Cotton seed cake	3-5 kg
Soymeal	1-2 kg
Mineral mixture	50-100 g
Salt	40-60 g
Vitamin E	1500-3000 IU
Salt	40-60 g
Yeast	5-10 g
Buffer	50-60 g
Bypass fat	200-400 g (mostly for high milk producing cows)

Timing of Feeding

- A Total Mixed Ration can be fed once per day, but twice per day is preferable especially

during hot months. Feeding twice per day, once in the early morning and once in the evening keeps the feed fresher and encourages feed intake. Watch out for sorting

- Cows will take their noses and wiggle down through a TMR to sort out the grain from the forage. This process provides the rumen microbes with a few mainly grain meals and a few mainly forage meals per day, just like component feeding without a TMR. The result is acidosis. Ration dry matter can dramatically affect the incidence of sorting. In the drier ration more sorting happen will be in case of more drier ration. Sorting has been reduced when water was added to rations containing more than 50% dry matter to bring ration dry matter down to 43%. Also, if the ration is too coarse (especially with coarse-cut dry corn silage) cows will sort more. Feeding cows more frequently will also help reduce problems with sorting.
- Observe feed refusals: In general, feed refusal should not exceed 3 to 4%. Feed refusals can be fed to older heifers, steers, or other beef cattle. Refusals should never be fed to pre-fresh or early lactating cows. First-calf heifers should be placed into a higher group than their production level to compensate for growth that they will have in the first lactation. If there are long forage particles, corn cobs or other noticeable large amounts of any single feed ingredient, this indicates cows are sorting and not consuming a balanced ration. Either chop the long forages or particle feeds finer or replace them in the TMR with feeds that are more difficult to sort.

3.8.1. Crop Residue Improvement through Total Mixed Ration (TMR) Formulation and Supplementation *(Dr. Andrew Atuhaire, National Agricultural Research Organization)*

Complete feed is a homogenous mixture of feed ingredients (concentrate and roughages), which contain nutrients (proteins, carbohydrates, fibre, fat, minerals and vitamins) and also meet the dry matter requirement of animals. It can be fed either in mash form as total mixed ration (TMR) or pelleted by using expander-extruder technique. Complete feed is prepared by using agricultural wastes, crop residues like wheat straw, paddy straw, dry grasses and agro-industrial by-products like oil seed cakes, brans and molasses. In the dry seasons there is scarcity of green fodder. In such conditions complete feed is the appropriate option to meet requirement of animals.

Complete feed is more balanced feed and can be fed as per requirement of the animal. It is easy to regulate feed intake of the animal with complete feed. Complete feed is a better option for land-less and small farmers for whom there is always shortage of green fodder for their animals. The organized farms, urban and peri-urban dairies can also use complete feed with advantage.

Method of Preparation of Total Mixed Rations

Several combinations of roughage and concentrate feed ingredients can be used to prepare Total Mixed Rations for lactating cows, growing heifers and dry animals. Four combinations are given as an example for different type of animals (Table 19)

Table 19: Examples of a Total Mixed Rations (TMR) formula

Ingredients	TMR1	TMR2	TMR3	TMR4
Ground Maize	10	4	5	5
Soybean meal	15	15	10	5
Sunflower cake	10	5	4	4
Rice bran	24	25	20	10
Molasses	10	10	10	10
Crop residues	30	40	50	65
Mineral mixture	1	1	1	1
Total (kg)	100	100	100	100

Formulation (TMR 1): *For high producing dairy cows (more than 20 kg milk/day).* ***Formulation (TMR 2 and TMR3)****: For medium producers, growing heifers and pregnant cows. Formulation (TMR4): For dry animals.*

Crop residues and locally available by products are used in the formulation in proportions as per the requirements of the animals.

In a Total Mixed Ration (TMR) all the ingredients are homogenously mixed leaving no chance to animals for selection. TMR increases fat content of milk by maintaining right proportion of acetic and propionic acid in 3:1 proportion and resists rumen acidity. This also affects microbial flora of rumen by increasing cellulolytic bacteria in rumen. Digestibility of proteins increases by feeding complete feed.

3.9. Water in Dairy Cow Nutrition

Water is the most essential nutrient for dairy cattle production and is needed for numerous processes.

Importance of Water in Dairy Cows

- Cows are ruminant animals, that is, they have a stomach divided into 4 parts. Water helps break food down into nutrients that can then be absorbed.
- Nutrients from food are absorbed and are transported by the blood to the cells. Water helps keep the blood flowing and thus transport nutrients to the cells.
- Dairy cows are warm blooded animals, which means they need to keep their body temperature high. The water helps to regulate the cow's body temperature so that she sweats and breathes.
- Cows excrete their waste through salivation, urine, faeces and sweat. Water helps to dissolve waste and keep it flowing through the cow's body so it can be excreted.
- Milk is composed of water, lactose, proteins, fat, calcium, phosphorus, and other nutrients. Water makes up about 87% of the total volume of milk.

Factors Affecting Intake of Waster by the Cows

- Gestation,
- Lactation,
- Rate and composition of grain,
- Type of diet,
- Activity,
- Environmental temperature, and
- Feed intake.

The intake of water from feeds plus the *ad libitum* consumption of free water is the equivalent of the water requirements in livestock. *Ad libitum* access to clean, fresh water is essential to maintaining feed intake in livestock. A dairy cow requires about 5 litres of

water for every litre of milk it produces. Therefore, a cow producing 10 litres of milk a day must drink about 50 litres/day. The amount required also depends of breed, body size, and season.

Amount of Water Required by a Dairy Cow

Dairy cows have about 56% to 81% of their weight made up of water. The physiological state and body composition of the animal affect the total amount of water in the body. So, and more concretely:

- Younger, leaner cows have a higher body water content whereas older, fatter cows have a lower body water content.
- Dry cows, in advanced pregnancy, present 64.7% of their live weight in water.
- Cows in early lactation have 69% of their body weight in water.
- Cows in more advanced lactation have 62.4% body weight in water

Drinkers for Dairy Cows

The number of times a cow goes to the drinker is not a determining factor for the amount of water ingested, as this is directly related to the intake in each drink and not with the number of drinks per day.

Low cost plastic water trough

It is important to **provide dairy cows with fresh, clean water** *ad libitum.* The water must be free of impurities and at room temperature. The following points regarding drinkers are highlighted:

- Keep water fountains clean and in good working order.
- The water flow in the drinkers must allow it to be renewed at least twice a day.
- Make sure the water is fresh and tepid.
- Place the drinkers in shaded and wind-protected places.
- Drinkers must have appropriate dimensions so that a greater number of adult cows can drink water at the same time.
- Monitor the water consumption of dairy cows to ensure they are drinking enough.

Water Quality

The water provided to dairy cattle needs to be good quality to maintain production. The water must be clean, fresh, contain low levels of solids and alkalinity and free of toxic compounds. Water quality may be altered by contaminants, such as mineral salts, toxins, heavy metals, microbial loads, debris, and agricultural practices. Contamination, even a small one, can have harmful consequences for the animal, including **the healthiness of the milk**. Most contaminants will reduce water intake, which results in a reduction in feed intake and a loss of production. However, if the water or feed contains increased salt, water intake will increase as the animal attempts to eliminate the excess sodium.

When talking about water quality we are talking about both the water used for cleaning the milking equipment and the water for drinking. If the water is contaminated, it can affect animal health and well-being and, therefore, **this contamination can be transferred to foodstuffs (milk and meat**), jeopardizing human health. The most common contaminants are microorganisms and their toxins, viruses, protozoa and parasite eggs, as well as pesticides, nitrates, solvents and fuels.

It is important to note that the water can come from natural sources or even from the public supply network and this must be of good quality to the detriment of the dairy cow starting to ingest water or even refusing to ingest it and consequently verify reducing food intake.

Therefore, in summary, the water used in dairy farms must be colourless and odourless, so that the animals ingest the amount of water they want. Water from wells, mines, dams, rivers and lakes is often not suitable for consumption, so it is essential to treat the water properly for later use. Furthermore, water must be frequently subjected **to physical-chemical, microbiological and even radioactive analyses**.

Water is, therefore, regarded **as the most important nutrient or feed**, and the farmer is solely responsible for ensuring it does not become a limiting factor in animal performance. Water is essential for all metabolic processes, chemical reactions, and temperature regulation, eliminating waste from the body, and ultimately, health and survival.

3.9.1. Low Cost Water Harvesting Technologies for Urban Dairy Cattle Farmers

Water harvesting is the collection and concentration of rainwater/runoff for the production of crops, pasture or trees, for livestock or domestic water supply or for other productive purposes. All water harvesting systems comprise a catchment area and a storage component. Storage can be either short-term or long-term. Short-term storage techniques are usually for crop, fodder, pasture and tree production whereas long-term storage techniques are for domestic and livestock water supplies. A number of technologies for harvesting water for livestock and crop production and domestic use exist:

1. Roof Top Rainwater Harvesting

This technique involves collecting rainwater from roofs to storage tanks using gutters located at the edges of the roofs. It involves the following activities:

(a) Digging a pit—the size of a pit will depend on the capacity of your tank
(b) Laying a dam liner inside the pit
(c) Roofing

(a)

(b)

(c)

Construction of an underground rainwater harvesting tank

Constructing a small wall around the tank to prevent soil erosion entering the tank
Excavated reservoirs are lined with either a tarpauline of a dam liner.

Tarpaulin

Benefits
- Locally available
- Cheap/affordable
- Easy to install
- Replacement is easy
- Portable

Disadvantages
- Short life span
- Prone to damages
- Restriction on tank capacity

Tarpaulin

Dam Liner

Benefits
- Long life span
- Any capacity of tank
- Not prone to damages
- Easy to repair
- Relatively cheap depending on gauge

Disadvantages
- Imported
- Bulky

Dam liner

Tank Measurements

- Tank dimensions (6 x 3 x 1.5m)
- Tank capacity (s) 24-27m^3
- Roof catchment (5 x 10 = 50$m^{2)}$

Tank Size Determinant

- Households resources /income
- Catchment area (roof, rock embankment and surface run-off)
- Water demand by Households (irrigation, watering)
- Type and cost of materials

2. Surface Run-Off

In this method of collecting rainwater for irrigation, water flowing along the ground during the rains will be collected to a tank below the surface of the ground. The tank is constructed using bricks, which are coated with cement. During storage, it is important to incorporate efficient and effective water conservation methods – by reducing evaporation and also by adopting efficient irrigation techniques. It is a very 'easy to adopt' technology proven with many communities in the country that if used properly can be very profitable.

Surface run-off water reservoir containing the water lettuce that purifies water

Procedure of Runoff Rainwater Harvesting

Step 1: The tank should be close to the area of cultivation to ensure ease of irrigation.

Step 2: The tank should not be in close proximity to the house or to paths /roadways as it is possible for children and even negligent adults to fall in. Construct a fence around the tank.

Step 3: The opening of the tank should be to the direction of the flow of rainfall.

Step 4: It is not advisable to obstruct patterns of natural flow of water, as there is a possibility of mud and other waste getting into the tank. (The mud filters function only when the water flows directly through them).

Step 5: Clear the selected land thoroughly. Flattening the land is important for ease of taking measurements.

Step 6: Determine the quantity of water required for irrigation purposes

Step 7: The tank should not be more than 1.75 m in depth in order to withstand the pressure of the water. Low depth makes cleaning and use of the tank easier.

Step 8: The tank should have a slope of about one foot from the periphery to the middle of the tank.

Step 9: Various waste items are present in flowing water. Mud, sand and gravel deposits in the tank will lessen the quantity of water that can be stored in the tank. Therefore mud- filters are used as a simple method of reducing the flow of waste items into the tank.

method of reducing the flow of waste items into the tank.

3. Open Surface Rain Water Tanks

In areas where good water quality is needed for domestic and animal consumption but the roof catchment is too small to collect sufficient water, open surface water tanks can be constructed. These can however be constructed in areas that receive good rainfall amounts per rainstorm to ensure collection of enough water. The design is based on the precept that for every 1mm of rainfall, 1 cubic meter of water is collected in every square meter of surface. Therefore, a water tank constructed with surface area of 24 square metres will collect 24 cubic metres of water from a storm of 1mm rainfall. These tanks provide clean quality water for a variety of purposes including domestic use.

Open surface rain water tanks

CHAPTER 4: DAIRY CATTLE MANURE MANAGEMENT INNOVATIONS FOR INCOME GENERATION AND ENVIRONMENTAL SUSTAINABILITY IN URBAN AREAS OF UGANDA

Although urban dairy cattle farming is a valuable source of income and nutrition for many households in urban areas, the dairy cattle wastes generated from the zero grazing units has potential to become hazardous to the communities. A well-fed average (450 kg liveweight) cross bred cow produces about 30 kgs of manure (8-16 times) per day equivalent to 11 tons of manure per year. A cow urinates 10-12 times/day with an average of 2 litres equivalent to 20-24 litres/day totalling to 8760 litres/year. Dairy cattle waste is a 3:1 combination of faeces and urine and is mostly composed of lignin, cellulose, and hemicelluloses. Improper manure disposal causes environmental degradation, diseases and loss of valuable nutrients that could be added to soil.

Composition of Cattle Manure

Cow manure is not just waste, as many farmers believe. Cattle manure contains about 13.2% protein and 24 minerals like potassium, nitrogen, phosphorus, potassium, sulphur, calcium, magnesium, manganese, cobalt crude fibre like cellulose with lignin and hemicelluloses. Cow manure contains valuable nutrients such as nitrogen, phosphorus and potassium, which are needed for crops to grow, as well as fibre that can be used in other applications on-farm. Cattle manure contains approximately 80% of water which supports the undigested herbivorous medium containing beneficial microbial population and nutritive substances. As a whole, more than sixty bacterial species, hundred species of protozoa and yeasts are present in the cow dung. Cow manure is considered as a "**gold mine**" because of the broad applications as a resource of energy, agriculture, protection of environment and the therapeutics.

Sustainable Cattle Manure Management

Sustainable manure management is described as *"effective collection, storage, treatment, and application of manure nutrients in crop production to use the potential energy associated with manure and to minimise off-site transport of potential contaminants and environmental pollution".*

4.1. Benefits From Sustainable Cattle Manure Management practices

(a) Environmental, Economic and Social Benefits

The **environmental** benefits of sustainable manure management include preventing the negative impacts on air, water, soil, wildlife, and the marine, protecting human health in communities and at waste management facilities, minimising the risks associated with the waste, improving occupational health, reducing greenhouse

The **economic** benefits include increase in business opportunities, contribution to Gross Domestic Product (GDP), providing savings to businesses especially in resource extraction and use by waste prevention actions, recovery and recycling activities, achieving economic savings by improvements in human health and the environment, leading to higher productivity, lower medical costs, better environmental quality, and the maintenance of ecosystem services.

The **social** benefits include creating employment including low, medium, and high-skilled jobs, integrating and professionalising employment in the informal sector, delivering more attractive and pleasant human settlements and better social amenity, and encourages changes in community attitudes and behaviours. Manure separation systems can help reduce greenhouse gases (GHG) and ammonia emissions in stables through faster separation and removal of faeces and urine.

(b) Reduced Cost of Commercial Fertilizers

Cattle manure contains major plant nutrients, nitrogen, phosphorus and potassium, as well as many essential micronutrients such as calcium, sulphur, zinc, boron, copper, magnesium and manganese. In addition to supplying plant nutrients, manure generally improves soil tilth, aeration, and water-holding capacity of the soil and promotes growth of beneficial soil organisms. Manure applied in the proper amounts at the appropriate time can supply some, if not all, of the nutrient requirements of many crops grown in Uganda.

(c) Improved Production Efficiency

Sound cattle manure management plans allow farmers to direct their time and skills to other important facets of the operation without continued worry about manure accumulation and potential detrimental effects.

(d) Improved Animal Health

Good cattle manure management practices result in improved animal health. By getting the animal out of the manure and removing manure from buildings on a regular basis, the animal environment within the buildings is improved. Mastitis is one of the major diseases caused by poor hygiene in the dairy unit. Prompt removal and proper disposal of cattle waste such as manure, feed refusals and urine minimize the risk of pathogen and pest outbreaks, protecting crops and overall farm productivity.

(e) Protection of Water Resources and Air Quality

Ground and surface water are valuable and essential resources. Virtually all drinking water and recreational use of water resources comes from groundwater or surface water. Many other uses, such as food processing and irrigation, dependent on abundant supplies of high-quality water.

(f) Renewable Energy Generation

Certain farm waste materials, such as crop residues and animal manure and urine, can be utilized to produce renewable energy through processes like anaerobic digestion or biogas production.

(g) Cost Savings and Efficiency

By optimizing resource utilization, for example, composting organic waste can create nutrient-rich fertilizers, reducing the need to purchase synthetic alternatives. Additionally, efficient manure management reduces the risk of regulatory fines associated with improper waste disposal.

4.2 Cattle Manure Management Challenges

- Managing cow manure requires to include extra costs into the prices of animal products for the consumers.
- Rapid cattle manure removal from the production buildings improves air quality within the barns and the health of the workers, but it is necessary to develop an in-barn waste collection and handling system.
- Concentrating larger volumes of cattle and larger quantities of nutrients at a given location increase the risk of point source pollution.
- Inefficient operating conditions can make anaerobic digestion units the most polluting stage in terms of carbon dioxide, methane, and sulphur dioxide emissions.
- There are some limitations to cattle manure relocation including the lack of farms with nutrient deficits in areas with high livestock density, unpleasant odours, disease and pathogen transmission, reluctance of other farmers to bear costs of storing, handling, and applying manures as opposed to commercial fertilisers, and economic competition from other generators of organic nutrients.

4.3. Flies in Confined Dairy Units

The stable flies and house flies are the major insect pests at confined dairy units. The stable fly has a piercing-type mouthpart which is used to pierce the skin to obtain a blood meal. House flies do not bite because they have a sponging-type mouthpart, with which they feed on semi-liquid material.

Biting flies

Effects of Biting Flies on Cattle Production

- Cattle under attack by stable flies will bunch together with each animal attempting to find a position within the bunch which protects their front legs—the favoured feeding site of the flies.
- Considerable energy is expended by foot stomping, tail switching, and throwing the head toward the front legs in an effort to dislodge the flies or prevent feeding.
- Cows become restless and spend less time lying down when under heavy fly pressure.
- High levels of biting activity of stable flies and horn flies can reduce cattle weaning weight, feed conversion efficiency, weight gain, milk production, and overall farm profitability.
- Biting flies elevate physiological stress of animals by increased cortisol levels. Stress responses are associated with animal age with younger cattle reacting more strongly to biting flies than older animals, potentially resulting in greater economic damage as young cattle are in a period of rapid growth.

A cow exhibiting fly-repelling behaviour to dislodge biting stable flies

- The house fly mouth-parts and feeding habits (filth sources) make it efficient in transmitting bacterial and viral agents.

4.4. Odour From Dairy Cattle Operations

Complaints about odour from dairy cattle operations have increased as growth in the number of large dairy cattle operations, increases the concentration of animals in small geographical areas. Many of these large operations store manure for long periods under anaerobic conditions in open manure storages. Liquid manure, especially, can have high concentrations of odorous compounds. Dry manure tends to emit less odours. Most objectionable odours from dairy cattle operations are the result of volatile compounds generated during the decomposition of manure. Odour complaints are more common when the humidity is high and the air is still or when the prevailing breezes carry odours toward populated areas. Odours emanating from feedlots and manure storage ponds may lead to complaints. In the early planning stages for such facilities, farmers should check local and state regulations for separation distances required for various sizes of new or expanded confinement facilities.

4.5. Methods to Control Biting Flies and Odour on Dairy Cattle Farms

To be successful in controlling flies and odour on the dairy farm, it is important that farmers implement a control program that **best fits their particular operation**. Reliance on a single practice or pesticide product is not the best approach to achieving effective and economical pest control. A better approach is to combine routine sanitation with a variety of pesticide strategies whenever flies are a problem. Do not wait for heavy fly populations to build up. Below are mitigation strategies to consider when dealing with stable flies and house flies, the two species that most commonly impact confined cattle.

(a) Sanitation Management

Fly control starts with sanitation and is the most crucial step in your overall fly management plan. Stable flies and house flies thrive in damp, filthy environments. Reducing moisture in zero grazing units and frequently removing manure and spoiled feed can help reduce potential breeding grounds and ultimately, lessen adult fly populations. Additionally, scraping pens frequently can decrease the breeding areas available for flies to reproduce. Pay particular attention to these often overlooked areas: under water troughs and fence lines, feed build-up in cattle guard pits, and spilled feed or silage.

Non-composted manure becomes a breeding ground for airborne pests and flies and manure allowed to build up in pens will give off a foul odour, increase the presence of parasites in animals, and give the property an unclean, uncared-for feeling. Good manure management also increases a farm's curb appeal and will help foster a good relationship with neighbours who may not appreciate the smell of manure next door. In addition to removing manure from animal pens regularly, you will need to compost or remove the accumulated pile of manure from the farm on a regular basis. Although removing the entire manure pile at one time would be an ideal outcome, that option is not always feasible. Motivate your workers and encourage them to remove cow dung at least every 3 hours (depending on the number of cows). Disposal should be done at a reasonable distance from the cattle shed.

(b) Use Cow Mats

As the odour is attractive to flies, a clean dairy unit has fewer fly problems. Using **cow mats** instead of other materials for animal bedding reduces fly development.

Imported cow mats are available (Contact: 0773078000)

Cow mats made from car tyres

Benefits of Cow Mats

Comfort and Safety: Cow mats provide comfort to cows while they stand, walk or lie down. Cow mats are designed to absorb shock and provide cushioning, reducing stress on the animal's joints and hooves. This leads to improved blood circulation, and animals feel more relaxed and safe. Additionally, cow mats have an anti-slip surface that reduces the risk of injuries and falls. Cow mats can help prevent several health problems in animals, such as lameness, arthritis, and joint problems. The cushioning provided by cow mats reduces the pressure on the hooves and legs, and it prevents injuries and infections.

Improved Productivity: Animals that are comfortable, healthy and stress-free are likely to produce more milk and gain weight faster (with good nutrition and other management factors). Additionally, cows that are not standing or lying on hard surfaces for extended periods are less likely to suffer from fatigue and exhaustion, leading to better productivity and reduced veterinary bills.

Cow Mats are Easy to Clean and Maintain: Cow mats can be washed with water and soap. The mats are also resistant to corrosion and can withstand all kinds of weather conditions, making them long-lasting and durable.

(c) Use a Disinfectant

A disinfectant is a chemical liquid that destroys bacteria. **Kerol** is a strong disinfectant and should be used wherever a strong disinfectant is required at the farms. Kerol can help you keep your stalls fresh and odour-free. After cleaning the floor, sprinkle Kerol mixed with water on the floor at least twice a day. Kerol is available in the Container Village (Tel: +256 772 018268). Store Kerol properly as it can be poisonous to both livestock and humans. Kerol also serves as snake repellent.

Other disinfectants such as povidone iodine, betadine and potassium peroxymonosulfate are effective in destroying a wide range of pathogens harmful to cattle such as viruses, bacteria and fungi and are useful both prior to and following surgical procedures.

(d) Eliminate Silage Seepage Areas

Wet manure stacks, old wet hay or straw bales, and other organic matter accumulations attract flies anywhere on the farm. Wet feed remaining at the ends of mangers will breed flies.

(e) Provide Proper Drainage in Barnyards

Use clean gravel and other fill to eliminate low spots in livestock yards. Proper grading and tiling can reduce wet barnyards. Keep water troughs leak-free.

(f) Remove All Decaying Organic Matter

Because flies need warm, moist breeding grounds in which to lay their eggs, remove all decaying organic matter from your property. Piles of rotting leaves, grass clippings, decaying fruits or vegetables from gardens all provide an attractive environment in which eggs can be laid.

(g) Remove Fly Resting Areas

Remove fly resting areas near your shed, compound and pastures by keeping grass and weeds cut short. Flies rest on long grass to escape direct sunlight.

(h) Use Sticky Insect Trap Cards

Sticky insect trap cards are glue-based traps used to catch and monitor pests including flies. Sticky traps attract pest insects using a specific colour spectrum.

Sticky insect trap cards

The glue is Ultraviolet (UV) light and adheres more to the board than to human skin or clothing fibre. The UV light has a higher frequency than visible light. The cards are available at Holland Greentech, Muyenga Kironde road (Tel: +256 785369453 and Task Farm, Rubaga (Tel: +256 773999934/788500968). Hang the cards inside and outside the zero grazing unit.

(i) Use Natural Repellents

Natural repellents include Neem oil which can be applied regularly to repel both biting flies and ticks. This does not have any harmful effects of chemicals and chances of resistance developing are also remote. Application should be always done against the direction of the hair and should cover the entire body, especially underbelly and legs.

(j) Use Diatomaceous Earth Feed Grade Additive

Diatomaceous is a naturally occurring silicon rich sedimentary rock made of fossilised remains of hard shelled pant algae. It is a 100% organic and natural highly effective feed mineral supplement for livestock. For pest control purposes, diatomaceous earth is generally used as a barrier repellent to hard-bodied insects. Diatomaceous earth (DE), when applied in the form of a fine powder, can be highly effective in controlling pest problems, including ants, fleas, roaches, and slugs, among other home and garden pests. By sticking to the exoskeletons of these insects, DE causes them to dehydrate and eventually die. See more details in Chapter 3.

(k) Chemical Control

Chemical control methods rely mainly on synthetic pyrethroids, examples of which include permethrin and cypermethrin. The active ingredients are similar in mode of action, although differences in concentration and formulation of the products on sale affect their persistence.

(l) Residual Sprays

Residual sprays are applied to walls, ceilings, partitions, stanchions, posts, and other fly resting places. These sprays are much more effective in stanchion barns than in loose-housing, open barns where landing and resting surfaces are minimal. Also, barn surfaces vary in the amount of spray that should be applied to them. Smooth surfaces require less spray than rough, porous surfaces. Avoid contaminating feed, drinking water, milk, milking utensils, and milk rooms. The importance of following directions exactly according to the label cannot be stressed enough when using any pesticide.

4.6. Dairy Cattle Manure and Urine Value-Added Co-Products

Although raising dairy cows can become quite expensive considering the cost of feed, veterinary care, and supplies, cattle wastes (dung and urine) are essentially free and plentiful by-products. With a little planning and ingenuity, however, cattle wastes can become an important **value-added co-products** in just about any size operation. The two main goals of a successful value-added cattle wastes marketing plan are to: (a) establish ready markets for excess wastes and; (b) keep operational costs low enough to make a profit from the sale of the products. Conversion of cattle manure into commercial products subscribes to a sustainable urban dairy cattle production system.

1. Generate Revenue from Sale of Fresh or Dry Cow Dung

Ensuring you have a regular supply of fresh or/and dry cow dung to work with means you will be able to provide a product to your customers consistently. Use a simple solar dryer to dry cow dung, pack and store the dry dung in a well-ventilated store. Good solar dryers can be obtained from Task Farm, Rubaga.

Cow dung is collected, dried, and used as fuel in many parts of rural India and Ethiopia. The dried piece is lit to provide flames and heat for cooking.

Drying cow dung in a solar dryer (Source: Task Farm, Tel: +256 782747326).

2. Turning Cow Manure into Energy

Cleaner energy sources are being sought to replace traditional gas and charcoal power because they do not pollute the environment. Some common sources of clean energy include solar, wind, water, and geothermal power. However, another potentially strong candidate for clean energy is cow manure, which is a biofuel. Biofuels are derived from plants and animals and have a wide range of applications. While the primary focus of those biofuels like ethanol is alternative fuel, cow manure can be used for both electricity and fuel. In both applications, the concept behind energy production is the collection of methane gas that is a product of manure. Because methane is the primary gas that is turned into energy when burning natural gas, there is a huge potential for collecting methane gas from cow manure.

(a) Manure for Power

Some dairy cattle farms have invested in a **digester** that collects the cow manure into a pile. Waste vegetables from the local grocery store, like lettuce, are added to the digester, and the contents are mixed. This mixture serves as a good place for microorganisms to brew, and the process produces methane gas. The methane gas is collected into an engine and converted into power. This power can then be used to heat homes and produce electricity. While this method is used relatively scarcely with dairy farms around the country, those that have invested in the digester can become self-sufficient with energy, removing the need to pay electricity bills. Some farms even produce excess energy and are able to sell the energy and make a profit.

(b) Manure for Fuel

Cow manure as energy not only interests dairy farms, but the idea has also interested car company Toyota. The company has plans to build a power plant that turns the methane from cow manure into hydrogen and power for electricity. The hydrogen in particular could be used to fuel Toyota's fuel cell hydrogen cars. Using methane gas from cow manure is a cleaner alternative to gasoline powered cars and natural gas to heat homes.

(c) Biogas Production

There is a lot of damage being caused to local forests and trees in Uganda as a result of the daily collection of firewood for fuel by mostly the women and youth. Additionally, the women responsible for firewood collection have to travel long distance to collect firewood because of the deforestation caused by their activities, which is taking them away from their other household duties. So, desperate to put food on the table for their families, poor women often resort to using unhealthy sources of fuel such as plastic waste, at the expense of their health. In an effort to reduce expenditure on cooking fuel, they are also pushed into abandoning nutritionally rich traditional foods that take long to cook, further affecting their families' nutrition security.

Biogas is a renewable fuel that is produced when organic matter, such as food or animal waste, is broken down by microorganisms in the absence of oxygen. This process is called anaerobic digestion. For this to take place, the waste material needs to be

enclosed in an environment where there is no oxygen. Biogas can be used for cooking, domestic lighting, etc.

One kg of cow dung can produce 15 to 30 litres/day of biogas. One cow can produce enough biogas for use at home. Biogas is a source of income, decreases expenditure on chemical fertilizers and reduces production of greenhouse gases. The biogas production of 25kg of dung per day replaces 5kg of firewood, 1.5kg of charcoal and 0.6 litres of kerosene per day.

How Home Biogas System Works

Step 1: Put the organic waste into the digester via the inlet sink.

Step 2: Anaerobic digester system decomposes waste and transforms it into renewable energy.

Step 3: Renewable biogas for your cooking needs is generated.

Step 4: The system generates liquid bio-fertilizer with essential elements for healthy plant growth.

Biogas production at SISTEMA BIOGAS produced by Ecosafe Ltd, Kayozi Plaza, Kabaka-Njagala Road, , Mengo, Tel:, +256773625000

NaLIRRI portable biogas unit (left) and 75 KVA generator operated by biogass (right)

Advantages of Biogas

- Used as cooking gas and for lighting.
- Less emission of greenhouse gasses.
- Reduces farm costs for animal bedding and fertilizer.
- Generate income.
- Reduces deforestation.

Disadvantages of Biogas

- High cost of production and system maintenance.
- Time-consuming.
- Requires significant volumes of cow manure.
- When compressed, to be used as fuel, biogas is highly corrosive to the container.

(d) Cow Dung-Charcoal Dust Briquettes

A **briquette** is a block of compressed coal dust, charcoal dust, sawdust, wood chips or biomass and is used as a fuel in stoves and boilers. Cow dung is a very important ingredient in the production of high quality briquettes.

How to Make Charcoal Briquettes Using Cow Dung and Chrcoal Dust

Step 1: Sieve charcoal dust to free it from any impurity.

Step 2: Crush charcoal dust into fine powder.

Step 3: Mix clean (remove feed refusals) cow dung with charcoal dust and little water in a ratio of 1:3:0.5 (cow dung to charcoal dust to water).

Step 4: Put the material inside a briquette mould, hit 2 or 3 times (or make balls using your hands) and remove.

Step 5: Remove the briquettes and dry under a shade where they stay for 4 days (depending on the weather) before being used. Drying fuel briquettes on the ground slows down the process as some pieces receive low amounts of sunlight. Spreading briquettes on roof tops speeds up the drying process, but results in breakages.

Briquettes made from charcoal dust and fresh cow dung at Kyakuwa Farm

How to Use the Briquettes

- Light your charcoal stove with a little charcoal.
- When the charcoal has lit up, add the briquettes.
- Briquette making can be a money venture that you can involve your children at any age.

Benefits of Briquettes

- Briquettes are a clean cooking fuel that help to conserve the environment and do not damage one's health since they are smokeless.
- They reduce household indoor air pollution with carbon monoxide and fine.
- Briquettes made of cow dung and charcoal dust burn for over four hours, compared to two and a half hours for regular charcoal.
- They do not emit smell nor sparks.
- They leave no soot on saucepans.
- Briquette production is a profitable business for the youth since materials used to make them are locally available and the demand for charcoal is high.

(e) Cow Dung Fuel Pellets

Pelletizing compacts fresh manure at high temperature and pressure to convert it into a dry finished product. Pellets are useful as a soil amendment or fertilizer. Because the pellets take up a smaller volume, they can be more easily stored and transported than manure. In some cases, processing can result in a product with a consistent and predictable nutrient content, making it more convenient for crop production and other uses.

How to Make Cow Dung Fuel Pellets

Step 1: There is too much water contained in the cow dung. If you crush the cow dung first, the wet dung may probably block the crushing machine. Dry the cow dung to a moistur content of below 15%.

Step 2: After drying, the cow dung will become loose and can be processed by the crushing machine. The crushing machine will pulverize the cow dung into powder with the diameter of 2-5mm.

Step 3: When the cow dung powder is fed into the pellet machine, it will be pressed by the great pressure inside the pellet machine. Then cow dung fuel pellets are made. Ring die pellet mill and flat die pellet mill are available for your selection. Whether to choose the small one or large one depends on your own needs.

Step 4: Cow dung fuel pellets) discharged from the pellet mill are high in temperature and moisture content, they have to go into the cooling step. After that, the pellets can be used as fertilizer in soil.

Cow dung fuel pellets (Source: NET)

The pellets can also be sieved when cooling, so that poor quality pellets and powder materials will be collected and reproduced.

Step 4: Once the cow dung fuel pellets are formed and cooled, they can be packaged in bags or stored in bulk.

Advantages of Cow Dung Fuel Pellets

- The fuel pellets are high in calorific value, and the cost of using is much less than that of oil energy. The ash after burning contains magnesium, potassium and sodium, which makes it be a superior inorganic fertilizer.
- After pelletizing, the density of cow dung pellets is greatly increased, more than 0.8-1.3. Small volume, large specific gravity and density, convenient to store and transport, and continuous usage.
- Cow dung fuel pellet is a kind of green energy. There is no smoke, smell and harmful gas generated when burning the pellets. After testing, sulphur content, ash content, and nitrogen content are far less than that of coal, oil, etc. Therefore, the cow dung fuel pellets are also called zero emission energy.
- It is also high in carbon activity and volatile matter, ash content is only 1/20 of coal. And the waste heat in ash is extremely low, the combustion ratio can reach up to more than 98%, therefore, the burning time is longer.
- The cow dung fuel pellets can be widely applied to industrial and agricultural production, electricity generation, heat supply, boiler firing, cooking, etc. Raw materials supply is not restricted by area, particularly suitable for the energy lacking areas.

(f) Dried Cow Dung Cakes for Fuel

One of the by-products from cow dung is **dried cow dung cake** (patty). Dried cow dung cake is deep-rooted in Indian and Ethiopian tradition. Farmers in villages use dried cow dung cakes as fuel to cook food.

Cow dung cakes

Cow Dung Cake Making Process

The cow dung cakes are prepared by using various ratios of cow dung along with husk of paddy (dried state) and saw dust. The size and shape of the cake are optimized as per the user's choice. The ratio of 76:24 percentage of cow dung and rice husks yields the maximum calorie value of 15.44 Mega Joules/kg. Hence this optimized ratio is considered as the most stable mixture when compared with the other mixtures prepared.

Step 1: Collect the dung in a single place and store for several days so that batch processing can be done.

Step 2: Mix the dung with water to make a thick paste. Use gloves for hygiene purposes.

Step 3: You can make cow dung cakes in any shape but it has to be kept in mind that it has to burn and has to be dried before that. So a thin flat round saucer shape is best fitting for the purpose.

Step 4: Leave it to dry in the sun for 3-5 days (depending on the weather) to dry completely.

Step 5: Store in a dry place and use when required: The dung cakes are high in calorific value and are very good for fire places and barbecue cooking.

2. Using Cow Dung in Building Construction

Cow dung is smeared on the floor in some rural homes in Uganda. It is also applied to the walls. The mixture forms a waterproof layer that insulates the house from heat loss or gain. The crucial part is that the mixture does not smell. People also use cow dung to make bricks when mixed with straw. The bricks are lighter compared to the conventional ones. Cow dung has been used as a building material in rural areas of Uganda. A paste of cow dung and mud is sometimes applied on the floors and walls of rural homes in Uganda which forms a waterproof layer that helps to insulate the house from heat entry.

Making Building Bricks from Cow Dung

To make cow dung bricks, collect fresh cow dung (75%), mix it with clay (10%), lime (10%) and sand (5%) all by volume. Thoroughly blend the mixture with water to achieve a workable consistency, mold the mixture into brick shapes using a mold, and allow them to dry completely in the sun before use; remember to protect them from excessive moisture during drying. The bricks are lighter compared to the conventional ones.

Cow dung bricks

Advantages of Cow Dung Bricks

- Cow dung bricks are **eco-friendly, high thermal mass, low cost, natural pest repellent and anti-radiation property.** The cow dung bricks are composed of with cow dung, clay, wheat straw/rise husk in different proportions.
- Cow dung is rich with minerals such as potassium, magnesium and phosphorous, which serve as a **good binder**. It also improves the texture of soil and helps it to maintain moisture. The fibre present in the dung helps in creating a fine and smooth floor finish, and also prevent cracking in floors and increase insulation properties of plaster.
- Earth is one of many alternative materials that can be used in place of residential stick building. A number of binders such as cement and lime have been used to stabilise earth, for construction. Such binders are aimed to improving water proofing or wear resistance properties of vulnerable earth based construction.
- Made from earth, cow dung, and agricultural waste, the bricks offer several advantages, including: cost-effectiveness, longevity, and the ability to regulate indoor climate by absorbing moisture. They are eco-friendly and contribute to a 90% reduction in carbon dioxide emissions compared to conventional bricks. At the end of the life span, the bricks are biodegradable and can be repurposed as fertilizer.
- Most of the households in rural areas of Uganda cannot afford conventional bricks made with the sand-cement mixture. In addition to their high intrinsic cost, these conventional blocks do not provide sufficient thermal comfort during the warmest periods, and populations need to spend a quite important amount of money to refresh their houses.

Disadvantages of Cow Dung Bricks

- You need relatively large quantities of fertilizer to ensure high-quality crops.
- Composting cow dung outside biogas units will release high amounts of methane into the atmosphere.
- Collecting, storing, and managing cow manure is time-consuming and dirty.

3. Livestock Feed

Increasing feed costs and international concern for the conservation of resources have focused attention on the nutrients in animal wastes that have in the past been used largely as fertilizer or as a major source of fuel for villagers in a number of countries. Using cattle dung to make livestock feed is a sustainable approach to reducing waste, promoting circular economy, and providing nutritious feed for animals.

Benefits

- Reduces waste disposal issues.
- Conserves natural resources (e.g., water, land).
- Lowers feed costs for farmers.
- Provides nutrient-rich feed for livestock.
- Helps mitigate climate change (reduces methane emissions).

Process

Step 1: Collect and process cattle manure.
Step 2: Dry (to reduce moisture content).
Step 3: Separate solid and liquid fractions.
Step 4: Anaerobic digestion (optional) to produce biogas and nutrient-rich slurry.
Step 5: Make pellets or briquettes to create feed products.

Feed Types

- Protein-rich feed for poultry, pigs, and fish.
- Ruminant feed (e.g., cattle and goats) with added fibre and nutrients.

Challenges and Considerations

- Pathogen control and sanitation.
- Nutrient balance and formulation.
- Palatability and acceptability by livestock.
- Regulatory compliance and quality standards.
- Economic viability and scalability.

Best Practices

- Ensure proper drying and processing to eliminate pathogens.
- Monitor nutrient content and adjust formulations accordingly.
- Conduct regular quality control checks.
- Consult with animal nutritionists and veterinarians.

Examples of Feed Rations form Processed Cow Dung

(a) Feedlot Cattle and In-calf Cows

Adding cattle dung powder (dry and milled) to feedlot cattle rations at levels of 20 to 60 percent has shown that the cattle dung is nutritionally valuable and that acceptance is not a problem. However, recycling through feedlot cattle removes only about 30 percent of the dry matter of manure. In-calf cows can be fed 75 percent dried dung pelleted with 25 percent barley. Initially the cows will refuse the pellets, but a 2 to 3 week adjustment period results in pellet consumption of 5.5 to 8.2 kg per head per day**.**

(b) Ensiling Cow Dung (Wastelage)

Wastelage is a material obtained after ensiling of animal waste in a suitable combination with forages and additives, under anaerobic condition through fermentation by lactic acid producing bacteria. A wastelage consisting of a mixture of 57 percent fresh cattle dung and 43 percent hay or hay plus grain can be fed to yearling cattle (heifer steer or bull between 1 to 2 years old). The product is ensiled and undergoes a typical lactic acid fermentation.

Research has shown that when yearling cattle fed wastelage were slaughtered, a comparison of meat quality indicated no difference from animals fed conventional rations. When wastelage containing 60 percent fresh cow dung and 40 percent grass hay was fed to growing steers, it was found that a 40 to 70 percent wastelage ration resulted in weight gains almost equal to the control ration containing 62 percent maize silage. Rations containing 100 percent wastelage depressed weight gains by about one half compared to the control ration.

(c) Poultry Feed

For layers: Mix 10% milled dry cattle manure to improve egg production, hatchability and body weight. Cow manure has no deleterious effect on the **growth of chicks** if it is added to a complete and balanced diet. Cow manure has a marked beneficial effect on growth in chicks if it is added to a diet deficient in riboflavin.

Chicken feeding on a mixture of dry cow dung and poultry ration

(d) Pig Feeds

Cattle dung contains 8-12% crude protein which can contribute to an improved protein status of the animals (especially, essential amino acids). In addition, the vitamin status of pigs (B group of vitamins) may also be improved by incorporating cow dung in the diet. In addition, if cows are fed grains, part of the grain passes through cows not fully digested. Under normal conditions, this type of product would be wasted.

Research has shown that replacing maize with cattle manure as a filler, at levels of 10 to 20% of the diet is practicable without causing serious nutritional or health hazards to the pigs. In feeding cattle manure to pigs, it must be borne in mind that only manure from cattle fed high concentrate rations will be suitable, while manure derived from higher roughage rations would contribute very little or could even produce negative results.

(e) Bio-slurry for Livestock Feed

Bio-slurry dried under direct sunshine for 40 days is used as a feed supplement to cattle, fish, pigs and poultry. It reduces feed cost and lowers price of animal products. Research conducted in Vietnam recommended that in times of fodder scarcity, bio-slurry could be used as emergency feed for crossbred bulls to maintain body weight.

4. Biomass Conversion

Bioconversion involves growing organisms on manure or manure nutrients and then harvesting them to use as components of animal feed, fertilizer, or soil amendments. Azolla grown on nutrients from dairy wastewater can be harvested to produce high-protein animal feed supplements.

Black soldier fly larvae eat manure, killing disease-causing agents (pathogens) and transferring the manure nutrients to their bodies. The nutrient-rich larvae are a value-added product that can be exported off the farm. The manure left over after the larvae are harvested is useful as a soil amendment or fertilizer similar to compost.

Vermicomposting uses worms to digest manure, creating pathogen-free, nutrient-rich products that can be sold and exported off the farm. Worms produce nutrient-rich castings. The castings, along with the manure used to grow the worms, are useful as a fertilizer or soil amendment. The vermicompost contains more available plant nutrients than conventional compost. In addition to the revenue from selling the vermicompost, the worms can be sold as fishing bait or processed for supplemental feed for poultry or fish operations.

Vermicomposting

Advantages of Vermicompost

- Improves soil aeration, texture, and water retention capacity of soil.
- Improves nutrient status of soil both macro and micro nutrients.
- Promotes better root growth and nutrient absorption.
- It does not have any adverse effect on soil, plant and environment.

5. Cow Dung as a Source of Fertilizer

The usage of inorganic fertilizers has drastically dropped due to the energy crisis, which has immensely affected most of the developing countries. A low-input agricultural system which relies on the input of organic materials holds great promise not only to diminish the use of synthetic fertilizer but also to recover crop productivity and ensure ecosystem sustainability against nutrient mining and degradation of soil and water resources. Soil is a sink of plant nutrients that remain in both soluble and insoluble forms. Plants can easily take up the former but difficult to get assessed with insoluble forms which are transformed into a soluble form by various mechanisms.

Cow dung possesses a wealth of benefits that can significantly contribute to plant growth and soil fertility. This organic material, derived from the digestive processes of cows, serves as a potent natural fertilizer, fostering a range of positive effects on plants. Cow dung/cattle manure is made of digested grass and grain.

Cow dung contains high concentrations of organic materials that are rich in nutrients. It contains about 3% nitrogen, 2% phosphorus, and 1% potassium (3-2-1 NPK). Additionally, cow dung contains high levels of ammonia and possibly dangerous pathogens. Consequently, it is usually recommended that it be composted before using it as a form of fertilizer.

Cow dung enhances soil structure by increasing its organic matter content. This improvement in soil structure results in better aeration, water retention, and drainage. As a consequence, plant roots can more effectively access nutrients and water, creating an environment conducive to optimal growth.

Cow dung acts as a catalyst for microbial activity in the soil. The organic matter present in dung serves as a substrate for beneficial microorganisms, such as bacteria and fungi that contribute to nutrient cycling and decomposition. This microbial activity enhances the overall health of the soil ecosystem, creating a symbiotic relationship that benefits both the soil and plants.

Remarkably, cow dung exhibits natural disease-suppressive properties. Certain compounds present in cow dung have been found to inhibit the growth of harmful pathogens, providing a protective shield against plant diseases. This aspect of cow dung's benefits contributes to sustainable and eco-friendly plant cultivation practices.

Using cow dung as a fertilizer aligns with environmentally friendly and sustainable agricultural practices. Unlike synthetic fertilizers, cow dung is a renewable resource that helps reduce dependence on chemical inputs. Its integration into farming systems supports a more balanced and eco-conscious approach to agriculture. Farmers can harness the benefits of cow dung through various application methods. These include incorporating well-rotted dung directly into the soil, using it as a top dressing, or creating compost by combining it with other organic materials. Proper composting ensures that potential pathogens are broken down, making the dung safer and more effective as a fertilizer.

How to Make Compost with Cow Dung

Step 1: The size of the tank (plastic or a concrete tank) depends upon the availability of raw materials.

Step 2: Collect the biomass and place it under the sun for about 8-12 days. Chop it to the required size using the cutter.

Step 3: Prepare a cow dung slurry and sprinkle it on the heap for quick decomposition.

Step 4: Add a layer (5 –10 cm) of soil or sand at the bottom of the tank.

Step 5: Prepare a fine bedding by adding partially decomposed cow dung, dried leaves and other biodegradable wastes collected from fields and kitchen. Distribute them evenly on the sand layer.

Step 6: Continue adding both the chopped bio-waste and partially decomposed cow dung layer-wise into the tank up to a depth of 15-60 cm.

Step 7: After adding all the bio-wastes, release the earthworm species over the mixture and cover the compost mixture with dry straw or gunny bags.

Step 9: Cover the tank with a thatch roof to prevent the entry of ants, lizards, mouse, snakes, etc. and protect the compost from rainwater and direct sunshine.

Step 10: Have a frequent check to avoid the compost from overheating. Maintain proper

Organic fertilizer aerobic composting principle
(Source:https://fertilizerequipmentmanufacturer.com/how-to-make-compost-with-cow-dung/)

Disadvantages of Cow Manure as a Fertilizer

- You need relatively large quantities of fertilizer to ensure high-quality crops.
- Composting cow dung outside biogas units will release high amounts of methane into the atmosphere.
- Collecting, storing, and managing cow manure is time-consuming and dirty. Moreover, incidents can quickly turn into public health issues.

6. Use of Cow Dung as Insect Repellent and a Disinfectant

When you burn cow dung, it produces "Cow Dung Incense Dhoop" that repels insects and mosquitoes. The feature has led to the deliberation of its use as an insect repellent. Unsterilized cow dung, however, contains microbes that are harmful to humans.

7. Anti-Radiation Agent

Cow dung plays a very import role in screening harming radio magnetic radiation which radiates from mobile and electronic appliances, making it unsafe to use. Flooring of cow dung is an excellent agent for earthing, thus flooring with cow dung prevents harmful effects of electromagnetic radiation. Using a mobile chip made from Cow Dung ensures protection from electromagnetic radiation emitted from mobile phones.

8. Cow Dung as a Source of Fibre

It is possible to produce specialty value-added products from dairy cattle manure for marketing to consumers based on the fibre content of the manure. For the most part, the examples given below are either experimental or done on a boutique scale. Most involve extracting and using the solid fibre from manure.

9. Peat Moss Substitute

Fibre recovered from anaerobic digestion of dairy manure is useful as a plant growth medium. Plant growth trials have shown that, when properly processed, the fibre performs like peat moss for growing container plants.

10. Novelty Fibre Products

Farmers and other innovators are finding creative ways to make value-added products from fibre recovered from manure.

- Sculptures made with composted manure and marketed as fertilizing garden art.

- Paper made from processed manure from a variety of animals, including elephants and cows. The dried manure is rinsed in water, leaving the undigested fibre, which is boiled and mixed with other natural fibres to manufacture a variety of paper products.
- Nursery cow dung pots, manure-fibre based seed starter pots, made with biodegradable composted cow manure. These innovative cow dung planters help reduce the menace of plastic bags causing pollution and sickness in animals.

Making Paper from Cattle Dung

Research conducted at the University of Vienna, Austria showed that cattle dung can be used as a great source of cellulose for paper manufacturing.

Step 1: Clean the raw material to remove impurities.

Step 2: The cow dung undergoes dehydration to remove excess moisture.

Step 3: The dung is steamed to further eliminate any remaining impurities.

Step 4: The dung is pulped, resulting in cow dung paper pulp that can be used to produce industrial packaging paper or sheets. This process not only provides a novel resource for papermaking, but also offers a solution for the waste cow dung generated by the breeding industry, reducing pollution and achieving low-input and high-utilization of waste. Additionally, the use of cow dung for paper pulp production allows for the development and utilization of waste materials, creating valuable and recyclable products.

Paper production process from cow dung (Source: NET)

Cow Dung Pot

Plastic bags

Steps to Creating These Eco-Friendly Planters (Pots)

Step 1: Collect the cow dung.

Step 2: Remove earthworms from the dung.

Step 3: Fill the mould with the cleaned dung.

Step 4: Compress with manual effort is the next step.

Step 5: Remove the compressed pot comes next.

Step 6: Finally the pot is ready to be sun dried for 24 hours.

Cow Dung Pots last for months above ground, but once you have transplanted the entire pot into the soil, the manure begins to quickly degrade. The Cow Dung Pots are 100% biodegradable.

11. An Aromatic Foaming Cattle Dung Bath Soap

In India soap is obtained by mixing dry and milled cattle dung (powder) with neem powder, neem seed oils and other materials. The soap serves as a skin tonic and is effective in treating eczema. A mixture of crushed neem leaves and cattle dung helps against boils and heat rashes.

Cow dung soap production in India (Source: NET)

12. Cow Urine for Enhanced Plant Growth Enhancer, Bio-Fertilizer and Pesticide

A cow produces 20-24 litres/day of urine. Cattle urine contains nutrients to improve soil fertility and crop yield.

Composition of Cow Urine

Cow urine contents are water 95%, urea 2.5%, minerals, salt, hormones and enzymes 2.5%. It contain iron, calcium, phosphorus, potassium, urea, uric acid, amino acids, enzymes, cytokines and lactose etc. Cow urine is an aqueous solution of nitrogenous and sulphurous compounds, minerals, and other minor components. The pH of ruminant urine is usually between 8.4 and 8.6 but may be as low as 7.2

(a) Cow Urine as a Fertilizer

Cow urine is reported as a growth enhancer of plants and widely used as a bio-fertilizer for different crop plants. Foliar application of cow urine is considered to be the best way of supplying nutrients. Cow urine uses is proved to enhance the resistance of plants against a wide range of plant pathogens like mycoplasma, viruses, bacteria, fungi, nematodes and insects causing diseases and damages to cultivated plants. The Nurturing effect of these products on useful soil bacteria enhances their activity resulting in better growth of plants and higher crop yield. Urine has applications in gardening and agriculture as a fertilizer.

Cow urine as a fertilizer

Positive Impacts of Cow Urine on Soil Properties and Plants

- Micronutrients increase in soil after application of cow urine.
- Colour of leaves is greener compared with the use of urea application.
- Residual effect of cow urine is present in next crop.
- Improves soil texture.
- Creates good environment in soil for earthworm growth.
- It serves as growth promoter of plants.
- Cow urine sprayed after 14 days of storage in cool place works as an insecticide against aphids and other insects.
- The spraying of urine not only provides nitrogen for plants but also protects the plants from aphid and other insects and provides resistance to diseases

Cow urine can be used as a foliar spray or applied to soil. The urine can be used as a foliar spray or applied to the soil.

(b) Cow Urine as a Bio-pesticides

A notable method to prepare botanical biopesticides is the combination of cow urine with medicinal plant leaf extract. This unique combination provides a better alternative to synthetic chemicals, which are expensive and cause toxic effects to the farmer, consumer, marketers, and environment.

Cow Urine for Preparation of Bio-Pesticides

Step 1: Take one-litre fresh cow's urine or pot manure or vermiwash/bio sol/compost tea.

Step 2: Mix it with 14 litres of water and spray for plant growth.

Step 3: Pot manure procedure: Take 5 kg fresh dung, 5-litre fresh urine and half kg old jaggery.

Using Urine and Ash to Control Crop Pests and Diseases

(a) *Dilution*

Dilution is done to reduce the concentration of nitrogenous compounds in the urine that could burn the young plant tissues. The dilution levels vary between approximately 2:1 (2 parts urine to 1 part water) to 1:4 (one part urine to 4 parts water). A dilution level of 1:1 (one part of urine to one part of water) was found to be the most common practice among the farmers.

(b) *Storage*

Storing urine is important to reduce the risk of spreading diseases caused by microorganisms that may be in the urine. It is important to note that diluting the urine

before storage lowers its concentration and therefore increases the chances of survival of microorganisms. Whether stored before or after adding other ingredients, urine must be stored in closed containers to avoid loss of ammonia and entry of pathogens. Diluted urine if kept open would also act as a breeding place for mosquitoes. Urine should also be kept out of reach of children and domestic animals to reduce chances of disease spread.

(c) *Filtering*

Before application, the ash and urine preparation may need to be filtered depending on the application procedure to be used. When using a spraying pump, the mixture should be passed through a porous bucket to remove big ash particles and then later through a fine filter or mesh cloth that will allow only the liquid to pass through. This is to avoid blocking the nozzle of the spraying pump and depositing ash particles on harvestable plant parts. The residue obtained after filtering can be incorporated in the soil around the plants as it is rich in nutrients like potassium and nitrogen.

Advantages of Urine and Ash to Plants

Urine and ash are rich in several plant nutrients. Urine is specifically a rich nitrogen source while ash is a rich potassium source. Both of these nutrients are important for proper plant growth. On top of preventing/controlling pests and diseases, applying this preparation helps to boost soil fertility. The improved plant vigour as a result of the improved soil fertility to some extend explains the action of this concoction.

13. Cow Urine for Personal Care and Wellness Products

The National Livestock Resources Research Institute under the National Agricultural Research Organization has developed technologies to turn cow dung into **body care products** such as: face creams, shower gel, hand wash, shampoo, sanitizer, soap and others.

Personal care products produced by NaLIRRI

The aroma in cow dung, is due to undigested feed that cows consume and growth of methane producing bacteria present in the dung. All of the personal care items have excellent fragrances due to the presence of essential oils added to them.

(a) Cow Urine Shampoo

Shampoo is an important item for keeping your hair fresh, oil-free, fragrant. Cattle urine contains ammonia found in many shampoos. Ammonia found in many advanced shampoos, is found in cow urine. Cow Urine Shampoo is anti-fungal and anti-bacterial. Thus, using this product can help with acne, dandruff, and scalp infections. Its anti-oxidant characteristics help to prevent hair loss. The “Q Shampoo” also includes sunflower and coconut oils to conceal the odour.

Process for Making Cow Urine Shampoo

Step 1: Take a big mixing bowl and add ½ litre cow urine, 2 litre water, 50 gm Shikakai, 50 gm Reetha, 50 gm Amla, 50 gm Neem leaf, 50 gm berry leaves.

- Shikakai powder is made by drying and grinding the pods of the *Acacia Concinna* tree, and often includes other ingredients such as Hibiscus. These ingredients each have their own distinctive scents, and when combined, can create a pleasant, earthy aroma.
- Reetha powder contains natural saponins with mild foaming properties that make it an effective, all-natural hair and skin cleanser. It comes from the dried fruit of the Sapindus Mukorossi tree.
- Amla *(Phyllanthus emblica)* is a small tree with yellow-green flowers that blossom into round, edible fruits of the same colour .

Step 2: After that, mix it thoroughly and set it aside for 24 hours to soak.

Step 3: Pour the mixture into steel bowl, enabling it to boil for a few minutes before adding the two lemon slices and thoroughly mixing it.

Step 4: After that, set it aside for cooling and allow it to cool.

Step 5: Strain the mixture into a steel bowl and add 50gm water and 50gm Aloe vera gel.

Step 6: Add some face powder and thoroughly mix it in. Add some lemon ascent and store it in an airtight container.

Skin Tonic

Cow dung mixed with crushed neem leaves and made as a paste is applied on boils and heat rashes for a fast remedy. Cow dung polishes the tooth and prevents the toothache. Hence, cow dung can be one of the major ingredients in the preparation of toothpastes.

(b) Shower Gel from Distilled Cow Urine

Shower gel is a natural bathing gel/body wash made using: coconut-based surfactant, antiseptic distilled cow urine, herbs aromatic essential oils. The shower gel is made from: cow ark (liquid by-product of metabolism in cows), neem, palash flowers (Parrot tree), turmeric and grapefruit.

Moisten your body with water and use a sufficient amount of moisturizing shower cream on the pre-most loofa and work up a lather on your body.

(c) Hand Sanitizer From Cow Urine

A hand sanitizer made from cattle urine is a 100% natural alternative to alcohol-based sanitizers. Hand sanitizer is made of 'distilled cow urine" mixed with aromatic essential oil to avoid that distinctive urine smell. Hand sanitizer formula combines:

- 2 parts isopropyl alcohol or ethanol (91–99% alcohol)
- 1 part aloe vera gel
- a few drops of clove, eucalyptus, peppermint, or other essential oil.

If you're making hand sanitizer at home, you should adhere to these tips:

- Make the hand sanitizer in a clean space. Wipe down countertops with a diluted bleach solution beforehand.
- Wash your hands thoroughly before making the hand sanitizer.
- To mix, use a clean spoon and whisk. Wash these items thoroughly before using them.
- Make sure the alcohol used for the hand sanitizer is not diluted.
- Mix all the ingredients thoroughly until they're well blended.
- Don't touch the mixture with your hands until it's ready for use

Improper ingredients or proportions can lead to:

- lack of efficacy, meaning that the sanitizer may not effectively eliminate the risk of exposure to some or all microbes
- skin irritation, injury, or burns
- exposure to hazardous chemicals via inhalation
- Homemade hand sanitizer is also not recommended for children. Children may be more prone to improper hand sanitizer usage, which could lead to a greater risk of injury.

How to Use Hand Sanitizer

- You need to rub it into your skin until your hands are dry.
- If your hands are greasy or dirty, you should wash them first with soap and water.

With that in mind, here are some tips for using hand sanitizer effectively.

- Spray or apply the sanitizer to the palm of one hand.
- Thoroughly rub your hands together. Make sure you cover the entire surface of your hands and all your fingers.
- Continue rubbing for **20 seconds** or until your hands are dry. It can take at least 60 seconds, sometimes longer, for hand sanitizer to kill most germs.

(d) Medicinal Uses of Cattle Urine

Cattle urine can get rid of skin problems (pimples, sunburns, eczema, acne others). In Nigeria, convulsions in children are treated using a mixture of garlic, tobacco, rock salt, cow urine and lemon basil juice.

Cow urine products can help in reducing skin allergies, rashes and skin reddening, relieves itching and burning sensation, helps reduce inflammation, swelling and dry skin.

Medicinal uses of cattle urine: (Before and after treatment) (Source: NET)

15. Bio-Slurry

During digestion, about 25-30% of the total dry matter (total solids content of fresh dung) of animal wastes will be converted into a combustible gas and a residue of 70-75% of the total solids content of the fresh dung comes out as sludge which is known as digested slurry or **biogas slurry**.

Composition of Bio-Slurry

The composition of bio-slurry after fermentation consists of 25% ± 5 dry matter and 75% ± 5 water. If the dry substance is decomposed, it contains 18- 27% organic matter. The production of liquid organic fertilizers from BioSlurry requires some anaerobic fermentation process lasting 20 days. On average, the composition of biogas slurry is 1.5% Nitrogen, 1.1% Phosphorus, and 1% Potassium.

(a) Bio-Slurry as Fertilizer

Bio-slurry is a natural fertilizer that can bind soil nutrients and loosen hard soil. Due to the processing in biogas it causes bio-slurry to be a fertilizer that is rich in nitrogen compared to phosphorus and potassium. Another case with pig manure which is richer in phosphorus and potassium. Also, bio-slurry has probiotic microbes that can increase soil fertility so that it impacts the quality and quantity of the harvest.

Bio-slurry (Source: NET)

With its rich nutrition and humus, bio-slurry is indeed suitable for plants. Bio-slurry has probiotics that can fertilize the soil. With this myriad of nutrients, bio-slurry can be a solution for breeders and farmers who need a place to dispose of their livestock waste but need a supply of natural fertilizers. There are two main forms of bio-slurry: the liquid and solid forms.

(b) Bio-Slurry as a Pesticide

Wet bio-slurry can be used for pesticides. You can pour bio-slurry on the part of the land that is planted regularly. To get liquid bio-slurry, you need to mix it with water. The mixing ratio can be 1: 1 or 1: 2. However, before use, the liquid bio-slurry that has just come out of the outlet is good to be deposited for one week. This deposition process is useful for removing gases that are not needed by plants and soil.

Bio-Slurry Neem Leaves Pesticide

Step 1: Take 500 gram of neem leaves, wash it and chop it for a faster result.

Step 2: Mix it with 5 litres of bio-slurry.

Step 3: Put the mixture in the jerrycan and let it ferment for around 14 days. To make sure that the solution is ready, see if the cap of the jerry can is bulging.

Farmers in Tanzania use a mixture of liquid bio-slurry from cattle together with neem *(Azadirachta indica)* plant extracts to protect maize seeds that are stored by for use in the next growing/planting season. Through the use of the mixture of liquid bio-slurry and neem plant extracts stored maize seeds will be protected from storage insect pests as well as maintaining their germination ability.

In Ethiopia, farmers are getting positive results by using bio-slurry as an organic fertiliser, pesticide and in recent times as a faba bean seed dresser. Slurry treatment allows complete covering of the seed surface with the fungicide used. In effect, the fungicide treatment control the fungal pathogen detected in the seeds and also provide protection from soil borne fungal pathogens during seed sowing.

16. Livestock Bedding

The undigested pieces of feed fibre can be separated from dairy manure, dried and used for bedding.

17. Cattle Dung as Mushroom Growing Agent

Cattle dung is a high-nitrogen material that provides valuable nutrients and minerals to help support the growth of mushrooms. Using cattle dung as a growing agent increases size and yield of mushrooms.

Mushrooms growing on cow dung

Conclusion

Large quantities of cattle dung and urine are generated daily from dairy cattle farms which are of environmental concern due to methane emission present health risks if not adequately managed. Youth groups can process dairy cattle wastes into high quality products as a source of income. *"A dairy cattle means more than just milk and meat"; "Manure brings in high returns to investment because it is produced throughout the year".*

4.7. Waste Water Management in an Urban Dairy Cattle Farm

Wastewater is water that has been used in the home, in a business, or as part of the dairy cattle production process. *"This water recycling facility treats waste water so that it can be reused".* As the urban dairy cattle industry expands to meet demand, there will be a significant increase in the use of scarce water resources and therefore an increased generation of wastewater. The milking parlour is one area where wastewater can be minimised. Here, wastewater is generated through cleaning processes that occur before and after milking. This results in two wastewater streams:

- Wastewater from cleaning, disinfection and sanitation of milking machinery and equipment (i.e. containing water, milk, detergents etc.), and
- Floor washing which generates wastewater containing animal waste in the form of manure and urine, waste milk and dirt. These could be a considerable proportion of the waste burden since dairy wastewater contains a variety of suspended and dissolved solids, nutrients, fats, sulphates, chlorides, trace and soluble organic compounds; and is characterised by a high biological oxygen demand and chemical oxygen demand. While the exact composition of dairy wastewater may vary depending on the specific production operation, it must be appropriately treated before being discharged into any aquatic or terrestrial environment.

Composition of Dairy Industry Wastewater

Dairy industry wastewater has a higher organic content than other food sector effluents, as well as higher quantities of proteins and carbs. Organic substances including lactose, whey proteins, minerals, and lipids give out unpleasant scents as they degrade, upsetting

the stomach.

Key Drivers of Wastewater Use in Agriculture

Wastewater is being increasingly used for irrigation in agriculture and is driven by a range of multiple and complementary key drivers. Rapid population growth and high urbanization rates, particularly in cities, increased water scarcity and stress and agricultural water demand for urban food production are, among others, key interacting factors whose interdependencies influence current and future magnitudes of wastewater production, treatment and use in several ways.

In countries such as Uganda, the main driver for reclaimed wastewater use is water scarcity. The main objective when using reclaimed water, as opposed to untreated water, is health and environmental protection. This is a costly approach but reduces risk to a minimum. Poverty is the key underlying factor that significantly influences the above-mentioned principle drivers of wastewater use. In dense and rapidly growing regions, where ever increasing volumes of wastewater are being produced, insufficient financial and coping capacities constrain the establishment of comprehensive wastewater management systems for proper collection, treatment and use of wastewater in order to respond to the infrastructural needs of urbanization. However, the use of untreated wastewater is not limited to the countries and cities with the lowest gross domestic product but is also a common practice in many middle-income countries as well.

Wastewater Management Practices

- **Manure Management:** Implement efficient manure collection, storage, and treatment systems (e.g., anaerobic digesters, composting).
- **Water Conservation:** Implement water-saving measures (e.g., low-flow equipment, rainwater harvesting).
- **Wastewater Treatment:** Use natural or mechanical treatment systems (e.g., constructed wetlands, sedimentation ponds).
- **Recycling and Reuse:** Reuse treated wastewater for irrigation, flushing, or cleaning.
- **Regular Maintenance:** Regularly inspect and maintain waste management systems.
- **Water Conservation Strategies:** Water-efficient equipment (e.g., low-flow milking systems);
- **Rainwater Harvesting and Water Reuse** (e.g., flushing, cleaning).

CHAPTER 5: NOISE AS A FACTOR OF ENVIRONMENTAL STRESS IN DAIRY CATTLE FARMING SYSTEMS

Noise is defined as *"unwanted sound, whether chronic or periodic, and can be described in a variety of terms, including its frequency, intensity, frequency spectrum, and sound pressure shape over time".*

5.1 Noise Sources in Cattle Farming

The sources of noise can be technical devices, various hydraulic systems, the engines of various machines, routine work (opening and closing doors, repairing stalls, talking of workers, feeding), mechanical ventilators, animal activities, including climbing barriers, chewing barriers, vocalizations of cows.

Effect of Noise on Health Status and Productivity in Dairy Cows

Exposing animals to unfamiliar noises can induce stress. Prolonged sound can have negative effect on animals' health status. Noise directly affects the reproductive system of animals. In essence, loud noise is a stress factor that suppresses the conditioned reflex activity of the body and negatively affects the health and productivity of animals. It was established that under the influence of constantly repeated high-intensity noise stimuli, changes occur in animals in clinical-physiological indicators and in metabolic processes. An increase in body temperature, an acceleration of the heart rate and respiratory rate, a decrease in hemoglobin, erythrocytes, total protein, and albumin levels were reported.

Noise has a direct impact on reproductive physiology and feed intake and leads to a decrease in appetite and milk productivity in animals. Noise induces a variety of physiological changes in the mammalian organism, such as changes in car-diovascular homeostasis and hormone secretion. Screaming for dairy cows is likely to be highly un-pleasant. Noise produced by people shouting and banging on metal doors and objects increases the heart rate and activity in cattle.

Cattle respond with restlessness and increased heart rate when exposed to noise during their handling and milking. High level of farm noise adversely affects the welfare and comfort of cows, which is then reflected on their productivity and health status. Lactating cows are exposed to vibration and noise during milking in the milking parlour, which has a negative impact on their milk yield and milk quality (increased somatic cell count).

Milking parlour noise directly affects work productiveness linked to betterment the behaviour of cow and the interplay between human and animal. Milk let-down initiated at milking might even be interrupted. When in the premise where cows are milked a loud noise is present, they become crowded, nervous and it is not possible to be completely milked due to which udder diseases occur

Noise Reduction Strategies

- Implement noise-reducing measures (e.g., sound-absorbing materials)
- Regular maintenance of equipment to minimize noise
- Train workers to handle cows calmly and quietly
- Provide a calm environment during milking (e.g., soothing music)
- Consider noise-reducing technologies (e.g., noise-cancelling headphones for cows)
- Soundproofing milking parlours and barns
- Using noise-reducing materials (e.g., acoustic panels)
- Implementing quiet milking equipment (e.g., vacuum pumps with silencers)
- Scheduling noisy tasks during non-peak hours
- Creating a noise buffer zone around cow areas

Noise-Reducing Technologies in Dairy Cattle Units

(a) Milking Parlour Noise Reduction

- Sound-absorbing panels
- Acoustic curtains or dividers
- Noise-reducing milking equipment (e.g., silent vacuum pumps)
- Anti-vibration mounts for machinery

(b) Barn and Housing Noise Reduction

- Sound-insulating materials for walls and ceilings
- White noise systems to mask external noise
- Strategic placement of fans and ventilation systems
- Rubber or cork flooring to reduce hoof noise

(c) Automated Milking Systems (AMS)

- Quiet milking units with noise-reducing features
- Robotic milking systems with sound-dampening materials
- Automated cow identification and sorting systems

(d) Noise-Cancelling Headphones for Cows

- Custom-designed headphones for cows
- Noise-cancelling technology to reduce ambient noise

(e) Smart Farming Technologies

- Noise monitoring sensors and analytics
- Artificial Intelligence (AI)-powered noise prediction and mitigation systems
- Real-time cow behaviour and welfare monitoring

Implementation Considerations

- Consult with acoustic experts and dairy specialists
- Assess noise levels and identify priority areas
- Choose solutions compatible with existing infrastructure
- Monitor and evaluate effectiveness post-implementation
- Train staff on maintenance and operation of new technologies

Potential Benefits

- Increased milk production (2-5%)
- Improved cow welfare and reduced stress
- Enhanced farm efficiency and productivity
- Extended cow lifespan

5.2. The Impact of Music on Milk Production and Behaviour of Dairy Cattle

In dairy cow production, environmental enrichment has become a significant advancement in providing a higher quality of life for these animals, enabling them to cope with the stressful challenges of daily management, as this is one of the production lines that require greater human–animal interaction. Using music and tactile stimuli separately or in combination before the milking period shows that when stimuli are provided, there is a real change in the productivity of the animals.

Source (NET)

A study conducted at the University of Leicester's School of Psychology, discovered that milk yield rose by 0.73 litres per cow per day when they listened to slow music. Practical experience suggests that music can have a positive effect on the welfare of dairy cows, which for some other animal species has been shown in earlier studies. Music could, furthermore, be a useful tool to support, for example, daily milking routines.

A University of Pretoria study has shown that playing soothing classical music to dairy cows lowers their stress levels and increases their milk production. A report from a study by the University of Leicester found that slow music can mitigate stress in cows and increase the amount of milk they produce by 3 percent. A farmer in Turkey reported that playing classical music for his cows increased milk production by 5%.

CHAPTER 6: STRATEGIES TO INCREASE CASH FLOW ON DAIRY FARMS

As an entrepreneur looking to venture into urban dairy cattle industry, your primary goal is to increase revenue. Like any other venture, the dairy sector requires careful planning innovative strategies to achieve sustainable growth. Below are some of the strategies to boost your current income.

1. Money is Made in the Milking Parlour

Understanding how to increase a dairy farm's cash flow begins within the milking parlour. This pivotal area functions as the heart of every dairy enterprise, and optimizing its performance is crucial. We need to ask ourselves – is it operating at its fullest potential? The first strategic priority to increase cash flow for any dairy farm is to evaluate the milking parlour. Is it running at maximum capacity?

Often, it is the restructuring of labour within the milking parlour that can ignite impressive improvements in cow flow and milking efficiency. Good employees are the most valuable players on the team, and often, are also the ones who welcome being cross-trained to perform other roles on the dairy. This approach may even permit you to eliminate certain positions and save substantial funds on labour costs. This strategy enhances overall team skills and flexibility, and contributes to cost-efficiency – both crucial for boosting your cash flow. Milking is where your dairy makes its money. Making strategic improvements here can be the key to unlocking your farm's full financial potential.

2. Diversify Revenue Streams

"Keeping all your eggs or rather, all your milk in one basket can result in financial instability for dairy farmers". Just like the herd needs a diversified diet to stay healthy, your farm's revenue it is time to broaden your horizons and explore additional income venues. Diversified revenue isn't just about survival; it's about thriving in an ever-changing agricultural landscape. When you tap into multiple revenue sources, you insulate your dairy farm against market fluctuations that could negatively impact your primary income from milk sales. By strengthening your strategy in this way, you help secure a steady cash flow, even during the off-peak season or a downturn in the dairy market.

Strategies to Diversify Farm Revenue Streams

(a) **Value-Added Opportunities:** Take a step up the supply chain by creating and selling dairy products directly to consumers. Items such as cheese, yogurt, or ice cream can offer a significant boon to your bottom line, and often command a higher price point than raw milk.

(b) **Agritourism Activities:** Turn your working farm into a unique destination. Activities like farm tours, events, and farm stay experiences can draw in a new customer base and provide an additional revenue stream.

(c) **Sell/Cull Animals:** saves money in feeding and housing costs, as well as generating income. Optimising cull cow value is important and will be influenced by access to a market, as well as your stocking capacity on the farm. It is important to assess costs if keeping culls to gain condition is of benefit to you.

By diversifying revenue streams, dairy farmers create a dynamic ecosystem of income sources that not only complement milk sales but also bolster the financial resilience of their business. In this way, we can secure enhanced profitability in both the short and long term.

3. Optimize Feed and Nutrition Management

Feed costs form a hefty chunk (over 60%) of dairy farm expenses. Therefore, to enhance profitability, it is essential to focus on efficient feed and nutrition management. It is important to regularly conduct feed analysis. This is not just about ensuring optimal nutrient composition and feed quality but also to implement strategies that maximize feed efficiency and slash waste. "There's a saying in farming that *'what's measured, gets managed'*. Consistent feed analysis enables mindful management of resources." Moreover, precision feeding techniques, such as ration balancing and feed additives, can drastically optimize cow health, milk production, and the overall feed conversion efficiency. By optimizing feed and nutrition management, it's not just about trimming costs – it's about boosting profitability on your dairy farm.

4. Labour Optimization and Cross-Training

Good employees are the most valuable players on the team. These are also the ones who welcome being cross-trained to perform other roles on the dairy. This approach may even permit you to eliminate certain positions and save substantial funds on labour costs. This strategy, therefore, serves a dual purpose. It not only enhances overall team skills and flexibility, but also contributes to cost-efficiency – both crucial for boosting your cash flow.

5. Adopt New Technologies

A worthwhile investment is technology and automation solutions. Examples could include robotic milking systems, automated feeding equipment, or data management software. These advancements can streamline operations, presenting opportunities to improve efficiency. An optimized farm not only saves time but also money; it increases productivity and profitability while lowering operational costs. By continuously seeking opportunities to enhance efficiency, dairy farmers can pave the way for both increased productivity and profitability, minimising operational costs in the process.

6. Automate Tasks

You can automate irrigation planting, eliminating significant human errors freeing up labour for other essential duties. Automating tasks also reduce time and improves accuracy, allowing you to get more done faster. Additionally, automation can help you monitor your farm's performance detect potential problems before they become too serious.

7. Data Analytics

Modern data analytics software can enable you to monitor and manage your farm in real time. By utilizing the data collected from these technologies, you can make better decisions that further increase production maximize profits.

8. Enhance Herd Health and Reproduction

Healthy cows are productive cows! Any investment in herd health and reproduction programs can yield significant returns for dairy farmers. It is highly recommended to implement proactive health management practices. Set a clear plan that includes regularly scheduled vaccination protocols, disease prevention strategies, and routine veterinary care. These measures will decrease the risk of health issues and lessen treatment costs in the long run. *"A stitch in time saves nine."* – An old proverb that rings true in dairy farming. Preventative care is always more cost-effective than treatment.

9. Implement Efficiency Improvements

Identifying and implementing efficiency improvements throughout your dairy farm operation could be a game changer when it comes to reducing costs, thereby magnifying profitability. To flourish in a highly competitive dairy industry, it's paramount to evaluate all aspects of farm management. This includes labour, equipment, energy, and resource utilization. Once you identify areas for optimization, it's time to create innovative solutions to tackle these challenges.

10. Manage Debt and Financial Resources

In the intricate dance of dairy farming, effective debt and financial management plays a crucial role. Having a comprehensive financial plan is not just an option, but a necessity to maintain cash flow and stability. This plan includes a robust trifecta of budgeting, cash flow forecasting, and risk management strategies.

(a) **Budgeting:** An accurate and realistic budget helps you stay in control of your finances and aids in identifying areas where you can potentially save.

(b) **Cash Flow Forecasting:** This is all about prediction. It is about having a clear picture of your farm's incoming and outgoing cash over a certain period, helping you plan for both the expected and the unexpected.

(c) **Risk Management Strategies:** In the world of farming where uncertainty is the only certainty, being prepared to manage risks—whether they're related to unpredictable weather patterns, commodity price changes, or unforeseen health issues within your herd—is paramount.

11. Collaborate with Other Farmers

Collaborating with other farmers can help you access new markets, leverage economies of scale and reduce production costs. You can form cooperatives or partnerships to share equipment, knowledge, resources. By coming together, you can also use joint bring efforts to increase awareness of your farm's products become more competitive.

12. Collaborate with Restaurants

Also, forming alliances with local restaurants can help you access a larger customer base directly. Not only will these relationships benefit your bottom line, but they can also provide valuable insights into what kind of products customers are looking for. Finally, joining farmers' associations or attending networking events can allow you to increase your business's visibility make essential connections in the industry.

13. Participate in Government Programs

The government offers several programs to support farmers boost their business growth. Programs such as subsidies, grants, loans can help you invest in your farm, improve production, increase profits. Be on the lookout for government-sponsored programs that could benefit your farm business take advantage of them.

14. Assistance Training

Government programs also provide assistance training to farmers, teaching them new techniques strategies that could help them increase their yields. Contact your local agricultural extension office for more information if you are unsure where to start.

CHAPTER 7: EFFECTIVE DIGITAL MARKETING STRATEGY

A digital marketing strategy is a plan for using channels to grow your visibility online. It should look at factors such as your target audience, strengths and weaknesses, and competitors. To create an effective strategy you should use data across the business to inform and speculate. This will help you establish which marketing channels to use or test, your target audience, and how to communicate your message or brand.

7.1. Tips for Creating an Effective Digital Strategy

1. Understand Your Customer

No digital marketing strategy will be effective if you don't have a clear understanding of who buys your product, why they buy it, and where they buy it. Use data and demographics to create a robust profile of your audience and inform your tactics by following these steps:

Step 1: Define the channels that fit your key demographics
Step 2: Speak your customer's language
Step 3: Understand their pain points and how to switch on emotions
Step 4: Create buyer personas to help customize content and predict buying patterns
Step 5: Be culturally aware
Step 6: Consider partnerships such as with influencers
Step 7: Focus on action-oriented experiences and results rather than the product
Step 8: Use automation tools for segmentation and targeting

2. Audit and Assess

To create an effective strategy, it is important to know the digital marketing channels and assets you currently use and have. Therefore you should conduct a full channel and content audit and include everything on a spreadsheet to get a full picture of your marketing activities (across owned, paid, and earned media). You should then link each piece to your organizational goals. So if your key goal is to drive revenue, look at each channel and asset (you may just want to look at the top performers if you have a lot of content) and map it to revenue. Doing this will help you understand what is currently driving revenue and what isn't. You can then double down on what's successful and look to explore new content pieces or channels for any further impact.

3. Focus on the End Result

In marketing and product development, there can be so much emphasis on the product and the 'numbers' around it (i.e. revenue) that sometimes people lose sight of the need that the product fulfills. What truly matters is who you are marketing to, and why. You need to understand their pain points to get what people are doing with your product or service. In other words, when you demonstrate the post-buying moments, they will remember why they need it in the first place.

4. Review and Refine

When you develop your strategy, it's essential to include Key Performance Indicators (KPIs) that fit with crucial business goals. You need to have a plan in place to understand your goals and objectives and then monitor the metrics to get insights about the KPIs that matter. To do this you'll need to:

- Step away from vanity metrics – don't pay attention to the numbers that aren't crucial to long-term success, e.g. Facebook likes.
- Use KPIs to measure success, but don't have them set in stone.
- Set up continuous intervals for analyzing, understanding, measuring, and reporting.
- Understand how to isolate critical metrics if it looks like something is not working.

7.2. The Most Effective Digital Marketing Strategies

The digital marketing strategies you use will depend on the needs and goals of your business: for example, to grow leads or build brand awareness. Keep in mind that any strategy you use should align with your brand and message. Below are a few digital strategies that are proven to get results and help you build online visibility and generate leads.

(a) Social Media Marketing

Social media marketing is an effective way to reach and influence 4.6 billion people across the globe. Dpending on the network, social media can enable you target specific age groups and locations. While you can simply use social media to promote your brand, product or service, it can also be instrumental in developing a community. This allows you to have meaningful engagement with prospects or customers and create brand advocates that will promote your brand without being asked. Social media marketing covers a highly varied landscape that is constantly changing, and each channel requires its own strategy and metrics. Make sure you keep social listening as part of your overall strategy to help you understand and engage with your audience.

(b) Paid Advertising

While organic marketing can go a long way to helping drive traffic and generate leads, using a paid channel can help you to be targeted and reach new audiences. The beauty of most platforms is that you can fix a budget and see the results easily. You can also gather data from your paid marketing campaigns to inform your marketing activities.

(c) Content Marketing

There are many ways of generating leads, but one tried and tested method is by providing valuable content and using digital channels to promote it. This is what's known as content marketing. Along with blogs, create videos, put some energy into creating a valuable e-book, or look at hosting a webinar with in-house staff or experts to drive leads and engagement.

(d) Influencer Marketing

Influencer marketing can help you gain reach in a targeted audience or niche and drive campaign performance. The key is to partner with an influencer that aligns with your brand and has an audience that will be interested in your product or service. Bear in mind it is not just about the number of followers when choosing an influencer, it is about how they engage with their audience and the topics they promote and are passionate about. You can collaborate with an influencer in several ways:

- Promote an event
- Gifting or sending a sample for them to try
- Giveaway
- Social channel takeover
- Use them as a host
- Challenge them
- Commission unique content

(e) WhatsApp Marketing

WhatsApp is one of the most widely used messaging services worldwide. It allows you to send messages, including text, audio, picture, video is used by more than 2 billion people worldwide. Through the messaging app, **WhatsApp marketing** enables farmers to interact with their clients in a more direct personal manner. Customers can readily contact businesses with any queries or grievances thanks to its ability to provide customized messages, promotions, updates to their clientele. For marketing client engagement, there is a distinct business app called WhatsApp Business. Similar to other social media, this marketing aids in connecting with a sizable audience fostering better relationships with the sole objective of boosting sales.

Benefits of WhatsApp Marketing That Boost to Your Sales and Business Growth

(a) Better Customer Engagement

One of WhatsApp's primary marketing goals is to encourage more and more effective customer involvement, which is essential for any organization. It makes it possible for customers and corporate representatives to speak honestly and directly by relationship selling. Additionally, any queries can get immediate responses. WhatsApp may assist a business with running a successful marketing campaign by creating interesting videos that promote the brand.

(b) Wider Global Reach

WhatsApp has over 2 billion users worldwide. And for dairy farms, that means you have the chance to communicate with people all around the world. It is similar to having access to a global loudhailer. Therefore, WhatsApp is the perfect platform for companies looking to grow and enter new areas.

(c) Personalization

You may target specific consumer demographics and tailor your WhatsApp marketing messages, enhancing the effectiveness of your marketing operations. Consider adding media elements like flyers, videos, and images with your message text to add a more personal and vibrant touch.

(d) Position of the Brand

While interacting with customers, you might discover what they anticipate from you and your company. You can therefore build your marketing messaging on what customers want. Customers will be happy to hear from you immediately in response to their inquiries since they see you as a real person. As a reputable brand, you have a wonderful opportunity to demonstrate your concern for your clients and customers.

(e) Effective in Building an Efficient Team

In order to have excellent communication, your topic can set up personalized WhatsApp groups for talking about new projects, task updates, work deadlines, and meeting schedules. The software makes it simple for everyone to communicate, including employers and employees.

Your workforce can share original ideas, points of view, problems, or even team-building activities that can considerably expand your company. WhatsApp can help you keep in touch with your colleagues at work effectively. Any crucial, quick information regarding a particular job or any inspirational message for creating a productive work atmosphere among your team members will be compiled by WhatsApp. While conversing with your team members, you can quickly find a solution to your problem.

(f) Business and Ads Promotion

One of the best channels for promoting your new products and sales is by WhatsApp marketing strategy. Along with information on the offers, how your brand or product is seen, and how the product is utilized, you might give an understandable description. Similar to this, eye-catching electronic brochures containing details on the company's offerings and product adverts can be distributed. Apart from this, there are many engaging WhatsApp advertising messages you can incorporate into your marketing strategy. To draw the interest of your target audience, you may also update your status with a video or image from your company.

(g) Cost-effective Method

Comparing WhatsApp marketing to other conventional marketing methods, it is incredibly affordable. It is a great alternative for businesses of all sizes because companies can send their clients an endless number of messages without paying more. Additionally, companies don't need expensive hardware or software to produce and deliver high-quality video.

(h) Improvement in Customer Service

Additionally, WhatsApp offers businesses a fantastic platform for offering top-notch customer service. To create a seamless and convenient experience, customers may contact businesses using WhatsApp to ask questions, offer comments, or report problems. Businesses may reply to consumer inquiries quickly and effectively with WhatsApp, increasing customer satisfaction and loyalty.

CHAPTER 8: STRENGTHENING SECURITY AND BIOSECURITY PRACTICES ON DAIRY FARMS

Dairy cattle farming is a vital part of our nation's economy and heritage, yet it often faces unique **security** and **biosecurity** challenges. From safeguarding livestock and machinery to protecting crops and farm buildings, the importance of robust security measures in the agricultural sector cannot be overstated.

8.1. The Need for Farm Security

Farms are not just homes; they are businesses with valuable assets, making them targets for theft and vandalism. The isolation of many farms also poses a security risk, as remote locations can be appealing to criminals. Implementing effective security measures is crucial to protect both livelihoods and rural communities

How to Improve the Security of Your Farm

The following security checklist is intentionally extensive. Most likely, no farmer will be able to implement all the procedures listed below. Select all applicable procedures to develop a security program tailored to your farm or production system.

(a) Prevent Unauthorized Entry

- Limit farm entry to one gated road. Keep the gate locked when not in use.
- Secure the farm perimeter using fencing.
- Minimize the number of entrances to restricted areas within the farm. Keep restricted areas locked when not in use.
- Do not advertise vacations or other times when buildings will be vacant.
- Minimize places where people can easily hide within and around the farm.
- Ensure areas surrounding and within farm buildings are well lit. Try to have back-up lighting for emergencies.
- Keep windows, doors, and storage areas locked when rooms are not in use.

(b) Fire Security

- Use fire alarms and check for proper function regularly.
- Locate fire extinguishers in strategic places.
- Have a "No Smoking" policy.
- Protect against lightning strikes.

(c) Surveillance

- Use electronic sensors (motion detectors, door alarms, glass break sensors) or other surveillance equipment (video cameras) to monitor the integrity of your physical barriers. This equipment can be linked to an off-site security system if cost effective.
- Have regular but unpredictable security patrols by employees, security guards, or local law enforcement.
- Plant/trim trees and shrubs so that they do not block lighting, provide concealment to criminals, or block visibility of security patrols.

(d) Vehicles

- Keep parking areas outside of the perimeter fencing or at least away from sensitive areas (storage areas for water, feed, or hazardous materials).
- Use stickers or parking passes to discriminate authorized vehicles from visitor vehicles.
- Monitor vehicles for inappropriate contents or unauthorized/unusual activity.

(e) Visitors

- Have a separate policy in place for essential visitors such as consultants, service people, and health professionals that are both (a) known to you and (b) have visited the farm on a regular basis. These essential visitors should be handled as non-service individuals if they do not meet the above criteria.
- Use shower-in, shower-out policies to discourage non-service visitors.
- Post signs to inform all visitors of rules.
- Designate a parking area for all visitors.
- Identify non-service visitors with badges. Collect badges when the visitor leaves.
- Escort non-service visitors at all times. Visitors should never be allowed to wander the premises.

(f) New Employees

- Have new employees sign a written security/ biosecurity policy in the presence of a witness.
- Provide all new employees with direct supervision.

(g) Employee Training

- Designate one person to oversee security issues.
- Train employees and supervisors to recognize and immediately report suspicious activity, unauthorized entry, or areas that may be vulnerable to tampering or intrusion.
- Build security awareness into daily job. Pre-employment screening can be a valuable tool to reduce employee turnover and decrease the risk associated with former employees. Improved efforts in screening will decrease the need for changing locks and possible police surveillance. 4 responsibilities and reward alert employees.
- Notify employees of contact people, back-up contacts, and procedures to report suspicious activity.
- Post internal, fire, and law enforcement emergency phone numbers in central locations and by each phone.
- Have a zero tolerance policy for workplace violence and animal abuse. Encourage employees to promptly report such incidents.

(h) Personal Items

- Restrict personal items allowed on the farm or into certain areas.
- Provide employees with a locker or desk drawer to keep personal items and valuables while at work.
- Notify employees that taking anything from work is theft.

(i) After an Employee Has Been Terminated or Leaves

- Collect all identification badges.
- Swap, re-key, or change the combinations of all mechanical and electronic locks.
- Notify law enforcement authorities if problems with terminated employees are suspected.
- Consider the need for night surveillance of your facilities for a period of time.

(j) Hazardous Materials (Drugs, Disinfectants, Pesticides, Herbicides)

- Physically secure all storage areas containing hazardous chemicals.
- Limit access to storage areas containing hazardous chemicals.
- Inspect all hazardous materials on receipt and verify authenticity with packing slip and supplier as needed.
- Keep an up-to-date and accurate inventory of all hazardous materials.
- Investigate missing materials or other irregularities.
- Notify law enforcement authorities of any unresolved problems.
- Supervise maintenance and sanitation staff with access to materials.

(k) Deliveries

- Have a single delivery receiving area. The employee in charge of mail can deliver packages within the facility.
- Be alert for suspicious packages.
- Inspect incoming products for authenticity.
- Supervise off-loading of incoming products.
- Disinfect, fumigate, or quarantine supplies and equipment entering the facility if deemed necessary.

(l) Phone Threats

- Attempt to verify caller's identity.
- Record the call or write notes during and after the telephone call.
- Notify your supervisor.

(m) Computers

- Restrict access to computers.
- Protect data with virus protection programs.
- Connect critical computers to Uninterruptible Power Supplies.
- Lock desktop computers and monitors to office furniture using cable locks.
- Protect wiring from environmental damage and tampering using conduit.
- End computer access when an employee is terminated.
- Back up all data frequently.

(n) Preparation For An Emergency

- Identify critical security decision makers to whom employees should report security problems or emergencies.
- Call herd veterinarian immediately if a foreign animal disease is suspected.
- Post contact information for fire, police, and other emergency responders.
- Identify a person to handle the media and provide them with press statements and background information for the farm.
- Maintain and clearly post an evacuation plan. Give the evacuation plan and a current floor plan to the local fire department. Have evacuation drills to periodically test the plan.
- Keep a current inventory of all hazardous materials and flammable products.
- Maintain an employee roster and visitor log to enable a head count if evacuation is needed.

(o) Backup Records

- Prioritized list of supplies, equipment, and facilities needed to maintain function
- Inventory of equipment and supplies (part numbers, quantity kept on hand)
- Accounts receivable and payable
- List of customers' names and contact information
- List of suppliers' names, contact information, items you purchase, and how much you pay for them
- Vehicle maintenance schedules, payment schedules, and registration information
- Exact payroll numbers

(p) Agroterrorism

- Train employees to recognize and report signs of foreign animal diseases.

(q) Water Security

- Secure water wells if possible.
- Ensure that water systems are equipped with backflow prevention.
- Chlorinate water systems.
- Identify alternate sources of water as a backup plan.

(r) Feed

- Clean storage areas between batches of feed.
- Clean feed delivery equipment between deliveries and farms.
- Examine all feeds and other ingredients closely for manure, mould, or foreign materials.

8.2. Bio-Security for Dairy Farms

Biosecurity involves management practices aimed at preventing the introduction and/or spread of harmful organisms (e.g. viruses, bacteria) to dairy farms and avoiding common or emerging diseases. The careful implementation of these practices is key to protect both people and animals, as well as to ensure a viable and safe food supply for consumers. Focus should be placed on four key areas:

(a) Biosecurity Mindset

- Develop, implement, and practice a detailed biosecurity plan for your dairy farm.
- Stay informed about common and new infectious diseases in your area.
- Understand the role each individual plays in maintaining biosecurity.
- Implement continuous education and training to keep up with the latest biosecurity recommendations.

(b) Protecting Dairy Cattle

- Work with your dairy herd veterinarian to maintain animal health and take further testing action as needed.
- For new or returning animals, isolate for approximately 30 days before integrating them into the herd.
- Identify the symptoms of common and emerging infectious diseases, monitor health, and maintain detailed records of illness and treatment. Manage sick animals and dispose of dead animals properly.
- Do not feed calves or other animal's unpasteurized milk or colostrum if cows pose as a risk for disease transmission.

(c) Protecting People

- Build awareness of the importance of biosecurity measures on human health. Post biosecurity signs around the farm to encourage every one of best practices.
- Use personal protective equipment (PPE) to limit contact and spread.
- Ensure that farm staff and visitors wash their hands frequently, wear clean clothing, and disinfect their footwear. Keep visitor and employee logs.
- Never consume raw milk and avoid eating or drinking around animals.

(d) Protecting the Farm

- Establish a Line of Separation (LOS) around your facility to control movement of people, vehicles, and equipment onto the farm.
- Determine specific routes for farm traffic that limit unnecessary contact with animals and prevent feed/manure cross-contamination.
- Use effective cleaning and disinfectant products for facilities, vehicles, and equipment.
- Implement measures to control pests such as rodents, birds, and wildlife to reduce potential transmission and protect feed and feed storage from contamination.

CHAPTER 9: LABOUR SAVING TECHNOLOGIES TO IMPROVE DAIRY CATTLE PRODUCTIVITY

Labour-saving technologies exhibit a considerable impact on labour demand and supply and therefore usually have significant policy implications. From a policy perspective, mechanization technologies might lead to decreased demand for labour and increased concentration among firms. Considering the impact on economic agents, labour-saving technologies are adopted because they can potentially increase revenue and reduce labour input costs and related risks. However, to ensure adoption, labour-saving technologies must be economically viable. Once a technology has proven feasible, several factors can impact diffusion patterns, including the inherent risks associated with the agriculture activity, investment costs, uncertainties around the innovation's performance and reliability, appropriateness for a specific agricultural operation, and environmental conditions. Table 20 shows some of the labour and time saving technologies for urban dairy farmers.

Table 20: Some of the labour and time saving technologies for dairy farmers in urban areas to enhance productivity on a dairy farm

Labour and time saving technologies	Uses/Benefits/Impact
1. Motorized forage choppers 	• A forage chopper serves a crucial role by efficiently processing forages and crop residues • Chopping fodder reduces labour and time spent chopping using a hand shear/panga • Improves feed intake and overall production. • Chopping fodder reduces the size of forage parts----- improves forage acceptability by the animals, feed intake reduces feed wastage.
2. Solar dryer 	• Solar dryers use the heat from the sun to reduce the moisture content of food/feed substances. • Solar dryers are used to reduce the moisture content from crops, vegetable, manure and fruits.

3. Animal feed block moulding machine  	• Feed blocks are made by improving the nutritional status of agricultural and agro-industrial by-products, improve productivity of dairy animals.
4. Underground rain water harvesting tanks using a dam liner 	• Rainwater harvesting is the simple process or technology used to conserve rainwater by collecting, storing, conveying and purifying of rainwater that runs off from rooftops, open grounds, etc. for later use.. • Helps in reducing the water bill. • Decreases the demand for water. • Promotes both water and energy conservation. • Improves the quality and quantity of groundwater. • Does not require a filtration system for landscape irrigation. • This technology is relatively simple, easy to install and operate. • It reduces soil erosion, stormwater runoff, flooding, and pollution of surface water with fertilizers, pesticides, metals and other sediments. • It is an excellent source of water for irrigation with no chemicals, dissolved salts and free from all minerals.
5. Solar powered Ecostove 	• Ecostove uses reusable volcanic rocks and solar instead of charcoal to cook, with benefits of lighting, phone charging, FM radio and mp3 music player • Huge loss occurs during the production and consumption of charcoal. • Provides a clean cooking environment • Volcanic stones are much cheaper than charcoal. A bag of volcanic stones lasts more than 6 months compared to charcoal which lasts 2 weeks. • Reduces deforestation (cutting down trees for firewood).

6. Milking machine 	• The machine helps to save labour expenses. • Less dependent on skilled workers. • Milking is done way faster compared to routine practice. • Rise in the quantity of milk than in regular method. • Machine is safer than hand milking as it doesn't hurt the cows as the teats are in contact with rubber liners, wherein routine process fingernails hurt the cattle's teats. • It helps to reduce stress during the lactation process, which creates a good milking routine
7. Fireless cooker 	• A fireless cooker is an insulated basket container or a box that is designated to complete the cooking that has been partially started on conventional cooking methods, e.g. solar cookers, open fires, charcoal, firewood, paraffin, gas or electrical cookers. • The 'fireless cooker' uses stored heat to cook food over a long period of time. • The food is cooked on a traditional stove, before it's transferred to the fireless cooker. • The cooker is well insulated, keeping the heat in the food and allowing it to continue cooking inside.

CHAPTER 10: MILKING, MILK HANDLING AND MILK PROCESSING TECHNOLOGIES FOR URBAN DAIRY CATTLE FARMERS

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Milk is an important dairy product that can easily perish if handled in an unhygienic manner. In Uganda, farmers lose over 30% of their milk before it reaches the cooling plant. This is attributed to poor milking procedures, poor hygiene and poor milk handling on the farm and during transportation. A dirty milking environment and poor milking techniques may also cause infection of the mammary glands (mastitis). Mastitis causes poor milk quality and reduces milk yield. It may also cause systemic illness and death of the cow. Production of clean milk is therefore an important aspect of dairy farm activities.

10.1. Milking and Milk Handling

When milk comes from a healthy udder it contains very few bacteria. However, milk is a perishable product because it is easily contaminated and is an ideal medium for bacterial multiplication. Almost all bacteria in milk originate from the environment i.e. air, dirt, dung, hairs and other extraneous substances. In other words, milk is mainly contaminated with bacteria during milking. When almost at body temperature, milk is suitable for growth of a wide variety of bacteria. However, milk has a natural inhibitory mechanism, which prevents a significant rise in the bacterial count during the first 2 to 3 hours after milking. If milk is cooled within this period to 4^0C, it maintains nearly its original quality.

Timely cooling ensures that milk quality remains good for processing and consumption. The bacterial load in fresh raw milk should be less than 50,000 per ml when it reaches the collection point or processing plant. Therefore, to prevent bacterial multiplication, farmers should ensure hygienic milk production, cooling or boiling at the earliest.

To guarantee clean milk production farmers must ensure that milking cows are healthy and free from mastitis. Sick cows may secrete microorganisms in the milk they produce. Such milk especially when consumed raw is dangerous to the consumer. Diseases like tuberculosis, and brucellosis can be transmitted to the consumer through milk. Whatever the milk is used for, hygienic production at farm-level forms the basis of the quality of the end product.

Quality milk production should therefore be the concern of all stakeholders, which include: dairy farmers; dairy cooperatives; milk processors; retail distributors (shopkeepers and super markets); consumers of dairy products; state regulatory agencies; extension staff and veterinarians.

10.2. Clean Milk Production

To guarantee clean milk production the following practices are quite essential and should be observed by all persons involved in the dairy enterprise.

(a) Ensure Good Health of The Milker and Milking Herd

A milker must be healthy and free from contagious diseases. There are many diseases that are transmissible between cattle and man through milk. Notable among these is tuberculosis and brucellosis. Urine from cows infected with leptospirosis can also contaminate milk and man can be infected if such milk is not properly cooked. Farmers should therefore work with their veterinarians to ensure that the milking herd is free from diseases by vaccinating them against endemic diseases in the area and giving appropriate treatment to those that contract disease. Only healthy cows should be milked.

Mastitis is one of the most important causes of milk spoilage and the attendant economic losses in dairy enterprises. In addition to other management practices, segregation can contribute to containment of spread of mastitis in a milking herd. The order in which cows are milked can have an impact on controlling the spread of mastitis. Cows in first lactation should be milked first, followed by those in second lactation (with low somatic cell counts), followed by those in third lactation (with high somatic cell counts) and lastly cows with clinical mastitis. This reduces the chance of spreading mastitis organisms from cow-to-cow. Milk from cows with clinical mastitis should be discarded. Milk from cows on antibiotic treatment should not be sold until the specified withdrawal period (usually 72 hours or more) has elapsed.

Good management dictates that the person milking must be constantly alert to conditions that may spread mastitis organisms from cow to cow. Correcting such conditions helps in the production of high quality milk from healthy udders.

Simple Tests for Diagnosing Mastitis

Clinical mastitis may be detected by examining the udder for signs of inflammation that include; hotness, swelling of quarters, pain and redness. Misshapen, hard and fibrotic quarters indicate damage caused by chronic mastitis.

(a) The Strip Cup Test

This is a practical and effective method of identifying cows with clinical mastitis. A few drops of the foremilk of each teat are milked into a strip cup or on a plate with a black surface.

Strip cups

Abnormal milk is usually discoloured, watery, sometimes bloody and may contain flakes or clots. In chronic mastitis the milk is not always seen abnormal. The strip cup test is sufficiently sensitive to detect clinical mastitis by an experienced milker. When a strip cup is used it should be cleaned and disinfected after every milking. Foremilk samples should not be mixed with the other milk because it contains a high bacterial count.

(b) The California Mastitis Test (CMT)

The California Mastitis Test more sensitive than the strip cup test and enables sub-clinical mastitis to be detected. For reliable results the CMT should be conducted just before milking, after stimulating the cow and having discarded the foremilk.

The California Mastitis Test

A four well plastic paddle is used and 2-3mls of milk from each quarter is drawn into a separate well. An equal amount of the CMT reagent is added to each well and mixed gently with the milk. Milk from teats that are infected with mastitis will appear jelly like. If such cows are encountered a veterinarian should be consulted before commencing treatment.

10.3. Milking Equipment

One of the major sources of contamination of milk is the use of equipment and storage vessels, which cannot be easily cleaned and sanitised. These include jerrycans and buckets made of non-food grade plastic. Utensils and equipment for milk handling should be made of non-absorbent, corrosion-resistant material. Metal containers such as aluminium and stainless steel cans are recommended under the code of hygienic practices. The surfaces of such containers should be smooth, have minimal joints or open seams and should be free from dents.

Stainless steel milk cans and buckets

Plastic is not advisable as the surfaces will develop scratches with time which can hardly be seen and therefore impossible to clean. Similarly, in case of milking machines the rubber components have to be renewed at regular intervals.

(a) Cleaning and Disinfection of Utensils

To ensure clean milk production, milking utensils must be cleaned and disinfected. First, the utensils should be washed with hot water and a detergent. A clean brush with good bristles only designated for cleaning of the milk equipment should be used to scrub the utensils. There after the equipment must be rinsed with clean water. There after the equipment should be disinfected with either hot water or with mild disinfectant like hypochlorite. Do not dry the utensils with a piece of cloth, but drain them immediately after washing. The equipment should then be dried in an inverted position on a rack under direct sunlight.

(b) Water Supply

A clean water supply is essential to minimize contamination. Unless an approved piped supply is available, it must be assumed that water is contaminated. Some water borne bacteria are dangerous and can easily enter the milk. Examples are the Coliforms, Salmonella and Cholera, which cause stomach disorders and may even lead to death. Therefore the water must be boiled first or hypochlorite must be added at about 15 ml per

10 litre water. Alternatively, the quality can be improved by adding one drop of household bleach (JIK) to one litre of water. Hard water (i.e. high levels of dissolved calcium and other salts) will cause surface deposits on the equipment and reduce cleaning effectiveness. In such cases, it is necessary to use de-scaling solutions periodically.

(c) Detergents and Disinfectants

Detergents are necessary to clean milking equipment effectively before disinfection. The effectiveness is increased when warm water is used. This helps to displace milk deposits and to remove dirt, dissolve milk protein and emulsify the fat. Make sure that the correct concentration is used. Many detergents are available in the market, but if not, an inexpensive mixture can be made by using a solution of washing powder. About 1 teaspoon per litre of water gives the correct concentration. Disinfectants are required to destroy the bacteria remaining after washing and to prevent these from multiplying on the cleaned surfaces. Also their effectiveness is increased with temperature. Sufficient contact time should be allowed with the surfaces to be cleaned and disinfected. When hot water is used, it is best to begin the routine with water at not less than 85^{0}C. Many chemicals are suitable as disinfectants. Some of them are combined with detergents (i.e. detergent-sterilizers). Use those that are approved only as some can taint milk. Always follow the manufacturer's instructions.

(d) The Milking Parlour/Milk Shed

The milking shed should be appropriate with no leaking roof, should have a slanting and easily cleaned floor (preferably concrete), with compartments and provision for feeding troughs. The milking parlour or milk shed should be thoroughly cleaned with a scrubbing brush and sufficient water after milking. It should then be allowed to dry before the next milking. The milking parlour should be well ventilated and have adequate lighting.

(e) Personal Hygiene

Personal health and hygiene should be observed for all persons handling milk right from the farm to the final consumer. All persons handling milk should be free from communicable diseases. Persons undergoing treatment should take leave until they are fully recovered before they resume work. At all times milk handlers should;

- Keep short finger nails
- Wash hands and nails with clean water and soap before handling milk
- Wear clean white overalls/dust coat and gumboots while handling milk
- Not be suffering from a communicable disease or have open sores or abscess on the arms, hands, head or neck
- Not cough or sneeze over milk or milk containers
- Bathe or shower regularly
- Seek medical treatment and resume work only after getting well

The Milking Process

(a) Before Milking

Before milking commences it is important to do the following hair removal from udders, udder washing and drying, stripping

- Periodic hair removal from udders reduces the amount of dirt and manure that may adhere to the udder and contaminate milk. In addition, cows with long hair on udders will require more time to properly clean and dry teats. It is recommended that udder hair be removed every 3 months. In addition, udder hair should be removed from fresh cows and heifers as soon as possible after calving.
- Clean the udder and teats with soapy water. Warm water may help stimulate the release of the hormone oxytocin, which acts on the milk secretory (alveolar) cells causing release of milk. Dry the teats, but don't rub or irritate them. During udder washing attention should be paid to minimizing water splash onto cow udders and milking equipment while maintaining clean equipment and stall surface. Use of hoses should be limited while cows are in the parlour.

- Stripping the first milk from each teat should be done for conducting the strip cup test or the California mastitis test as described previously in this chapter. The strip cup test is a practical and effective method of identifying cows with infected udders. Stripping enables the detection of milk with abnormal colour or presence of blood clots. This may indicate infections like mastitis. Milk from infected quarters should be discarded accordingly.

(b) Milking

Milking is the act of removing milk from the mammary glands of a cows. Milking may be done by hand or by machine.

- **Machine Milking:** Most milking in the developed world is done using milking machines. Milking machines have various types and sizes. For an urban dairy farmer a small sized milking machine can be very useful. Using a milking machine ensures efficient milk extraction, minimizes damage to the udder and reduces drudgery. Today there are fully automated milking machines, which give a cow the freedom to choose when to be milked, allowing for a larger amount of milk to be obtained more efficiently.

Teat cups fixed on teats (Source: NET)

The teat cups are attached to the cow›s teats as above. When started, the cups alternate between vacuum and normal air pressure to extract the milk. The milk is filtered and cooled before being added to a large bulk tank of milk for storage.

- **Clean Hand Milking**: Hand milking is performed by massaging and pulling down on the teats of the udder, squirting the milk into a bucket. During milking, the cow should be handled in a quiet manner and should not be beaten, disturbed or denied access to concentrate feed. Stressing the animal in any way, such as beating it, banging utensils can be dangerous to the milker. Young animals should be milked first, then older cows later. This will minimise the risk of transferring infection from the older cows to the young ones.

Key Steps to Clean Hand Milking

Step 1: Restrain the cow properly. Hind legs and tail should be tied together to prevent contamination of milk when the cow swings the tail suddenly. If the tail end (switch) has long hair, always trim the hair.

Restraining a cow

Step 2: The milker should wash hands up to the elbow with soap and clean water before milking.

Step 3: Clean and wash the udder properly. Use one towel/cloth on one cow. Wash teats only using the towel dipped in disinfectant solution. Use a fresh section of the towel to clean individual teats (don't use the same spot to clean more than one teat). Avoid touching the teats that are already washed. Do not wet the udder with excessive water.

Step 4: Dry the teats with a clean dry cloth/towel completely before milking (Figure 73). This removes more bacteria as well as excess disinfectant solution.

Clean and wash the udder properly and dry the teats

Step 5: Check the fore milk by stripping in a strip cup (strip cup test). Observe for any abnormalities in the milk (clots, stringy milk, blood stains or watery milk) as earlier described in this text. If one of the teats has abnormal milk, milk that teat last and don't mix the milk with the rest in the bucket. Make sure you re-disinfect and dry your hands before handling another cow. Seek veterinary advice in cases of suspected mastitis.

Step 6: Start milking immediately (at least 1 minute) after the start of milk let down stimulation. Hold the bucket underneath the udder between your legs. This position reduces the chance of the cow kicking over the pail of milk. Remember to apply milking salve to soothe the teats. An appropriate amount of dairy meal should be put into the feeding trough during milking time.

Step 7: Dip teats using non-return dipper with iodine solution (Mastrite) immediately after milking. Iodine or mastrite (1 part to 2 parts of clean water) is recommended to kill bacteria on the surface of teat skin and inside of teat duct. Effective coverage of the teats is as important as the type of teat dip cup. Dip 2/3 of each teat. Teat dipping should be done routinely on farms. Keep the milked animals standing at least for 15 minutes after milking by providing feeds or water. Iodine or mastrite is recommended to kill bacteria on the surface of teat skin and inside of teat duct

One of the teat dips on the market and iodine solution

Iodine or mastrite is recommended to kill bacteria on the surface of teat skin and inside of teat duct

Step 8 Measure the amount of milk from each cow.

Step 9: Pour the milk into a suitable container through a strainer to trap unwanted particles.

Step 10: Keep the milk in a cool place, a fridge or deliver to a cooling facility immediately.

10.4. Milk Testing and Quality Control

Milk testing and quality control is an essential component of any milk processing industry whether small, medium or large scale. A milk processor or handler will only be assured of the quality of raw milk if certain basic quality tests are carried out at various stages i.e. transportation of milk from the producer to the processor and finally to the consumer.

Simple Techniques Used in Milk Testing and Quality Control

Accurate milk sampling is the first pre-requisite for fair and just quality control system. Liquid milk in cans and bulk tanks should be thoroughly mixed to disperse the milk fat before a milk sample is taken for any test. Representative samples of packed products must be taken for any investigation on quality. Plungers and dippers are used in sampling milk from milk cans.

(a) Organoleptic Tests

The organoleptic test permits rapid segregation of poor quality milk at the milk receiving platform. No equipment is required, but the milk grader must have good sense of sight, smell and taste. The result of the test is obtained instantly, and the cost of the test is low. Milk, which cannot be adequately judged organoleptically, must be subjected to other more sensitive and objective tests.

Procedure

- Open a can of milk
- Immediately smell the milk
- Observe the appearance of the milk
- If still unable to make a clear judgement, taste the milk, but do not swallow it. Spit the milk sample into a bucket provided for that purpose or into a drain basin, flush with water
- Look at the can lid and the milk can to check cleanliness

Judgment: *Based on the findings, the quantities involved, the magnitude of losses that may be incurred and the final destination of the milk; further tests can be performed before a final decision is taken.*

- Abnormal smell and taste may be caused by;
- Atmospheric taint (e.g. barny/cowy odour).
- Physiological taints (hormonal imbalance, cows in late lactation- spontaneous rancidity).
- Bacterial taints
- Chemical taints or discolouring
- Advanced acidification (pH < 6.4)

Clot on Boiling (C.O.B) Test

Boil a small amount of milk in a spoon, test tube or other suitable container. If there is clotting, coagulation or precipitation, the milk has failed the test and should be condemned accordingly.

(b) The Lactometer Test

Addition of water and other adulterants to milk can be a big problem where we have unfaithful farm workers, milk transporters and greedy milk hawkers. Any milk buyer

should therefore assure himself/herself that the milk he/she purchases is wholesome and has not been adulterated. Milk has a specific gravity. When it is mixed with water or other materials, the density of milk changes. The lactometer test is designed to detect the change in density of such adulterated milk. A lactometer, a cylindrical vessel made by blowing a glass tube.

Principle of the Method

The test is based on the fact that the density of whole milk ranges from 1.026 to 1.032 g/ml. Adding water to milk lowers its density, while addition of solids increases the density of milk. Any deviation from the normal range would indicate that the milk has been adulterated.

Materials

- Cup or measuring cylinder (200–250 ml)
- Lactometer calibrated at 20°C (European standard) or 27°C (India Standard)

Procedure

Ensure that the milk has been left to cool at room temperature for at least 30 minutes and its temperature is about 20°C. If the milk was cooled below 10°C, warm it to 40°C, and then cool it to 20°C. Mix the milk sample and pour it gently into the measuring cylinder. Then let the lactometer sink slowly into the milk. Take the lactometer reading just above the surface of the milk.

Interpretation

If the temperature of the milk is different from the calibration temperature of the lactometer (20 °C), then use this correction factor: For each °C above the calibration temperature, add0.2 units to the observed lactometer reading and for each °C below the calibration temperature, subtract 0.2 units from the observed lactometer reading. These calculations are done on the lactometer readings, e.g. 29 instead of the true density of 1.029 g/ml. Normal milk has a specific gravity of 1.026–1.032 g/ml (or 26–32 on the lactometer reading). If water has been added, the lactometer reading will be below 26. If any solid such as flour has been added, the reading will be above 32. Judgment should be done accordingly.

(c) The Alcohol Test

The alcohol test is used on fresh milk to indicate whether it will coagulate on thermal processing. This test is especially important for the manufacture of UHT milk, evaporated milk and milk powders. This test is more sensitive than Clot-on Boiling (COB) test. It is based on tendency of milk protein to get unstable as a result of disturbance in the mineral balance of milk. Milk with high developed acidity, or having calcium and magnesium compounds in greater than normal amounts, will coagulate when alcohol is added. Increased levels of albumen (colostrum milk) and salt concentrates (mastitis) may also results in a positive test.

In dairy industries, normally three different concentrations of ethanol solution are used for the test, depending upon the further use of milk. These are 68% v/v, 65% v/v and 60% v/v. Milk that passes 68% ethanol test is considered as that of superior quality. For manufacturing UHT milk and milk powders, the raw milk should pass 68% ethanol test. Dairies generally consider 60% ethanol test negative raw milk for manufacturing pasteurized polypack milk, as it does not have to undergo rigorous heat treatment as in case of UHT milk. The milk, which does not even pass 60% ethanol test, is rejected at the processing units.

Procedure

For routine testing, 5 ml milk is mixed with 5 ml of ethanol solution. If the tested milk is of good quality, there will be no coagulation, clotting or precipitation. Presence of flakes or clots indicates poor quality milk.

10.5. Milk Processing Technologies for Small-scale Urban Dairy Farmers

Most urban zero grazers keep less than 5 dairy cows. Therefore, milk production is not stable throughout the year, but fluctuates with season. These type of farmers wish to obtain more milk and dairy products for family consumption and for sale. To do this, they need to learn proper handling and processing methods (adding value to milk) that can help to improve the quality of milk and milk products such as making butter, sweetened condensed milk, cheese and yogurt.

Advantages of Milk Processing

- Preserves milk and improves its shelf life
- Changes taste and creates appeal to consumers
- Provides regular income
- Improves nutrition
- Selling processed milk products is more profitable than selling fresh milk
- Generates employment
- Improves quality and safety

Hygiene in Milk Handling and Processing

Milk is very rich in nutrients. Because of this, it is easily attacked by bacteria that cause spoilage. At high and conducive temperatures the bacteria easily multiply within the milk, causing spoilage. Poor hygiene during handling of milk and undesirable practices like addition of water or other substances introduce bacteria to the milk; causing the milk to go bad. For good practice the following must be done:

- Always handle milk in clean stainless steel or aluminium cans and buckets
- Transfer milk from one container to the other by pouring, instead of scooping
- Do not milk cows or handle milk if you are sick. Seek medical treatment and resume work only after getting well
- Do not store milk at high temperatures
- Avoid keeping milk for a long time before processing or delivery to the cooling centre.

Milk Processing Methods

1. Pasteurization

Pasteurization is the first step in milk processing. Pasteurization means heating every particle of the milk or milk product to a specific temperature for a specified period of time (e.g. at 63°C for 30 minutes or 72°C for 15 seconds). This destroys the germs that would otherwise spoil the milk and affect consumer health. It makes the milk safe and healthy, and also improves the keeping quality, so that milk and milk products can be stored for long without spoilage.

Simple Method of Pasteurization

(a) Direct Boiling

Many farmers pasteurize their milk by direct boiling. However, direct boiling is undesirable, because it leads to burning at the bottom of the pan and browning of the milk. Indirect heating is a better way to pasteurize milk. Place the pan containing milk inside a larger metal vessel containing water, so that the water forms a jacket around the milk pan. Heat the larger outside vessel using an open flame, or gas stove, or electrical hot plate. When the temperature of the milk reaches the pasteurization temperature, hold at that temperature for a specified time (e.g. 30 minutes at 63°C); then remove from the heater.

(i) *Batch pasteurization:* 63°C for at least 30 minutes.

This is suitable for small-scale producers and farmer cooperatives.

(ii) *High temperature short time (HTST) pasteurization:* 72°C for at least 15 seconds

This is suitable for processing large quantities of milk, e.g. more than 250 litres at a time. It is applied in factories.

(iii) Ultra-high temperature (UHT) heat treatment at 135°C.

This is used by big factories. It requires special machinery. UHT milk can be stored for 6 months even without refrigeration.

2. Preparation of Yogurt

Yogurt is one of the most basic traditional foods, and even if you are just getting started with real food, including yogurt in your diet is an easy way to reap so many of the health benefits of cultured dairy**.**

Ready-to-drink yoghurt

One of the main health benefits of yogurt, besides the protein, calcium, vitamins and minerals, are the probiotics which are the good bacteria that inhabit our guts, help to promote better digestion and boost our immune systems. Yogurt is an easily digestible food. Even people who have trouble with lactose intolerance can often eat yogurt because most of the lactose has been "eaten" by the good bacteria during the culturing process.

Yoghurt is produced by fermenting milk using two types of lactic acid bacteria (*Lactobacillus* and *Streptococcus*) either bought as a dry powder or taken from a portion of a previous batch of product. The bacteria produce lactic acid, which causes the characteristic curd to form and restricts the growth of some spoilage bacteria, so that yoghurt can be kept for up to 10 days under refrigerated storage.

Streptococcus grows faster and produces both acid and carbon dioxide. This stimulates *Lactobacillus* growth. *Lactobacillus* produces peptides and amino acids, which are used by *Streptococcus*. The yoghurt mixture coagulates during fermentation due to the drop in pH. The *Streptococcus* causes the initial pH to drop to approximately 5.0, and then the *Lactobacillus* cause a further decrease to pH 4.0. The taste and texture of yoghurt are determined by the amount of lactic acid produced during the fermentation and this in turn depends on the amount of starter added and the temperature/time of incubation.

In processing, milk is standardized to the required fat content and the different ingredients are blended in a mixing container. The mixture is pasteurized to destroy contaminating bacteria and, to denature and coagulate whey proteins to enhance the texture of the final product. Yoghurt is cooled to 40–45°C and fermented for 4–6 hours until the acidity is 0.85–0.90%. It is then cooled and for stirred yoghurt it is stirred to break the gel. The product is then packaged and stored at refrigeration temperatures (5°C) to slow down chemical and microbiological changes that would shorten its shelf life.

Yoghurt incubators can be locally made using a wooden or steel box insulated with cotton material or expanded polystyrene. Insulation prevents heat loss and maintains the fermentation temperature for 4 - 6 hours

Yoghurt cultures

Dried yoghurt cultures can be obtained from commercial dairy centres. To develop a mother culture, the culture powder is mixed with pasteurized milk, left to grow and kept in a refrigerator. A part of the mother culture is inoculated into the pasteurized conditioned milk. Commercial yoghurt which has not been sterilized can also be used as starter culture. However care must be taken to avoid contaminating yoghurt.

Requirements for Making Yogurt

- A big pan to heat milk; spoon to stir milk (always use a non-metal spoon to stir or serve dairy products, to keep them fresh longer);
- Glass jars with lids that are big enough to hold the amount of yogurt you are making;
- Insulated cooler or small box to hold your jar of yogurt;
- Jar of very hot water, with lid on;
- Kitchen towel(s) or a small blanket (to wrap your jar of yogurt in);
- Kitchen thermometer to measure the temperature of the heated milk.

Raw Materials

Yoghurt is made with a variety of ingredients including milk, sugar, stabilizers, fruits, flavours and a bacterial culture.

How to Make Yogurt

Step 1: Rinse inside of pan with cold water, dump out, but do not dry pan (this helps keep the milk from scorching and sticking to the bottom of pan).

Step 2: Pour milk into pan and warm over medium heat, stirring frequently. Allow the milk to come to 82.20C. Hold at the same temperature for 30 seconds to 1 minute, while constantly stirring.

Step 3: Remove pan from heat and allow cooling to about 780C. Stir every-so-often to help the milk cool faster.

Step 4: Meanwhile, measure out your yogurt starter culture (from the mother culture or the store-bought yogurt). Allow it to come to room temperature while the milk cools.

Step 5: Once the milk has reached 47.7oC, not any higher, slowly stir the yogurt culture into the cooled milk. Make sure it is thoroughly combined.

Step 6: Pour this mixture into your glass jar(s) and cap. Do this all quickly, so that you put it in the cooler while it is still at 43oC - 46oC. Do not re-heat the milk once the culture is added.

Step 7: Place filled-capped jar(s) inside insulated box. Wrap jar(s) with kitchen towel(s) or a blanket.

Step 8: Close the insulated box completely. Allow to culture, undisturbed for 12-hours, or more up to 24 hours. The 24-hour yogurt will be sourer than the 12-hour yogurt, but will have less lactose.

Step 9: After culturing, remove jar(s) from cooler and transfer to fridge to chill. Wait until well chilled before serving or your yogurt will breakdown and separate easily.

3. Preparation of Butter

To produce butter you have to make the butterfat more concentrated. Butter should contain 80% fat, 16% moisture, and 2% milk solids non-fat (SNF). It may contain a small amount of salt (2%) to improve shelf life and taste. However, excess moisture (more than 20%) reduces the quality of butter.

Ready to use butter

Materials and Utensils

- Pasteurized cream, sour milk or sour cream
- A heat source
- A thermometer
- Cold water
- Sour milk or a starter culture
- A container for churning
- A sieve
- A bowl
- A tray for kneading
- Wooden spoons
- A pan
- Fine salt (optional)
- Packing material e.g. a jar
- Clean water

Note: Work exceptionally hygienic to obtain a sweet cream butter.

- Heat the milk or cream to a temperature of 85°C.
- Let it cool down to about 18°C as quickly as possible (use a thermometer) using cold running water on the outside of the pan.
- Add 1-2 tablespoons of fresh fermented sour milk or a starter culture to one litre of milk or cream and stir
- Maintain at 16–18°C for about 24 hours, so that the mixture becomes thick and sour enough to be churned.
- Churn the milk in a jar, glass pot or gourd. Churn with a regular up and down or sideways movement. Stop churning when the butter particles reach the size of rice grains or peas, and the buttermilk looks rather liquid.
- The butter particles will float on top of the buttermilk. Separate the butter particles from buttermilk by pouring through a coarse sieve.
- Wash the butter grains if necessary by churning with clean cold water for about 3 minutes, so as to wash away buttermilk.
- Salt the butter slightly (if desired) by kneading in about 10 grams of salt for every kilogram of butter. Keep aside.
- Mix the butter again the next day to allow the salt grains to dissolve.
- Using a well-rinsed kneading board, knead the butter with the back of two wooden spoons until butter has a nice, smooth surface (and drops of water and buttermilk are nor perceivable any more)
- Store the butter in a cool dark place. Wrap it in greaseproof paper or aluminium foil. Sprinkle with on the surface to prevent mould growth.

4. Preparation of Ghee

"**Ghee**" basically means that the milk fat is rendered from the butter to separate the milk solids and water. It's made by melting butter and skimming the fat off of the top. You'll be left with a yellow liquid when it's hot and a creamy looking solid one when the ghee cools down.

Ready to use ghee

Step 1: Pre-heat fresh filtered cow milk in a stainless steel (or aluminium) panto 36 – 40°C. This optimizes separation.

Step 2: Separate pre-heated milk into cream and skim milk using a cream separator. (Traditionally cream is not separated; milk is boiled and cooled several times and the fatty scum is skimmed off).

Step 3: Boil the cream in a pan over low heat and stir continuously until the milk proteins start to coagulate, and the cream changes from white to golden brown.

Step 4: Leave the product to cool and allow particles to settle at the bottom of the pan.

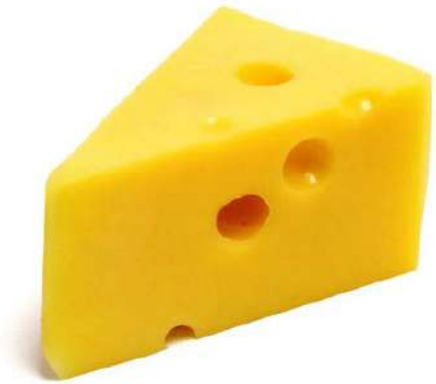
Step 5: Filter the oil carefully using clean cheesecloth, so that it is clear without any particles.

Step 6: Pack the oil in food grade stainless steel cans or glass tins with plastic lids, or as traditionally in calabashes.

Step 7: Store at room temperature away from heat and sunlight. The shelf life can exceed 12 months with correct packaging and storage conditions.

5. Cheese Making

Cheese is a food derived from milk that is produced in a wide range of flavours, textures, and forms by coagulation of the milk protein casein. It comprises proteins and fat from milk, usually the milk of cows, buffalo, goats, or sheep. During production, the milk is usually acidified, and adding the enzyme rennet causes coagulation. The solids are separated and pressed into final form. Some cheeses have moulds on the rind or throughout. Most cheeses melt at cooking temperature.



Ready to use ghee

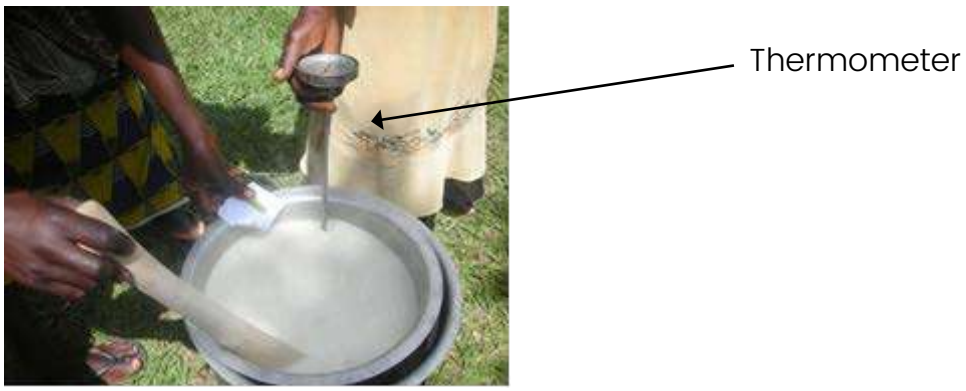
Utensils for Making Cheese

- A thermometer with a range of 20 -100°C.
- A cheesecloth
- A bucket for coagulation of milk
- A measuring cup
- Cutlery (spoons to measure rennet and /or acids; knife to curdled milk; skimmer to scoop curd out of whey)
- Cheese moulds

The Cheese Making Process

Step 1: Heat the cheese milk to 63°C and maintain at that temperature for 30 minutes to destroy all germs. Note: The milk for making cheese should preferably be pasteurized (e.g. 72°C for 15 seconds, or 63°C for 30 minutes). More intense heating is not desirable because it reduces the curdling of milk.

Step 2: Cool the milk to 40 -45oC, and then add coagulating acid or rennet enzyme.



A thermometer is used for testing temperature during processing

Step 3: Stir the milk-enzyme mixture to distribute the enzyme evenly. Then leave to coagulate.

Step 4: Add rennet (1 ml. rennet to every 4 litres of milk). The milk will coagulate in 1 hour.

Step 5: Cut the curd into 2-3 cm cubes.

Step 6: Leave for 15 minutes. Cut the curd gently to cause whey separation

Step 7: When the curds settle, pour out the whey

Step 8: Transfer the curds and some whey to wooden cheese mould lined with cheesecloth.

Cheese cloth and moulds

Step 9: Fold the cheesecloth and place lid on mould.

Step 10: Allow curds to drain. Leave the curds in the mould overnight.

Step 11: Cut the curd into blocks of suitable size and sprinkle them with salt

Step 12: Place the salted blocks in 15% brine solution for 12 hours. Turn the curd blocks at least once during the salting.

Curd blocks

Step 13: Remove and place in curing and ripening room, preferably at 12 – 20°C. Leave for several days, while turning as regularly, until mature.

Step 14: Remove moulds from the ripening cheese by cleaning with water or vinegar.

Step 15: For some types, the ripening cheese can be smoked with fire to develop a flavour.

Whey is the by-product of cheese making. Whey can be used as animal feed, especially for pigs, dogs, depending on its acidity. Some types of whey are used for making cheese or whey drinks.

CHAPTER 11: FACTORS AFFECTING ADOPTION OF IMPROVED DAIRY CATTLE TECHNOLOGIES IN URBAN AREAS OF UGANDA

The adoption of improved dairy technologies in urban areas of Uganda can be influenced by several factors, which can be broadly categorized into social, economic, technical, and environmental factors.

1. Social Factors
- Farmers' education level and awareness of dairy technologies.
- Influence of social norms and cultural values.
- Younger, more experienced farmers may adopt technologies faster.
- Larger families may adopt labour-saving technologies.
- Traditional dairy practices and cultural preferences

2. Economic and Financial
- High initial investment costs for dairy technology
- Government subsidies, grants, or credit facilities.
- Fluctuations in milk prices and demand.
- Larger farms may benefit more from technology adoption.
- Limited access to financing options for dairy farmers and processors
- Fluctuating milk prices and unpredictable market demand

3. Technical Factors
- Farmers' ability to operate and maintain technology.
- Availability of electricity, water, and transportation.
- Integration with existing farm infrastructure.
- Technology's performance and lifespan.

4. Technological
- Limited access to reliable and affordable internet connectivity.
- Limited technical expertise and support for dairy technology.
- High maintenance costs for dairy technology equipment.

5. Environmental Factors
- Technology suitability for local climate and terrain.
- Access to clean water for dairy operations.
- Space for technology installation and expansion.
- Government policies and regulations.

6. Infrastructure and Logistics
- Limited access to cold storage and refrigeration facilities
- Inadequate transportation infrastructure for milk collection and distribution
- High costs of setting up and maintaining dairy processing facilities.

7. Regulatory and Policy
- Lack of clear regulations and standards for dairy production and processing
- Limited government support and incentives for dairy technology adoption
- Complex and time-consuming licensing procedures

8. Other Barriers
- Competition from informal dairy markets
- Limited availability of quality dairy cattle breeds
- Disease management and animal health challenges
- Regulatory frameworks, subsidies, and extension services.
- Lack of access to information on dairy technologies.
- Farmers' willingness to adopt new technologies.
- Cooperatives, associations, and private sector involvement.

Understanding these factors can help policymakers, extension agents, and dairy industry stakeholders develop targeted strategies to promote the adoption of dairy technologies.

Adoption Factors by Technology

1. **Automated Milking Systems (AMS)**
- Initial cost and affordability
- Labour savings and efficiency
- Cow comfort and welfare
- Data analysis and decision-making

2. **Milk Cooling Systems**
- Energy efficiency and cost savings
- Milk quality and safety
- Regulatory compliance
- Farm size and production level

3. **Feed Management Systems**
- Nutrient management and efficiency
- Cost savings and profitability
- Environmental impact
- Data analysis and decision-making

4. **Cow Health Monitoring Systems**
- Early disease detection and treatment
- Reduced antibiotic use
- Improved animal welfare
- Data analysis and decision-making

5. **Management Systems**
- Environmental impact and regulation
- Cost savings and profitability
- Nutrient management and efficiency
- Farm size and production level

CHAPTER 12: EMPOWERING THE NEXT GENERATION: THE VITAL ROLE OF YOUTH IN THE DAIRY INDUSTRY

12.1. Youth Unemployment Challenges in Uganda

Based on the National Population and Housing Census (2024), the total population for Uganda as of September 2024 was 45,935,046 persons with the male population recorded at 21,566,736 while the female recorded at 24,338,681 persons. The youths (0-35 years) in Uganda constituted about 82% of the 45.9 million people. The unemployed people in Uganda is forecast to 0.67million in 2024. The employment rate in Uganda is forecasted to 81.45% in 2024.

Youth unemployment is a serious policy challenge in Uganda. Given the rapid growth of the Ugandan population, coupled with the fact that the youth are getting better educated through higher access to primary and secondary education, a stronger focus on job creation for this cohort of people cannot be overemphasized. Causes of youth unemployment are believed to be multifaceted, ranging from an inadequate investment/ supply side of jobs, insufficient employable skills (i.e., youth possess skills that are not compatible with available jobs) and high rates of labour force growth at 4.7 percent per annum.

The lack of adequate youth employment has made them dangerous to society, leaving them with no alternative but to engage in terrible acts that will give them money to support their bad habits. As urbanisation rates increase, many young people are moving away from rural areas towards cities, looking for better prospects and jobs. However, even under the most optimistic scenarios, it is expected that non-farm and urban sectors will not be able to absorb the youth labour market entrants over the next decade. Addressing the scourge of youth unemployment is central to most countries and development partners because its escalation can result in increased rural-urban migration, increased income inequalities, increased crime and violence as most engage in risky behaviour, as well as brain drain through loss of trained and experienced young people to other economies.

12.2. Emerging Opportunities for Youth in Urban Dairy Sector Services in Uganda

The Uganda Vision 2040 recognized dairy industry as one of the fundamental avenues for employment creation particularly for the youth. The dairy industry forms the largest agricultural sub-sector with unpacked fresh milk being among the top five foods consumed by most households in Uganda. The number of old farmers is increasing in dairy farming, and they cannot comprehend with changing of technology and innovation that is used in the dairy business. A well-structured urban dairy cattle industry, therefore, has the potential to play a pivotal role in job creation for the youth, thus propelling Uganda to achieve its development goals

There are massive opportunities available in the value chain of dairy production such as animal feed (fodder production), breeding, veterinary services, fattening, transportation, information sharing, processing (making ghee, ice cream, butter and other dairy products) , and marketing. If these opportunities are well known by youth, many youth will be attracted to invest in the value chain of livestock production. However, it is unfortunate that the future labour force is facing many challenges today and youth always choose quick earnings. The number of old farmers is increasing in dairy farming, and they cannot comprehend with changing of technology and innovation that is used in the dairy business.

12.3. Factors that Discourage Youth from Making a Career in Dairy Sector

Youth is considered to be exceptionally resourceful, innovative and crucial for the future of the dairy sector. Youth's openness towards new practices can be key in development

of, for example, new and environmentally responsible dairy practices, and to fully utilise the potential of new technologies such as Information Communication Technologies (ICT) for the dairy sector. Despite this, there are a number of constraints for youth to be employed in the dairy sector. Constraints that affect productivity levels of young dairy farmers, limiting them to subsistence farming and poverty. Below are some of the factors that discourage youth from making a career in dairy sector.

(a) Image of Dairy Farming and a Living Wage

Although millions of young people are ready to enter the workforce, the image of dairy cattle work is not as attractive as more 'sophisticated' jobs in urban areas. Dairy production has the connotation of not commanding respect and good pay. Dairy farming is seen as hard and dirty work with low rewards.

(b) Access to Land, Finance and Inputs

Land tenure systems often create a barrier for youth's access to productive land. In Uganda, land rights are divided between children as inheritance. Tiny plots of land are held through customary land tenure. These make it difficult and economically unattractive for youth to start a dairy business. The capital needed to acquire improved dairy cows makes it especially difficult to enter the dairy sector in primary production. Loans are often not easily provided to youth by financial institutions.

(c) Education, Knowledge and Skills

The educational level of youth in some parts of Uganda is still rather low. Although the interest of higher-educated people in the dairy sector is limited, a recent increase in interest from university graduates in the dairy sector is perceived in Uganda. The main problem with higher education is the lack of practical experience. University graduates starting as a farm manager often lack the practical and managerial skills needed to be successful.

(d) Hierarchical Structures

In cooperatives, the role of youth is minimal. Cooperative management is often dominated by older conservative members, who tend to have little confidence in the capabilities of younger members and leave little space for the involvement of younger members in cooperatives' activities or decision-making.

The influence of successful dairy farmers, a decent wage, and lack of jobs in urban areas have been mentioned by young farmers as drivers to participate in dairying. Good examples that utilise the drivers and overcome the challenges of youth inclusion in different parts of the dairy value chain are needed to stimulate youth-led transformations.

12.4. Youth and Commercial Fodder and Feed Production

Studies conducted by NaLIRRI have shown that currently Uganda has a fodder (fresh and conserved) deficit of over 50 million tons per year. Recognizing this market potential, a growing number of farmers and youth have begun to show interest in commercial fodder production such as napier grass, sweetpotato vines and maize silage. Individual farmers and government institutions have invested in large-scale commercial fodder production, and some have also developed businesses providing mechanized services to other farmers on a contract basis. Because commercial fodder production is a recent development, many youth lack knowledge, skill and experience on production, storage and utilization. Technical assistance to both financial institutions and farmers (for record keeping, financial management) could help overcome these barriers and support farmers to make the required investments in machinery and storage facilities.

Youth Engagement Fodder Production Models

- **Internships:** Pair youth with experienced farmers for hands-on training.
- **Apprenticeships:** Mentorship programs for youth to learn business and technical skills.

- **Youth-led cooperatives:** Empower youth to manage and operate fodder production cooperatives.
- **School-based programs:** Integrate fodder production into agricultural education.
- **Community-based initiatives:** Engage youth in local fodder production projects.
- **4-H (Head, Heart, Hands, and Health) Clubs:** Empowering youth through hands-on agricultural training. 4-H reflects the principles of positive youth development, experiential learning, and the importance of having fun. 4-H encourages family involvement and support by connecting families to their communities and to one another.
- **Junior Farmers' Field and Life Schools (JFFLS):** The JFFLS approach is participatory and aims at improving the children's self-esteem, sense of initiative and of solidarity. Using agriculture as a basis, social/health skills are integrated during the crop cycle, thus the children acquire agricultural and social skills as the two sides of a same medal.
- **Young Farmers' Associations:** The club prepares young students to be self-employed by encouraging them to embrace home farming projects, where they can put to use the training and information on the latest farming techniques and agricultural breakthroughs gotten from club meetings.

Specific Fodder Production Techniques

- **Hydroponic Fodder Production:** Soilless cultivation for increased yields and water efficiency.
- **Conservation agriculture:** Minimizes soil disturbance and promotes soil health.
- **Integrated pest management (IPM):** Sustainable pest control methods.
- **Crop rotation and diversification:** Enhances soil fertility and reduces pests.
- **Fodder conservation methods (e.g., drying, ensiling):** Preserving and storing fodder for year-round use.

Entrepreneurial Opportunities in Fodder Production

- Fodder production for dairy or livestock farms.
- Value-added products (e.g., hay, silage, or pellets).
- **Contract farming:** Partner with established farmers or companies.
- **Online marketplaces:** Sell fodder products through digital platforms.
- **Local market development:** Establish fodder markets in rural areas.
- **Contract fodder production:** Partnering with dairy or livestock farmers.
- **Fodder processing and value addition:** Creating hay, pellets, or other value-added products.
- **Fodder marketing and trading:** Establishing online or offline marketplaces.
- Dairy cattle waste processing and value addition: Producing products such as briquettes, fertilizers, pesticides, building bricks, cattle dung personal care products such as sanitizer, shampoo, face creams, shower gel, hand wash and liquid soap
- Processing agricultural and agro-industrial wastes into dairy cattle feeds.

Challenges and Solutions

- **Land access:** Lease or share land, or use vertical farming.
- **Finance:** Access loans, grants, or crowd-funding.
- **Market access:** Establish relationships with buyers or create online platforms.
- **Technical knowledge:** Provide training and mentorship.
- **Climate change:** Implement climate-resilient practices.
- **Land Access:** Leasing land, vertical farming, or container gardening.

Guidance on Starting a Fodder Production Business

- Conduct market research and feasibility studies.
- Develop a business plan and secure funding.
- Identify suitable land and equipment.

- Choose appropriate fodder crops and production methods.
- Establish relationships with buyers and suppliers.

12.5. Other Potential Areas for Youth Participation in Urban Dairy Value Chain

(a) Innovation: Youth can develop and promote novel ideas and modern technologies to enhance dairy farming efficiency and productivity.

(b) Labour Force: Youth provide essential labour, ensuring daily operations run smoothly.

(c) Market Access: Youth can utilize digital platforms to access markets, improving sales and profitability.

(d) Leadership: Youth can assume leadership roles, driving decision-making and **policy changes.**

(e) Animal Care and Management: Youth can learn about and take responsibility for feeding, breeding, health monitoring, and milking cattle.

(f) Milk Processing and Value Addition: Youth can engage in processing milk into various products like cheese, yogurt, butter, and ghee, enhancing the economic viability of the farm.

(g) Marketing and Sales: Youth can leverage social media and other digital platforms to market and sell dairy products directly to consumers, hotels, and restaurants.

(h) Farm Management and Technology: Youth can learn and apply modern dairy cattle farming technologies, such as automated feeding systems, veterinary care software, and farm management apps.

(i) Sustainable Practices: Youth can implement environmentally friendly practices like waste management, briquettes, composting, biogas, fertilizers, pesticides, and personal care products such as hand lotion, shampoo, sanitizer, soap, face creams and others. They can integrate and process agricultural and agro-industrial wastes into dairy cattle feeds.

(j) Education and Training: Youth can participate in workshops, training programs, and online courses to enhance their skills in dairy farming and entrepreneurship.

(k) Community Outreach: Youth can organize workshops, farm visits, and educational programs to promote urban dairy farming and its benefits.

Some Benefits of Youth Involvement

- Increased productivity and efficiency
- Improved farm management
- Enhanced technological adoption
- Better market access
- Sustainable farming practices

12.6. Support Required to Encourage Youth Participation In Dairy Cattle Production

- Provide training and mentorship programs
- Offer financial support and incentives
- Foster supportive policy frameworks
- Encourage networking and collaboration

Networking and Collaboration

- Social media platforms (e.g., Facebook)
- Online forums (e.g., Reddit, LinkedIn)
- Industry conferences and trade shows
- Local cooperatives and associations
- Mentorship programs

12.7. Recommendations for the Future

Based on the strategies used by existing youth employment initiatives in the dairy sector and their success factors, below are recommendations for policy-makers, development planners and dairy cooperatives to improve further involvement of youth in the dairy sector:

(a) Work with youth groups and investigate how group dynamics can be further improved: Effectiveness of this strategy can be increased by paying attention to the group dynamics and the way people work together.

(b) Support diversification of areas within the dairy sector for youth to work on: As a precondition for up-scaling and to allow for diversified income streams, it is advisable for youth groups to be trained on technical and entrepreneurial skills, to invest in a bundle of services, and to offer and services for various parts of the value chain.

(c) Establish a strong link with cooperatives: Increasing youth involvement in cooperatives and linking youth groups to cooperatives are effective strategies to scale initiatives to involve youth. Cooperatives can play a role in offering the training to youth and thus develop advisory services within their cooperative. This could increase the cost-effectiveness of training.

(d) Support development of youth councils within the cooperatives: The current under-representation of youth in cooperatives can be addressed if cooperatives adopt an active role in increasing young farmers' participation, by offering better economic benefits, by bridging the ineffective communication between young and old farmers, and by providing training and workshops on dairy farming and cooperative management.

(e) Promote the use of ICT opportunities and digitisation of training: Development of ICT skills will enable youth to make use of the opportunities that ICT has to offer for managing a dairy business. Digital or online training offers opportunities to gain knowledge about the dairy sector for youth not being able to follow face-to-face courses. These could make use of online platforms and social media sites, which have proven to be an important source of information.

By engaging in urban dairy farming, youth can develop valuable skills, generate income, and contribute to food security and sustainable urban development. For dairy farming to become an attractive career choice for young farmers, they need to witness its potential to generate a stable and appealing income. Role models demonstrating a successful and professional approach to dairy farming can play a significant role in changing the sector's image positively.

While the challenges faced by the new generation of dairy farmers may not be easy to tackle, it is essential for the sector's future to innovate and devise new ways of working to ensure their success. Only by doing so can we secure a prosperous and sustainable future for dairy farming.

CHAPTER 13: THE FUTURE OF DAIRY CATTLE FARMING: INNOVATIONS AND TRENDS

The future of urban dairy cattle farming is rapidly evolving, driven by factors such as sustainability, technology, and shifting consumer preferences. Innovative urban dairy cattle farming technologies are revolutionizing the industry, making it more efficient, productive, and sustainable.

13.1. Innovative Urban Dairy Cattle Farming Technologies

1. Cutting-Edge Technologies Being Used to Improve Dairy Cattle Production

Advancements in technology are revolutionizing the way dairy farms operate, offering innovative solutions to improve efficiency, productivity, and sustainability. **Automation** has become a key aspect of dairy farming, allowing for more efficient and streamlined processes. Farmers in developed countries are now able to implement precision feeding systems that optimize the nutrition of their cattle. Additionally, robotics are being used in the milking process, reducing the need for manual labour and increasing productivity. By embracing technology, dairy farms can enhance their sustainability efforts while maintaining profitability.

2. Precision Feeding Systems

Precision feeding systems have revolutionized the way dairy cattle farmers manage their cows' nutrition. These advanced systems use sensors and data analytics to monitor individual cow's feed intake and adjust their rations accordingly. By providing each cow with the right amount of nutrients, precision feeding systems help improve milk production and overall cow health. In addition, these systems also contribute to reducing feed waste and optimizing feed efficiency. With the adoption of precision feeding systems, dairy farmers in developed countries have seen significant improvements in their herd's performance and profitability.

3. Robotics in Milking Process

Robotic milking systems have revolutionized the dairy industry, providing numerous benefits for both farmers and cows. These innovative systems automate the milking process, allowing cows to be milked on their own schedule. The robots use advanced technology to clean the udder, attach the milking cups, and monitor the milk flow. This not only reduces the labour required for milking but also ensures consistent and hygienic milking practices. Additionally, the robots collect data on each cow's milk production, health, and behaviour, providing valuable insights for farm management. With the innovation of robotics, dairy farmers can improve efficiency, animal welfare, and milk quality.

4. Wearable Sensors and Data Analytics

Wearable sensors equipped with accelerometers, temperature sensors, and Global Positioning System (GPS) trackers provide real-time insights into cow health, activity levels, and reproductive cycles. Coupled with sophisticated data analytics algorithms, dairy farmers can proactively identify health issues, optimize breeding programs, and improve overall herd management. By leveraging this technology, farmers can minimize veterinary interventions, reduce medication usage, and enhance animal welfare outcomes.

Wearable Sensors (Source: NET)

5. Precision Agriculture

Precision agriculture employs cutting-edge technologies such as GPS, drones, and sensors to optimize farm management practices. By precisely monitoring soil conditions, crop growth, and environmental factors, dairy farmers can make data-driven decisions to enhance productivity while minimizing resource usage. This approach not only improves efficiency but also reduces environmental impact by minimizing fertilizer and pesticide usage.

6. Vertical Integration and Circular Economy Models

Vertical integration involves diversifying farm operations to include additional revenue streams, such as cheese, butter and yogurt production; adding value to manure to produce products like charcoal briquettes, biogas, bio-electricity and personal care products; (face creams, shower gel, hand wash, shampoo, sanitizer and liquid soap); agritourism and others. By adding value to dairy products and minimizing waste through efficient resource utilization, farmers can create a more resilient and sustainable business model. Embracing circular economy principles encourages the reuse and recycling of resources within the farm ecosystem, further minimizing environmental impact and enhancing economic sustainability.

7. Organic Dairy Farming

Organic dairy farming is a sustainable practice that focuses on maintaining the health and well-being of cows while minimizing the use of synthetic inputs. It involves providing cows with organic feed and access to pasture, and avoiding the use of antibiotics and growth hormones. Organic dairy farms also prioritize environmental conservation, implementing renewable energy solutions and water conservation techniques. By embracing organic farming methods, dairy farmers can meet the growing consumer demand for sustainable and ethically produced dairy products.

8. Renewable Energy Solutions

Renewable energy solutions are becoming increasingly important in the dairy farming industry. With the growing concern for environmental sustainability, dairy farmers are exploring alternative energy sources to power their operations. Solar panels are being installed on farms to harness the power of the sun and reduce reliance on traditional energy sources. Wind turbines are also being utilized to generate electricity, taking advantage of the strong winds often found in rural areas. Additionally, some farmers are implementing anaerobic digesters to convert manure into biogas, which can be used as a renewable energy source. These innovative solutions not only help reduce carbon emissions but also provide cost savings for farmers. By embracing renewable energy, dairy farmers are taking a step towards a more sustainable future.

9. Water Conservation Techniques

Water conservation is a crucial aspect of sustainable dairy farming. With the increasing demand for water and the need to reduce environmental impact, dairy farmers are implementing various techniques to optimize water usage. Efficient irrigation systems are being used to minimize water wastage and ensure that crops receive the right amount of water. Rainwater harvesting is also gaining popularity, allowing farmers to collect and store rainwater for irrigation purposes.

Additionally, recycling and reusing water within the farm is being practiced to minimize water consumption. These water conservation techniques not only help in preserving this precious resource but also contribute to the overall sustainability of dairy farming.

10. Vertical Farming

Vertical farming in the dairy industry is an emerging trend that has the potential to revolutionize dairy farming practices. This innovative approach involves growing crops and raising cattle in vertically stacked layers, maximizing land efficiency and reducing the environmental footprint. By utilizing advanced technologies such as hydroponics ("Soilless farming"), vertical farms can optimize crop growth and ensure year-round fodder/feed production. Improved animal welfare and milk quality. With its potential to increase profitability, vertical farming is gaining traction among dairy farmers looking for sustainable and efficient solutions.

11. Genetic Engineering for Improved Milk Production

Genetic engineering is a fascinating area of research that holds great potential for improving milk production in the dairy industry. By manipulating the genes of dairy cows, scientists are able to enhance desirable traits such as milk yield, quality, and composition. This innovative approach has the potential to address the difficulties faced by dairy farmers in meeting the growing demand for milk while ensuring sustainability. With genetic engineering, farmers can breed cows that are more resistant to diseases, have higher fertility rates, and produce milk with specific characteristics. However, it is important to carefully consider the ethical and environmental implications of these practices to ensure the long-term viability of the dairy farming industry.

13.2. Leveraging Artificial Intelligence in Dairy Farming

Artificial Intelligence technologies are reshaping the dairy supply chain through data analytics and predictive modelling, optimising inventory management, distribution routes, and demand forecasting. Artificial Intelligence also promotes a more efficient and sustainable dairy industry by reducing wastage and transportation costs.

The dairy industry in India is currently facing high demand for productivity, sustainability and animal welfare. In order to overcome these challenges, dairy farmers are opting for cutting-edge technologies like Artificial Intelligence. The potential of Artificial Intelligence in enhancing efficiency and productivity throughout the dairy value chain is transforming the face of the entire industry.

Artificial Intelligence technologies are reshaping the dairy supply chain through data analytics and predictive modelling, optimising inventory management, distribution routes, and demand forecasting. Artificial Intelligence also promotes a more efficient and sustainable dairy industry by reducing wastage and transportation costs. Nevertheless, challenges like data privacy, implementation costs, and specialised training must be addressed. Robust data security, financial incentives, and accessible training programs are essential for successful Artificial Intelligence integration.

Role of Artificial Intelligence in Dairy Farming

Artificial Intelligence offers unparalleled potential in improving efficiency, productivity, and overall management of dairy farms. Artificial Intelligence technologies are revolutionising traditional dairy farming practices by harnessing the power of machine learning, deep learning, natural language processing, and data analytics. The essential advantage of

Artificial Intelligence is its ability to process and analyse vast amounts of data in real-time, providing valuable insights and enabling data-driven decision-making for farmers.

(a) Precision Dairy Farming

One of the notable applications of Artificial Intelligence in dairy farming is precision dairy farming, which includes the individualised monitoring and management of cows. AI-driven sensors and smart devices are used to track various elements like the health and well-being of each cow. The sensors can easily monitor vitals like heart rate, rumination activity, body temperature, and overall behaviour. By analysing this real-time data, Artificial Intelligence algorithms can identify deviations from standard patterns, alerting farmers to potential health issues early.

(b) Artificial Intelligence in Fertility Management

Reproductive efficiency is vital for dairy farmers in maintaining a productive and sustainable herd. Artificial Intelligence technologies are crucial in optimising fertility management by closely monitoring the reproductive cycle of each cow. Artificial Intelligence -driven systems can analyse cow behaviour and physiological data to pinpoint the most fertile period, thus optimising breeding and insemination schedules. This precision in fertility management leads to improved conception rates and reduced calving intervals, ultimately resulting in higher reproductive success rates and increased milk production.

(c) Data-Driven Nutrition

Nutrition, one of the fundamental aspects of dairy farming, significantly impacts milk production and cow health. Artificial Intelligence -powered data analytics helps in preparing personalized and balanced diets for individual cows. The system considers aspects like the age, breed, weight, milk yield, and overall health status of cows. By modifying the feeding plans based on real-time data, Artificial Intelligence ensures that each cow gets the exact amount of nutrients needed, leading to optimized milk production and overall cow health. This approach minimizes feed wastage, promoting sustainable farming practices.

(d) Robotic Milking Systems

Artificial Intelligence -driven robotic milking systems have revolutionised the traditional milking process on dairy farms. The automated milking machines have Artificial Intelligence technologies to spot individual cows on unique identifiers. The system adjusts milking settings per each cow's preferences and physiological conditions, ensuring a stress-free and comfortable milking experience. This approach to milking enhances cow welfare and leads to increased milk yields.

(e) Artificial Intelligence In Disease Detection And Management

The capability of Artificial Intelligence to process and analyse vast volumes of data immediately enables early detection of health issues in cows. By continuously monitoring cow health parameters, Artificial Intelligence -driven systems can identify delicate changes that may specify the beginning of diseases. Early detection helps in timely intervention, enhancing treatment results and reducing mortality rates. Moreover, Artificial Intelligence can help veterinarians manage diseases by analysing historical data and treatment responses.

(f) Artificial Intelligence In Environmental Monitoring and Resource Management

Artificial Intelligence technologies contribute heavily to sustainable dairy farming by optimising resource management. Artificial Intelligence -driven systems can monitor environmental conditions like temperature, humidity, and ventilation, ensuring that cows are in ideal conditions for maximum comfort. Furthermore, Artificial Intelligence -powered data analytics aids farmers in handling resources efficiently, like water usage, feed consumption, and energy utilisation, reducing waste and promoting environmental sustainability.

These innovative technologies enable farmers to make data-driven decisions, optimize herd health, and improve milk quality. With the help of advanced algorithms and machine learning, dairy farmers can analyse vast amounts of data to identify patterns and trends, leading to more efficient farming practices. For example, butter production can be optimized by using predictive analytics to determine the best feeding strategies for cows. Additionally, artificial intelligence can assist in monitoring cow behaviour and health, allowing farmers to detect early signs of disease and take appropriate action and promote sustainable practices. The integration of data analytics and artificial intelligence in dairy farm management is paving the way for a more sustainable and profitable future.

REFERENCES

1. Ariong , R and Bjorn Van Campenhout. (2023). Opportunities for Innovation and Intervention in Uganda's Dairy Value Chain. A Scoping Report. Initiative Note No. 12. December 2023. https://cgspace.cgiar.org/server/api/core/bitstreams/16e7aff7-7b28-4ca7-b3fd-592537c22a0d/content

2. Bbaale. E.; Babyenda, P.; Kavuma, S.; Kimono, B.; Kyamugabwa, A.; Sebukeera, H.; Nakigudde, C.; Wainaina, S. and Mabugu, R. (2023). What works for Youth Employment in Africa: A review of youth employment policies and their impact in Uganda. Working Paper 2023-16. PEP Working Paper Series ISSN 2709-7331. https://mastercardfdn.org/wp-content/uploads/2024/02/Youth-Employment-Uganda-Working-Paper.pdf

3. Bakang Kedumetse Kgasudi and Modiri Mantswe (2020). Cow Urine: A Plant Growth Enhancer, Bio Fertilizer, Pesticide and Antifungal Agent *International Journal of Current Microbiology and Applied Sciences*. ISSN: 2319-7706 Volume 9 Number 2 (2020). Journal homepage: http://www.ijcmas.com.

4. Chaudhari, A. and Obero, P.S. (2018). Total mixed ration for dairy cows. *Indian Farming* 68(08): 27–30; August 2018. National Dairy Research Institute, Karnal (Haryana) 132001.

5. Clodagh O'Brien (2023). What are the most effective digital marketing strategies? Posted on Aug 22, 2023. https://digitalmarketinginstitute.com/blog/what-are-the-most-effective-digital-marketing-strategies#heading_72103.

6. Dias Sousa Ana Vanessa. (2024). Cattle farming. Succession plan for dairy farms: key points to consider. https://ruminants.ceva.pro/succession-plan-farm-succession

7. Dimo Dimov, Toncho Penev and Ivaylo Marinov. (2023). Importance of Noise Hygiene in Dairy Cattle Farming—A Review. *Acoustics* 2023, 5(4), 1036-1045; https://doi.org/10.3390/acoustics5040059

8. FAO (Food and Agriculture Organization of the United Nations. (2019). The future of livestock in Uganda. Opportunities and challenges in the face of uncertainty. Rome.

9. FAO. 2021. World Food and Agriculture - Statistical Yearbook 2021. Rome. https://doi.org/10.4060/cb4477en

10. Font-Palma, Carolina. (2019). Methods for the Treatment of Cattle Manure—A Review. *Journal of carbon research.* file:/// /Methods_for_the_Treatment_of_Cattle_Manure-A_Reviev(1).pdf

11. Galla N. A., Nampija Z.; Lutwama V.; Mayanja S.; Grant F.; Kyalo G.; Kiggundu M.; Zziwa E.; Nambi-Kasozi J. ; Kabirizi J.M. (2020). Effects of inclusion levels of sweet potato vine silage on feed intake, milk production profitability of lactating crossbred dairy cows. 2020. *Open Journal of Animal Science.* 2020, 10, 608-617.

12. Gürel Soyer and Ersel Yilmaz. (2020). Waste management in dairy cattle farms in Aydın region: Potential of energy application. https://www.mdpi.com/2071-1050/12/4/1614.

13. Gumisiriza, S. M.; Kabirizi, J.M.; Mugerwa, M.; Ndakidemi, P.A. Mbega, E.R. (2022). Can soilless farming feed urban East Africa? An assessment of the benefits and challenges of hydroponic in Uganda and Tanzania? *Environmental Challenges* Volume 6, January 2022, 100413.

14. Gumisiriza, S. M.; Ndakidemi, P.A.; Mbega, E.R. Nalunga, A. (2022). Building sustainable societies through vertical soilless farming: A cost- effectiveness analysis on a small-scale non-greenhouse hydroponic system. *Elsevier Sustainable Cities Society.*

Volume 83, August 2022, 103923.

15. Harasia, P. L., Garg, M. R. and Bhanderi, B. M. 2017. Pulses and Their By-Products As Animal Feed, Edited by T. Calles and H. P. S. Makkar. Rome, Food and Agriculture Organization (FAO). https://openknowledge.fao.org/server/api/core/bitstreams/899c07b3-a28d-4d46-a2e4-477deed8d90e/content

16. Heuzé V., Tran G., Hassoun P., Lebas F., 2021. Jackfruit (Artocarpus heterophyllus). Feedipedia, a programme by INRAE, CIRAD, AFZ and FAO. https://www.feedipedia.org/node/185. Last updated on November 22, 2021, 9:46.

17. Integrated Smallholder. Dairy Farming Manual © 2015 - Heifer International Tanzania. file:///C:/Users/dell/Downloads/integrated-smallholder-dairy-farming-manual-2015-3.pdf

18. Jandaik, S., Thakur, P. and Kumar, V. 2015. Efficacy of cow urine as plant growth enhancer and antifungal agent. *Adv. Agri.,* Volume 2015, Article ID 620368 (p: 7.)

19. Kaaya, D. and Ambwere, H. A. (2024). MolaPlus Livestock Microbes: A Game Changer for Urban Dairy Farming in Uganda. October 2024. (Unpublished)

20. Kabirizi, J. M.; Mugerwa, S.; Kirunda, H.; Lukwago, G.; Oluka J.; Butungi, S.; Ssemabo, D.K.K.; Mubiru, F.; Nakimbugwe, H. (2014). Feed resources management, genetic improvement disease control in smallholder dairy systems. ISBN 9789970926909.

21. Kabirizi, Jolly M.; Lule, Peter; Kyalo, Gerald; Mayanja, Sarah; Ojakol, James Francis; Mutetikka, David; Naziri, Diego Lukuyu, Ben. (2017). Sweet potato silage manual for smallholder farmers. Exploring utilization of roots, tubers bananas reducing their postharvest losses. file:///C:/Users/dell/AppData/Local/Temp/RTB-Endure-Sweetpotato-silage-Manual-for-Smallholders-Farmers.pdf

22. Kabirizi, J.M. (2020). Climate smart forages supplemental feeds for dairy cattle under zero grazing systems in Uganda. ISBN. 987-9970-865-00-0.

23. Kabirizi, J.; Musasizi, M.; Businge E. Gumisiriza M. (2021). Innovative urban agricultural enterprises: A Case of Kyakuwa Farm, Makindye Municipal Council, Wakiso District, Uganda. March 2021.

24. Kabirizi, J.M. (2022). How to produce hydroponic green maize fodder. The New Vision paper. 8th July 2022. https://www.harvestmoney.co.ug/how-to-produce-hydroponic-green-maize-fodder/

25. Kabirizi J.M.L. (2023). Unlocking the potential of feed production technologies, innovations management practices of smallholder dairy cattle farmers in Uganda. February 2023. ISBN. 9789970675951.

26. Kabirizi Jolly and Mwesigwa Robert. 2024. Climate smart dairy cattle farming business in urban areas of Uganda. *Presentation during Harvest Money Expo, 24th Feb 2024. Theme: "Farming as a Business"*

27. Kabirizi, J.; Mwesigwa, R. and Lutwama, V. 2024. Waste management in dairy cattle farming systems (recycling and biogas/slurry). Presentation during *"MAAIF & FAO Training to enhance stakeholder understanding of food systems transformation under dairy & maize value chain, national farmers leadership Center, Kamengo,* 12th to 16th Feb 2024".

28. Kabirizi, J.M.; Rumanzi, S.; Asiimwe, M. Mwesigwa, M. (2024). Feeds manure management innovations for a profitable smallholder dairy cattle enterprise. Paper presented during *"Uganda Best Farmers Masterclass: Dairy Management for Profit, Sight Farm, 7th Sept 2024"*

29. Kabwanga Ismail Tijjani and Atila Yetişemiyen. 2015. Dairy Cattle and Dairy Industry in Uganda: Trends and Challenges. *Research Journal of Agriculture and Forestry Sciences*. Vol. 3(10), 14-18, November (2015. ISSN 2320-6063

30. Karine Keyzy dos Santos Lemes et al. (2023). Music and Tactile Stimuli during Daily Milking Affect the Welfare and Productivity of Dairy Cows. Animals (Basel). 2023 Nov 27;13(23):3671. doi: 10.3390/ani13233671

31. Kyule, G. and Nguli, J. (2020). Exploring Kenya dairy industry for job creation for the youth. Kenya Institute for Public Policy Research and Analysis. KIPPRA Discussion Paper No. 232. 2020. ISBN 978 9966 817 40 2. https://kippra.or.ke/wp-content/uploads/2021/02/Exploring-Kenya-Dairy-Industry-for-Job-Creation-for-the-Youth-DP232.pdf.

32. Laswai, G. H.; Mgheni, D. M.; Mtenga, L. A.; Ndikumana, J. and Zziwa, E. 2013. Chemical composition and nutritional values of feed resources for ruminants in Eastern and Central Africa (ECA) feedstuff table for ruminants. https://www.researchgate.net/profile/Emmanuel-ziwa/publication/279213657_Chemical_composition_and_nutritional_values_of_feed_resources_for_ruminants_Eastern_and_Central_Africa_ECA_feedstuff_table_for_ruminants/links/5592268608ae1e1f9bb01da5/Chemical-composition-and-nutritional-values-of-feed-resources-for-ruminants-Eastern-and-Central-Africa-ECA-feedstuff-table-for-ruminants.pdf

33. Lize Erasmus. (2023). Moonlight Sonata: University of Pretoria study finds that cows soothed by classical music produce more milk. https://www.up.ac.za/research-matters/news/post_3133767-music-soothes-cows-and-boosts-milk-university-of-pretoria

34. Manimaran, V.; Sathish, M. and Aswitha, K. (2024). Utilization of fruit peels and vegetables for silage Production: a crop – wise analysis. https://krishiscience.co.in/storage/app/finalpdf/PAngAJF6AyGxGVSy6AYfXwRyGMvDbwj6sawMJjha.pdf

35. Manjeli, Y., Teguia, A., Djoukam, J. et al. (1996). Effects of feeding cattle manure on growth performance and carcass characteristics of large white pigs. *Trop Anim Health Prod* 28, 307–311 (1996). https://doi.org/10.1007/BF02240824

36. Marlow, J. (2001). Research on Bovine environment management to yield more milk, Sound Behaviourist, Founder and CEO of Pet Acoustics Inc. https://ecdveterinaria.com/wp-content/uploads/2021/01/Bovine-Music-Research-2019.pdf?srsltid=AfmBOoruiiMfVRcDFs5QmHw-qGFEYi7l_dnwg-rf02ctOAnkNopggD4e

37. Munishamanna K.B., Ajey, G., Veena, R., Kalpana, B., & Palanimuthu V. (2020). Development of Nutrient Enriched Animal Feed from Jackfruit (*Artocarpus heterophyllus L.*) Waste through Solid State Fermentation, Ind. J. Pure App. Biosci. 8(1), 135-144

38. Mellish, K.; Scothorn, D. and VanLeeuwen, J. and Richards, S. (2016). Feeding maize silage to Kenyan dairy cattle. https://www.farmershelpingfarmers.ca/wp-content/uploads/2016/03/cha-28-FEEDING-MAIZE-SILAGE-TO-DAIRY-COWS-21-02-16-2-jv-ds.pdf

39. Merritt Drewery. (2022). Feeding insects to cattle could make meat and milk production more sustainable. The Conversation. https://theconversation.com/feeding-insects-to-cattle-could-make-meat-and-milk-production-more-sustainable-176223

40. Mertens, D. R. (2002). Forage quality evaluation for ruminants. *Journal of Animal Science,* 80(13), 3359-3368.

41. Mohan, M. K.; Maruga Raja; Ravi Manne and Agilandeswari Devarajan. 2021.Benefits of cow dung. *Journal of Natural Remedies.* July 2021.

42. Muthukumar, S.; Saravanan, R.; Kannan, D.; Karthikeyan, N. and Kumaravel, P. (2024). Study of replacement of concentrate feed with jackfruit waste in dairy cow ration. *International Journal of Veterinary Sciences and Animal Husbandry*. 2024; SP-9(5): 10-14 . https://www.ve. ISSN: 2456-2912.VET 2024; SP-9(5): 10-14 © 2024 VET

43. Matovu, M. (2024). Eight dead, 14 rescued in Kiteezi landfill tragedy. Nile Post

44. NPA (National Planning Authority). 2017. Uganda Vision 2040. http://npa.go.ug/wp-content/themes/npatheme/documents/vision2040.pdf.

45. NPHC (National Population and Housing Census). (2024). Preliminary Results. https://www.ubos.org/wp-content/uploads/publications/National-Population-and-Housing-Census-2024-Preliminary-Report.pdf

46. OECD. (2013). "The OECD Action Plan for Youth: Giving Youth a Better Start in the Labour Market." *Paper Presented at the Meeting of the OECD Council at Ministerial Level Paris,* 29–30 May 2013.

47. Prabha, P.H. and M.Saradhambal, M. (2022). Sustainable agro waste processing technique for cattle feed production-a review *International Journal of Novel Research and Development* (IJNRD). Volume 7, Issue 6 June 2022. ISSN: 2456-4184. https://www.ijnrd.org/papers/IJNRD2206004.pdf

48. Prusty, S.; Gendley, M.K.; Singh, A.K.; Dubey, M.; Patil. P.V.; and Sharma, K.V. (2024). Jackfruit waste and peels: Potential as livestock feed. *Indian Journal of Animal Sciences* 94 (5): 395–400, May 2024/Review Article. https://doi.org/10.56093/ijans.v94i5.136138

49. Renee Bullock and Todd Crane. (2021). Young Women's and Men's Opportunity Spaces in Dairy Intensification in Kenya. International Livestock Research Institute. *Rural Sociology*, Vol. 86, No. 4, December 2021.

50. Sampson Edodi. (2023) Managing the environment: issues and priority actions for sustainable waste management in Uganda. *African Geographical Review* 42:3, pages 342-356.

51. Sharmin, M.S., Khan, M.R.I., Kabir, A.K.M.A., Sharifuzzaman, M., Islam, S.M.A., Aktar, S. 2020. Preparation of Wastelage using Poultry Droppings and Wet Rice Straw as a Cattle Feed. Journal of Bangladesh Agricultural University, 18(3): 000–000. https://doi.org/10.5455/JBAU.103080.

52. Sharvini Siva Raman et al. (2022). Opportunities, challenges and solutions for black soldier fly larvae-based animal feed production *Journal of Cleaner Production*. Volume 373, 1 November 2022, 133802. https://www.sciencedirect.com/science/article/pii/S0959652622033789.

53. Smith, T. G. (2017). The rumen microbiome: A key player in ruminant health and productivity. *Animal Frontiers,* 7(1), 10-18.

54. Stanly, M. (2024). Leveraging Artificial Intelligence in dairy farming enhances efficiency and productivity. https://indiaai.gov.in/article/leveraging-ai-in-dairy-farming-enhances-efficiency-and-productivity.

55. Tsegaye, K.; Mekasha, Y. and Bayssa, M. (2024). Effects of inclusion levels of sweetpotato vine silage in the concentrate mixture on feed intake, milk yield and composition of crossbred dairy cows fed natural pasture hay. Livestock Research for Rural Development 36 (4) 2024. https://www.lrrd.cipav.org.co/lrrd36/4/3633kassu.html.

56. Uganda's National Livestock Census 2021 Summary Report. https://ugandavetassociation.org/ugandas-national-livestock-census-2021-summary/

57. van Ryssen, J.B.J. (2018). Wood ash in livestock nutrition: 2. Different uses of wood ash in animal nutrition. *Applied Animal Husbandry & Rural Development* 2018, Volume 11.

58. Waiswa, D. and Günlü, A. (2022) Economic analysis of dairy production in Uganda, a case study on the performance of dairy cattle enterprises in South-western Uganda. Asian journal of agriculture. Volume 6, Number 2, December 2022.

59. Wallace, R. J. (2010). Rumen microbiology and its role in ruminant nutrition. *Animal Feed Science and Technology, 156*(1-2), 1-14.

60. Vasagar, J. (2001). Music hath charms to boost milk yield. https://www.theguardian.com/uk/2001/jun/27/highereducation.research

61. World Bank Report (2023). Uganda - Urban Population. https://tradingeconomics.com/uganda/urban-population-wb-data.html

62. Zewdu Abro et al. (2022). The potential economic benefits of insect-based feed in Uganda. Front. Insect Sci., 10 November 2022. Sec. *Insect Economics*. Volume 2 - 2022 | https://doi.org/10.3389/finsc.2022.96804.

63. Xiao, M. (2017). Turning cow manure into energy. December 17, 2017. Submitted as coursework for PH240, Stanford University, Fall 2017. http://large.stanford.edu/courses/2017/ph240/xiao-m2/

64. Younoussa Millogo, Jean-Emmanuel Aubert, Ahmed Douani Séré, Antonin Fabbri, Jean-Claude. 2016. Earth blocks stabilized by cow-dung. *Materials and structures,* 2016, 49 (11), pp.4583.

ANNEXES

Annex 1: Nutrient Composition of Common Feedstuffs in Urban Dairy Cattle Systems

Feedstuff	Dry matter (%)	Crude protein (%)	Calcium (%)	Phosphorus (%)	Metabolizable Energy (MJ/ kg)
Banana flower	23.9	10.2	0.22	0.52	4.3
Banana leaves	28.9	8.5	0.18	0.4	9.5
Banana peels	16.1	7.4	0.58	0.14	10.7
Banana peels	27.0	7.6	0.11	0.20	8.3
Banana stems	53.4	8.1	0.25	0.31	10.7
Bone ash	89	-	32	18	-
Brewery spent grain	20	25 to 34	0.23	0.53	8.8 to 10
Calliandra leaf hay	80.0	16.7	0.46	0.47	9.0
Cottonseed cake	88	40	0.2	1.2	4.1
Fish meal	88	60	4.37	2.53	9.7
Fresh calliandra fodder	40.9	28.3	0.29	0.55	7.1
Fresh lablab fodder	24.9	22.7.	0.16	0.30	9.9
Grasses from roadsides	28.1	5.6	0.31	0.46	6.2
Homemade concentrate	90	15.8	0.47	0.24	11.7
Jack fruit leaves	55.4	18.8	0.19	0.50	8.4
Lablab hay	88.3	15.6	0.48	0.47	9.0
Lake shells	98	-	36	-	-
Leucaena fodder	41.1	30.4	0.90	0.20	7.8
Maize	88	8	0.17	0.55	12.6
Maize bran	88	9.4	0.04	1.03	9.2
Maize stover	49.5	4.0	0.33	0.44	8.5
Mango leaves	61.1	10.6	0.38	0.44	10.4
Molasses	75	3	0.75	0.08	9.8
Napier grass and forage legume mixtures	23	12	0.26	0.23	9.6
Residues from an intercrop of maize stover and lablab	89	14	0.37	0.51	9.2
Rice bran	88	13.5	0.06	1.43	12.6
Soya bean meal	88	43	0.53	0.64	11.7
Sweetpotato vines	15.4	14.3	0. 87	0.30	10.6

***Source**: Laswai et al. (2013)*

Annex 2: Indicative prices for feeds/fodder and planting materials/seed in Uganda in 2024

1. Feed/Fodder/Seed (Common name)	Scientific name	Unit	Weight per unit	Cost (Ushs)
Mixture of pasture grass and forage legume hay		Bale	15 kg	10,000
Maize silage		bale	100 kg	40,000
Sweetpotato vine silage		bale	100 kg	50,000
Maize stover from farms		Pick-up	1 ton	40,000
Maize stover from Owino market, Kampala		Bag	10 kg	4,000
Dry cut grass from compound		bale	10 kg	4,000
Giant reed from Lubigi swamp	*Arundo donax*	Pick-up	1 ton	50,000
Fresh Napier grass fodder	*Pennisetum purpureum*	Pick-up		70,000
Napier grass silage (round bales)		Bag	100 kg	35,000
Brewery spent grain		kgs	1,000 kg	160,000
Brewery yeast solution		Jerrican	20 litres	5,000
Banana peels		Bag	80 kgs	7,000
Agricultural wastes such as sweetpotato vine from Owino market		Pick-up	1 ton	60,000
Alfalfa hay	*Medicago sativa*	Bale	16 kg	20,000
Calliandra leaf hay	*Calliandra callothysus*	Kg	Kg	6,000
2. Pasture planting materials/seed				
Napier grass cuttings (Pakchong 1 Super Napier grass)	*Pennisetum purpureum*	Bag	300-350 cuttings	30,000
Brachiaria splits	*Brachiaria mulato*	Bag of splits	30 kgs	30,000
Rhodes grass seed	*Chloris gayana*	Kg	1 kg	30,000
Lablab seed	*Lablab purpureus* cv Rongai	Kg	1 kg	30,000
Greenleaf desmodium seed	*Desmodium intortum*	Kg	1 kg	160,000
Centrosema seed	*Centrosema pubescens*	Kg	1 kg	30,000
Siratro seed	*Macroptilum atropurpureum*	Kg	1 kg	30,000
Alfalfa seed	*Medicago sativa*	Kg	10 kg	100,000

Sweetpotato vine (cuttings)	**Ipomoea batatas**	Sack	30 kg	15,000
Calliandra seed	**Calliandra callothysus**	Kg	1 kg	140,000
Calliandra seedling	**Calliandra callothysus**	Seedling	seedling	500
Sesbania seed	**Sesbania sesban**	Kgs	1 kg	80,000
Gliricidia cuttings	**Gliricidia sepium**	Bag	1 kg	40,000
Giant setaria seed	**Setaria sphacelata** var. splendida)	Bag of splits	30 kg	40,000
Chicory seed	**Cichorium intybus**	Kg	1 kg	100,000
Mulberry cuttings	**Morus alba**	Bag	30 kg	40,000
Kikuyu grass cuttings	**Pennisetum clandestinum**	Bag	30 kg	40,000

Annex 3: List of some service providers for dairy cattle inputs/services

Name	Products/services	Location/Contact
1. Austin Farm	• Pastures (fodder and silage) • Pasture seed/planting materials • Establish pastures	Luwero district Tel. contact: +256 774550349/ +256 702738607
2. BrazAfrique Enterprises	• Motorized forage choppers/hammer mill • Silos and garden equipment	Bweyogerere Tel. contact: +256772840968/ 779182521
3. Bulemezi Agro Vet Ltd	• Dairy meal	Container Village Tel. contact: +256 783294653
4. CAPITAL FEEDS	• Diatomeceous earth feed additive (Aflatoxin binder)	Tel: +256 753 476876
5. Highmark Uganda Llimited	• Forage choppers (from Brazil) & other agricultural equipment	Namasuba and Mbarara Tel. contact: +256 751726122
6. Holland GreenTech	• Sticky insect traps • Soil sample analysis • Materials for constructing greenhouse and solar dryers	Mutenga, Kironde road Tel. contact: +256 785369453/706230892
7. Itungo Pastures	• Capacity building / Agritourism • Pasture seed/planting materials • Silage and silage bags • Dairy cows • Establish pastures	Wakiso-Hoima road, Wakiso district Tel. contact: +256 786430790 /705167087
8. Karuhanga Enoch	• Supplies agricultural wastes from Owino market, Kampala	Tel: +256 777348087
9. Kiweebwa Mixed Farm	• Silage production & sale • Diatomaceous earth • Milled pasture grass hay • Napier grass planting materials • Train farmers	Tel: +256 751627759
10. Koudijs- Kaffika	• Calf milk replacer • Mineral blocks • Maziwa Plus • Dairy meal	Tel. contact: +256 755980160
11. Kwewayo Vet Pharmacy	• Veterinary drugs • Heart Girth Tape Measures	Container Village, Kampala, Mbarara and Masaka Tel. contact: +256 772425662/ +256 754866646

Name	Products/services	Location/Contact
12. Kyakuwa Farm	• Capacity building on urban farming (zero grazing dairy system, fish, goat and vegetable production) • Feed/fodder production • Agritourism	Seguku, Kampala-Entebbe road; Tel. contact: +256 777912716
13. Macho power Echo Organics	• Fertilizer • Growth booster for livestock	Tel. contact: +256 772451255
14. MADCO Investment LtD	• Silage production & service delivery • Hire forage choppers • Train farmers • Microbes and yeast	Buwambo Tel. contact: +256 774112810
15. Makerere University College of Agricultural and Environmental Studies	• Forage/feed nutrient & soil analysis • Research and extension services on livestock nutrition, health and breeding • Train youth and farmers	University road, opposite the Main library Tel. contact: +256 414-542277
16. Mindset Change Farm	• Forage choppers • Cattle mats	Kapeeka, and Luwero district Tel. Contact: +256 773078000
17. National Animal Genetic Resources Centre and Data Bank (NAGRC&DB)	• Semen for cattle, pigs, goats • Liquid nitrogen plants • Offers specialized training to technicians dealing in animal breeding. • Provides guidance in breeding and multiplication of improved breeds. • Promotes herd-recording, and performance testing on farms.	Plot 98 -106, Nsamizi Road Entebbe, Uganda Tel. Contact: +256 755805020
18. National Livestock Resources Research Institute (NaLIRRI)	• Research and technology dissemination (livestock nutrition, health and breeding) • Pasture seed/planting materials • Forage/feed nutrient analysis	Gayaza-Zirobwe road Tel. contact: +256 414-691047

19. Nkenenee Crofty	• Consultant on hydroponic ,aeroponic, aquaponic (Soilless farming) production systems • Capacity building on urban farming.	Tel. +256 752912127/777912127
20. Nutrafol calf pellets	• Calf pellets	Natete Tel: +256 704534718
21. REACH OUT TO THE YOUTH AFRICA	• Pasture seed/planting materials • Pasture establishment • Capacity building	Gayaza Tel. : +256706177025 or +256773683265
22. ROBRAN Holdings	• Pasture establishment • Capacity building • Feedlot • Mineral blocks	Kabanyolo. Gayaza-Zirobwe road Tel. contact: +256 78491350
23. Sight Farm Namu-longe Ltd	• Pasture seed/planting materials • Semen • AI services • Agrotourism • Pasture seeds, planting materials and establishment • Farm outreach services • Modern technologies on zero grazing • Training farm managers • Forage chopper hiring • Crop consultations	Namulonge, Gayaza-Zirobwe road Tel. contact: +256 752042995/704508275
24. Task Farm	• Solar driers • Greenhouses • Hydroponic systems • Vegetable nursery management • Agriculture consultancy • Irrigation systems	Rubaga near Rubaga church; Tel. contact: +256 788500968/ 072747326/0703490927
25. The Green Elephant Uganda	• Pakchong 1 Super Napier grass silage (round bales)	Kajjansi, Kampala-Entebbe road Tel. contact: +256 759752339
26. URUS- Uganda	• Milking machines, • Coolers and milk hygiene • Milk processing equipment • Genetic and supportive products	Kigo near Serena Hotel Tel. contact: +256 772895461

Annex 4: Some Important Whatsapp Groups Focussing on Crop, Fish and Livestock Production

Group	Major focus	Contact of Group Administrator
1. Cattle Farmers	• Livestock	+256 702850600
2. Cattle Generation	• Livestock	+256 772451255/+256 703352364
3. D & R Cattle Uganda	• Livestock	+256 772553732
4. Dairy Farmers Network (DAFAN)	• Dairy cattle	+256 77247006 and +256 774112810
5. Digital Extension-Heifer	• Digital Extension services	+256 784943861
6. Eastern and Southern African Dairy Association (ESADA)	• Livestock	+254 720616948
7. FARMEC PIGGERY	• Pig production	+256 703715439
8. Friends of KCCA (Kampala City Capital Authority), Kyanja	• Urban Farming	+256 785773968
9. GO FARMING	• Livestock and crops	+256 757634981
10. Green-X-Change Agri&Food	• Agriculture and food value chain	+254 752708535
11. Grow Brachiaria Grass	• Pastures/Brachiaria	+254 798447012
12. Harvest Money	• Crops, Fish & livestock	+256 789353585/ 708092355
13. HIGH MARK-WAST-LIVESTOCK & ALL FARM CONSULTANCY	• Livestock, crops and waste management	+256 750661998
14. Kaffiika-Khoudjis	• Dairy concentrates • Milk replacer for calves • Mineral blocks • Poultry feeds	+256 755980160
15. KAIFFA UGANDA	• Fish	+256 782019059
16. Livestock Development Forum (LDF)	• Livestock (all species)	+256 783390238
17. NECJOGHA MENTORING CENTRE	Climate/weather information	+256 772402659
18. Pasture Agronomist	• Pastures	+256 751566866
19. Research and Development Group	• Agricultural research and development	+256 772337117
20. Task Farm	• Vegetable seedling, production of solar dryers, irrigation and greenhouses etc.	+256 788500968

Group	Major focus	Contact of Group Administrator
21. U-FARM Pastures	• Pastures	+256 785692313
22. UG AG-EXTENSION PLATFORM (Uganda Agriculture Extension Platform)	• Extension services	+256 774536906
23. UG NAT. FARMERS FEDERATION (Uganda National Farmers Federation)	• Extension services	+256 787277014
24. Uganda Dairy Goat Farmers	• Dairy goats	+256 754224190
25. Uganda Dairy Farmers Forum	• Livestock	+256 782046118
26. Uganda Veterinary Forum	• Extension services	+256 756172112

Dairy Farmers' Network (DAFAN) – Uganda

Location: Old Mulago Hill, Kampala, Uganda. **Tel**: +256 778 496096, 0755112810, 0772470060.

Website: www.dafan.co.ug; **E-mail**: dafannetwork@gmail.com

Back ground

The Dairy Farmers' Network (DAFAN) is a farmer organization that is registered under the companies **Act No.1 of 2012** or as a business under the business name registration **Act Cap 110**. The network has a membership of over 300 dairy farmers (49% female, 10% youths) and development partners. The Network currently operates in the districts of Mukono, Buikwe, Mpigi, Luweero, Nakaseke, Lira, Gulu, Nakasongola, Kampala, Jinja, Mityana, Kyenjojo, Mbarara, Wakiso, Kayunga and others.

Vision

DAFAN shall bench mark for modern and improved climate smart dairy farming technologies and innovations in Uganda and beyond while enhancing the quality of the environment.

Mission

DAFAN promotes a practical farmer oriented dairy farming network geared towards production of safe, quality assured products in a sustainable manner that underpins the future of dairy farming industry in Uganda.

Objectives

- Develop a robust dairy farmers' cantered network aimed at enhancing information gathering and sharing.
- Increase household income through enhancing dairy farmers' awareness on sustainable and profitable climate smart dairy farming technologies and innovations.

- Foster collaboration with key players in development of dairy farming in Uganda and beyond.
- Create an integrated dairy value chain system which is in compliance with the National Environmental Policy.
- Build a strong bargaining, market oriented farmers' network with the capacity to explore local, regional and international market.
- Participate in the development (research) and promotion of climate smart dairy farming technologies, innovations and managing practices.
- **Bring services and inputs closer to rural communities through establishing "resource centres and demonstration farms".**
- Encourage families, youth and women to start commercial dairy farming as a means of wealth creation.

Executive committee

DAFAN has an executive committee which consists of the Chairperson, Vice Chairperson, General Secretary and Zone/Cluster Leaders who represent different areas/districts were farmers come. The Cluster leaders help in mobilization and communication.

Current Executive

Designation	**Name**	**Contact**
Chairperson	Dr. Sekimpi Patrick	0772470060
Vice Chairperson	Mr. Bariyo Benson	0782850500
DAFAN Savings Group	Mr. Kaggwa Daniel	0772489932,0704489932
Treasurer	Mrs. Kibirango Immaculate	0777445559
General Secretary	Mrs. Namabiro Martha Matovu	0755112810, 0774112810
Zone leaders		
Gayaza	Mr. Lugoloobi Henry Sight	0772508275, 0704508275
Wakiso	Mr. Muhairwe Julius	0772658055
Mukono	Mr. Sabika Moses	0752975221, 0782975221
Nakaseke	Maj. Kawesa Kigozi	0772343150.
Fortportal	Mrs. Kaliba Kitalengwa	0772641754.
Kampala-Entebbe	Prof. Kabirizi Jolly M. L. (PhD)	0777912716.

Source of Funds

DAFAN currently sources its funds through projects funded by development partners such as Bimeda, Semex, URUS and Coopers Ltd. It also gets finance from members through payment of membership fee. DAFAN has a committee that is responsible for the preparation and submission of funding proposals.

Membership Registration

A membership fee of Ushs 150,000 (about U$ 40) is paid on registration and annual fee of Ushs 100,000 (U$ about 27) for the smooth running of the group growth.

DAFAN ACTIVITIES

(1) Monthly study meetings

DAFAN members hold monthly meetings to discuss dairy farming challenges, possible interventions and to plan activities for group members. The meetings are held on a member's farm or a nearby research institute/training hall.

Dairy farmers workshop held at Silver springs Bugolobi where the guest presenters were two Irish nationals, Dr Padraig Hyland and Dr Nick McHardy and Mr. Pierre Marx, a South African national.

During the monthly study meetings, an expert is invited to train members on a given topic related to dairy farming. The workshops are open to all farmers and youths. This can also be done in conjunction with other development partners. After the meeting, members visit the farm or research institute to share ideas on dairy cattle management, nutrition, disease control, record keeping, breeds and breeding and others. Members also share their challenges and success stories.

(2) Farm visits/agritourism

Agritourism is a form of commercial enterprise that links dairy cattle production and/or processing with tourism to attract visitors onto a farm, ranch, or other agricultural business for the purposes of educating the visitors/farmers while generating income for the farm owner. Agritourism gives dairy farmers and youth an opportunity an avenue for direct marketing of their products to consumers.

A farmer visiting Gaza Dairy Farm in Busiika, Luwero district owned by Dr. Sekimpi Patrick

(3) Fodder/feed production

Feed and fodder are pivotal to the dairy sector, accounting for 60 to 70% of total costs. Proper feeding improves animal immunity, health, welfare, and reproductive performance; enables higher productivity under a given management regime and contributes to environmental sustainability by converting energy and nutrients from land that is unusable by humans into highly nutritious food. However, the demand for high quality feed resources has outstripped supply, leaving dairy cattle undernourished and impacting productivity that compromises the livelihoods of many farmers dependent on the dairy sector. DAFAN empowers youth, men and women with skills and knowledge on fodder/feed production as a measure to mitigate the gross challenge of poor dairy cattle nutrition and unemployment.

Mrs. Jolly Asiimwe, one of the Directors of Itungo Pastures in Wakiso district and a member of DAFAN is involved in commercial production of fodder varieties such as Rhodes grass, Pakchong 1 Super Napier grass, forage sorghum, alfalfa, stylo, siratro, glycine and different sweet potatoes varieties.

Mrs. Jolly Asiimwe, Itungo Pastures carrying Pakchong 1 Napier grass fodder

(4) Commercial Production of Pasture Seed/Planting Materials

Availability of affordable pasture seed/planting materials is a very important input in dairy cattle production and sustainability is not guaranteed if access to improved pasture cultivars is hampered. With the projected increase in demand for dairy products, more feed and fodder will be required and natural pastures alone will not sustain dairy cattle production. Limited/high cost or/and poor quality pasture seed supply remains one of the major challenges affecting adoption of improved forage cultivars in dairy cattle systems in Uganda. Members of DAFAN produce quality pasture seed/planting materials for sale to livestock farmers.

(5) Service Provision For Fodder/Feed Production

The idea of service delivery for silage, hay and concentrate feed production is practiced by some DAFAN members. The members offer services for mechanized harvesting and processing of pastures into hay or silage. Intensification of forage planting also create increased demand for these services, make investments in machinery interesting and create jobs.

Mrs. Martha Matovu (a youth and member of DAFAN) makes silage for farmers and hires out forage choppers

(6) Participatory on-farm research

DAFAN members participate in on-farm trial to develop climate smart dairy cattle technologies and innovations in collaboration with local and international research institutions and organizations. The major objective is to develop technologies to address challenges of poor dairy cattle performance.

The "**Climate Smart Sweetpotato Vines Silage Innovation**" was developed at Mr. Henry Lugoloobi's (a member of DAFAN) Sight Farm, Namulonge, Wakiso district. The study was funded by the International Potato Center (CIP) and implemented by a youth group *(Bavubuka Twekembe)* in collaboration with Makerere University, Kyakuwa Farm and other stakeholders. The adoption of sweet potato vines silage has reduced the need for costly commercial feed and mitigate both the wastage caused by spoilage of fresh sweet potato vines at harvest and recurrent feed scarcity during the dry season. This has translated into a lucrative business opportunity for Agri-Small and Medium Enterprises. Youth (women and men) working in urban food markets are earning income through sale of sweet potato to farmers to make silage. This has contributed to a clean environmental in markets, reduced disease incidences due to poor hygiene and improved their livelihoods.

Pakchong 1 Napier Grass ("Super Napier") was introduced from Thailand, evaluated and promoted in Uganda by a team of researchers from The Green Elephant, a Dutch/ Ugandan private enterprise looking to contribute to clean, affordable and sustainable energy in Uganda. The Green Elephant is a member of DAFAN. The research team included Prof. (Dr.) Jolly Kabirizi, a senior forage scientist who is also a member of DAFAN. Super Napier grass is currently revolutionizing small-scale dairy cattle farming in Uganda, Rwanda, Tanzania, Burundi and Kenya. Smallholder dairy cattle farmers attest that milk production has doubled as a result of feeding Super Napier grass fodder supplemented with forage legumes, minerals, vitamins and a concentrate.

(7) Regional Farm Tours

DAFAN members hold at least one regional tour across East and Central Africa every year to study how other farmers manage their dairy farms. These tours involve trainings and farm visits among others. DAFAN members have visited dairy farms and cooperative organizations in Kiambu, Naivasha and Eldoret, Kenya.

DAFAN members arrive at One Farm in Kiambu, Kenya

(8) International Trips

Bimeda International sponsored DAFAN Chairperson to visit dairy farms in the Republic of Ireland on behalf of DAFAN. He toured four dairy farms, the Irish Farmers Federation and Arrabawn cooperative. He later shared his experience with other DAFAN members.

Dr. Sekimpi Patrick with an Irish dairy farmer

(9) Uganda Best Farmers Awards

The "Best Farmers Competition" is an initiative aimed at recognizing and promoting excellence in farming practices in Uganda. It is designed to showcase the best practices, innovations, and technologies in agriculture, and to encourage more farmers to adopt these practices. It is held annually to celebrate farmers, showcase how farming is contributing to economic development of the country and rally the public to embrace commercial farming.

The Best Farmers Awards are organized by Vision Group in partnership with DFCU Bank, KLM Airlines, Koudijs Animal Nutrition, The Kingdom of Netherlands among others. Since the competitions began in 2014, ten DAFAN members have received awards for being among the top best 12 farmers in Uganda. The best farmers are facilitated to travel to The Netherlands to visit and learn from successful farmers.

Henry Lugoloobi Ssalongo, Director, Sight Farm-Namulonge was declared 2023's second best farmer in Uganda. Congratulations

On 11th December 2024, DAFAN was recognized as one of the three best farmer cooperatives.

2nd runner-up National Cooperative Award (19th December 2024)

Benefits of Being a Member of DAFAN

(1) **Social capital:** DAFAN is a platform with members from different sectors. Members are very cooperative and ready to offer help beyond dairy farming. DAFAN members contributed to the printing of a book produced by Prof. (Dr.) Jolly Kabirizi, *"Unlocking the potential of feed production technologies, innovations and management practices of smallholder dairy cattle farmers in Uganda. February 2023. ISBN. 9789970675951".* Many farmers and youth within and outside Uganda attest that they have been able to improve their dairy farming business and/or income using information in this book. *"Remember your social capital is your net worth".*

(2) **Sense of Belonging (DAFAN Reference as a Member):** If you need a reference letter as a farmer.

(3) **Information Sharing:** Members enjoy a lot of benefits that includes input procurement, market information, trainings, information, high quality dairy breeds/ semen and veterinary services. In addition to learning life skills, youth who raise dairy cows are learning how to produce food that is wholesome and nutritious. Boys and girls and young men and women are entitled to the kind of training and experience that will enable them to enjoy life to the fullest and to meet with eagerness, assurance, and satisfaction their social and economic responsibilities of both the present and the future.

(4) **Collaboration/Networking:** It is a bridge between farmers, government, non-government and international organisations. Through DAFAN, some members have received milking equipment, forage choppers and/or pasture seed from the Dairy Development Authority (DDA), Uganda and sexed semen from URUS and The National Animal Genetic Resources Centre and Data Bank. DAFAN members have been collaborating with Makerere University, National Agricultural Research Organization (NARO), International Potato Center (CIP), Heifer International and others to develop and/or disseminate improved dairy cattle technologies.

(5) **Dairy Marketing Strategy:** Members advertise and market their services, products and inputs through DAFAN platforms such as DAFAN- Uganda WhatsApp group and website. Some members have purchased milk cooling equipment. Members benefit from a range of schemes to further improve their dairy farming business.

(6) **National and International Consultancies:** DAFAN members have participated in national and international consultancies such as *'Cross boarder study on sustainable use of rangelands and cross-border natural grazing resources: the case of Karamoja pastoral area in Uganda"* funded by African Union and IGAD (Intergovernmental Authority on Development) and *"Training of feed service providers (youths) and farmers in silage and microbes production"* funded by Heifer International.

(7) **Joint Savings Account:** Members have a savings account to boost their farm activities.

(8) **Farm Visits as Hosts:** Members are given first chance to host the farm visits or as may be discussed from the executive committee.

Way Forward

(1) DAFAN will continue to form clusters, set up dairy collection centres, in different zones/clusters which will help farmers sell their milk and easy access to many dairy farming products.

(2) Regional clusters will be formed and hold meetings to ensure a sustainable dairy farming business. The clusters will serve to promote the vision, mission and objectives of DAFAN.

(3) DAFAN members will continue to source for funds for projects aimed at improving productivity along the dairy value chain.

DEDICATION

This book is dedicated to ***the women dairy cattle farmers in Uganda.*** *The women are largely responsible for feeding, watering, and milking the cows as well as cleaning the stalls and managing the manure. These are activities that must be undertaken every day or the health and productivity of the cow will be jeopardized. Dairy cattle farming has led to positive changes in the lives of women farmers, economically and socially. The women have become very stable, financially, as are able to increase their daily milk output. Socially too, women feel they are better recognized now than before. Today, women have roles to play on behalf of other female farmers in the dairy sector. Women should therefore be supported with improved technologies, innovations and management practices to participate in dairy cattle production as a full time employment with sufficient income generated on a regular basis.*

Men should be encouraged to incorporate their spouses on empowerment matters e.g. allow them to own land and make decisions. There should be efforts to strengthen small dairy cattle business organizations that are farmer (women) owned and managed, facilitated and coordinated investments in smallholder dairy sector and there should be concerted efforts towards value addition in dairy production.

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