STATUS OF FODDER PRODUCTION AND CONSERVATION, AND EFFECT OF GRASS-LEGUME SILAGE ON MILK PRODUCTION IN BURUNDI

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DECLARATION AND RECOMMENDATION

Declaration

This thesis is my original work and has not been presented in this University or any other for the award of a degree.

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Recommendation

This thesis has been submitted with our approval as university supervisors.

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DEDICATION

To Almighty God, creator of heaven and earth, full of love and peace, who has guided and protected us until now. This work is dedicated to my dear husband, Jean Japhet Nakintije, and my beloved children, Alpha Franck Iteka, Beta Japhina Impundu, Gamma Karen Ineza, and Brian Gift Inganji. Your love gave me the strength to accomplish this work. May God protect and bless you. I also dedicate this work to the family of Dr. Désiré Ntakirutimana and his wife, Francine Kwizera. Your advice will be unforgettable and the results of your guidance are evident here. Dedications are also addressed to my parents, brothers, and sisters. You stayed with my family while I was completing this work. May the almighty Lord bless you and your families. To all our friends and classmates at Egerton University,

I dedicate this work.

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ABSTRACT

As Burundi adopted the zero-grazing policy, fodder scarcity remained prevalent, especially during the dry season. This study assessed fodder production and conservation practices among smallholder dairy farmers and determined effective feeding strategies for improving milk production in the Imbo plain of Burundi. To achieve this, a survey was conducted with 384 smallholders' dairy farmers beneficiaries of the PRDAIGL project. It evaluated fodder production and conservation practices in the Imbo plain region. To identify the best feeding strategy for increasing milk yield, livestock feed was improved using a mixture of grass-legume silages. A feeding experiment was conducted over a period of 28days using nine randomly selected lactating cows at Randa public farm. Survey data were processed using IBM SPSS statistics version 20. Descriptive statistics were applied to analysis numerical data,while cross-tabulation was used for categorical variables. Experimental data were subjected to analysis of variance (ANOVA) using R software version 4.4.1 to evaluate differences among means. Fresh and ensiled fodder, along with milk samples were examined for their proximate nutrient content. The assessment of the effect of the mixture of *Cenchrus purpureus (*Napier grass*)-Velvet bean (*Mucuna pruriens*)* silage and Maize stalk -*Velvet bean* silage on body weight change, milk production, and milk composition was also evaluated.

The results showed low adoption of fodder conservation (38.00%), with silage making at only 1%. The DM and CP were higher in *Cenchrus purpureus-Velvet bean* silage than in Maize stalk -*Velvet bean* silage. However, the Crude fiber, Ash, and Crude Fat were higher in Maize stalk -*Velvet bean* silage compared to *Cenchrus purpureus-Velvet bean* silage. Milk yield showed significant variation between the treatment groups,with cows receiving the Maize stalk-Velvet bean silage producticing more milk(7.53±1.52 kg) than those fed the Cenchrus purpureus-velvet bean silage(5.36±1.07 kg). Significante difference($P<0.05$) were noted in solid not fat (SNF), lactose, and salt concentration in the milk whereas Fat and Protein content did not differ significantly ($P>0.05$) among the groups. The study concluded that, the low adoption of fodder conservation resulted to the lack of knowledge which was associated with low education level of smallholder dairy farmers, which led to issues adoption of innovations and technology related to animal nutrition. The study concluded also that the increase in milk production and quality depends on the improvement of the nutritive value of feed, and the incorporation of grasses and legumes (80%-20%) and their conservation in the form of silage increased milk production, affect milk composition, and body weight change for dairy cows.

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LIST OF ABBREVIATIONS AND ACRONYMS

ADF	Acid Detergent Fiber
CF	Crude Fiber
CP	Crude Protein
DM	Dry matter
EE	Ether Extracts
FSSAI	Food Safety and Standards Authority of India
ISABU	Institut des sciences Agronomiques du Burundi
Kes	Kenya shilling
LASPA	Laboratoire d'Analyse des Sols et des Produits Agroalimentaires
N	Nitrogen
NDF	Neutral Detergent Fiber
OM	Organic Matter
PRDAIGL	Projet Régionale de Développement Agricole intégré dans les Grand Lacs
SNF	Solid Not Fat
TDN	Total Digestible Nutrient
WSC	Water-Soluble Carbohydrate
^{o}C	degree Celsius

CHAPTER ONE
INTRODUCTION

1.1 Background Information

In Burundi, Sustainable dairy milk production faces challenges due to the seasonal variation in the availability of animal feed. While the rainy season provides an abundance of fodder, the dry season is marked by a significant shortage. Moreover, the feed availability during the dry season period tended to have poor nutritional value. The fluctuation, along with imbalanced and insufficient feeding practices, presented key issues that contributed to lower overall milk output and reduced productivity per cow. (Mengistu, 2019). In developed countries, Maize stalk was one of the most important annual cereal crops that provided food and was used as a source of income for many populations. It was considered a source of carbohydrates for human diets and animal feed. (Mengistu, 2019).

To alleviate the dry season feeding problems, it was important to train farmers on how to produce fodder and conserve the surplus fodder available in the wet season. Fodder production and conservation were considered as a crucial sustainable intervention to increase household income and nutrition sources through improved animal production. The high cost of commercially produced stock feed was beyond the reach of smallholders. Cultivation, processing (silage making), and preservation of high-yielding fodder (e.g., *Cenchrus purpureus*, Maize stalk, *Velvet bean*) could minimize feed shortage during the dry season period. The major problem faced by smallholder dairy farms was finding feed during the dry season. Some were forced to buy fresh fodder, which remained insufficient.

Maize stalk is widely utilized as a key feed source due to its high availability and affordability. Due to these advantages, it is considered a low-quality forage because it contains high levels of fibrous components, primarily cellulose (34%), hemicellulose (37.5%), and lignin (22%). Hay refers to forage that has been dried in the open air until its moisture level drops to between18% and 22%. In contrast, silage is produced through fermentation in the absence of oxygen, where natural sugars break down under acid conditions. (Orodho, 2006). Specifically, the definition of hay and silage can be traced to the dry matter content (DM) of the stored crops. Nevertheless, the quality of silage depended on several factors, including species of plants, agrotechnical procedures and practices involved, time of preparation, inoculants applied, as well as plant growth stage at which the silage was prepared, among others (Bijelic et al., 2015). Consequently, beans, which are a good source of protein, became highly difficult to ensile because of the low level of easily soluble carbohydrates. Their mixture of grass, in any event, might improve their fermentation properties.

This study aimed to increase milk production for small-scale farmers in the dry season by feeding a mixture of *Cenchrus purpureus* - *Velvet bean* and Maize stalk - *Velvet bean* silage in the Imbo plain of Burundi.

1.2. Statement of the Problem

The Imbo Plain has an average temperature and rainfall ranging from 25°C and 900mm/year, respectively, with a dry season of six months. In October 2021, Burundi introduced a zero-grazing policy. While this policy was progressively adopted, fodder availability remained very low, particularly during the dry season. The conservation of fodder in the form of silage, which could prevent the feed shortage in this period, was not well adopted, and the fodder was of low quality. This resulted in a decrease in milk production and quality. The effect of improved feeding all year round on milk production was not well known, and the improvement of the nutritive value of the feed was not well adopted. This led to dry-season feed scarcity, which resulted in a decrease in milk production and household income. Since maize was the most established fodder, the increase in the nutritive value of available grasses through its mixture with rich protein sources such as legumes could prevent the dry season feed scarcity and increase household incomes, and prevent challenges in food and nutrition security.

1.3. Objectives

1.3.1. Overall Objective

To boost milk production by providing sufficient and high-quality feed all year round to support sustainable household incomes.

1.3.2. Specific Objectives

i. To assess the forage production and conservation practices in the Imbo Plain of Burundi.
ii. To determine the forage mixing ratios for *Cenchrus purpureus* (Napier grass), *Velvet bean* (Mucuna pruriens), and Maize stalk: *Velvet bean* silage.
iii. To evaluate the effect of feeding dairy cattle with *Cenchrus purpureus: Velvet bean*, or Maize stalk: *Velvet bean* silage on body weight change, milk production, and quality.

1.4. Hypotheses

i. There was no significant difference in forage production and conservation practices in the Imbo Plain of Burundi.
ii. There was no significant difference in forage mixing ratios for mixed crop silages comprised of *Cenchrus purpureus*: *Velvet bean* or Maize stalk: *Velvet bean*.
iii. The feeding of dairy cattle with *Cenchrus purpureus*: *Velvet bean*, or Maize stalk: *Velvet bean*

silage has no significant effect on body weight gain, milk production, and quality.

1.5. Justification

Burundi has adopted the zero-grazing policy, and smallholders have problems supplying enough fodder in the dry season. This has led to a decrease in milk production in relation to sustained demand led to an increase in milk price. In this area, the primary crops were maize and rice, which are primarily used for human consumption. The use of crop residues was not well adopted. This has resulted in feed scarcity, which has caused a decrease in animal product, decreased household income, and challenges in food and nutrition security. Since fodder was available during the wet season, it was necessary to conserve part of it to ensure a sustained supply during the dry season. To achieve livestock production, smallholder farmers have to practice the recommended breeding and feeding practices. The leguminous utilized as animal feed in Burundi was *velvet beans. Velvet bean* was the leguminous plant used in Burundi as animal feed. Since public and private investors have embarked on developing dairy animals, it was necessary to contribute to increasing milk production by improving feed quality. *Cenchrus purpureus* and maize stalk were common forages fed to cattle in Burundi, but the best mixing ratios in silage production and their effects on milk production and quality were not well known.

1.6. Scope, Limitations, and Assumptions

The study took place in the Imbo Plain region of Burundi. Three phases (survey, forage establishment, and experiment) were involved with the study. A survey covered 384 smallholder dairy farmers from the PRDAIGL project, located in five provinces of this plain. Human and material resources were needed, and the study lasted for six months. The main limitation of this study was to find experimental animals with the same average age, body weight, milk production, and parity. Due to this, housing was only done depending on the average body weight and milk production.

CHAPTER TWO
LITERATURE REVIEW

2.1. Importance of Livestock Farming

Livestock plays a very important role in the economy of Burundi. It contributes to fighting against poverty and procures food and nutrients required for the population to maintain health. Livestock is mostly comprised of different species of cattle, pigs, goats, sheep, poultry, and rabbits. Some of these species are local (Ankole cattle) or imported (Holstein Friesian cattle). Livestock provide meat, milk, and eggs, used in human nutrition. Livestock also provides manure to be used in agriculture for soil fertility. Milk production is mainly used for human consumption. For smallholder dairy farmers, milk production provides income to help them in their needs (school fees, hospital fees…). For most dairy farmers, the milk produced is sold through cooperatives. The organization of the milk value chain is a very important strategy to help farmers in increasing milk production and achieving outcomes. Milk is consumed as raw milk, pasteurized milk, milk powder, and yoghurt. By providing meat, livestock comes as a protein source, a very important nutrient needed for growth, production, reproduction, and maintaining health. It contributes to the fight against malnutrition in infant and adult farmers. Smallholder dairy farmers also received an outcome from the sale of meat. Manure from livestock helps farmers to maintain soil fertility as well as the population growth increases exponentially, and the arable land is subdivided, making smallholder dairy farmers landless

2.2. Burundi Dairy Farming

There existed several species of breeds. Include cattle, goat, sheep, camels, and dromedaries. Burundi dairy farming was mainly made on different species of cattle, some of them were local and others imported. Among these, cattle were grouped in dairy production, and Others with mixed finality (cattle that can produce milk and meat). The genetic structure of dairy cows was diverse. They reported the presence of improved cows (crossing of local breeds with exotic breeds) and local breeds (Ankole). Most farms combined cattle breeding with other animals, in particular sheep and goats. The average cattle herd size was 6.0 ± 1.5 and 5.0+/-2 (Most farms also have two cattle production systems. The first was an exclusively dairy system, and the second was a mixed speculation oriented towards both milk and meat products (Albert et al., 2024).

2. 3. Dairy production Breeds

2.3.1. Holstein Friesian

The Holstein Friesian breed originated in Holland and was distributed worldwide later. It had been raised in Scandinavian countries, Britain, North America, Africa, Asia, and

especially in the Middle East due to its adaptability to hot climates and high milk production. The breed is known for its general morphological characteristics, particularly its black, white, and red and white coat. The red color was a recessive and less desirable trait. Friesian cattle are the largest dairy breed. The average weight ranges from 600 to 650 kg, while a bull weighs between 800 and 850 kg. At birth, calves typically weigh 35- 45 kg. Holsteins were characterized by their large body shape and high milk production per cow. Holstein milk was also rich in useful matter, with an average fat and protein content of 3.54% and 3.08% respectively.

2.3.2. Montbéliard

Montbéliard was the pie rouge breed chosen by its productivity and size, with rapid growth. The quality of carcasses was also the main factor for the appreciation of this breed. Montbéliard was highly performance and was classified as an ultra-specialized dairy livestock that meets the requirements of all cattle breeders.

2.3.3. Ayrshire

This breed was the breed mainly liked for its milk production. It was also known for its milk content, especially milk fat and protein. Ayrshire was formed by crossbreeding cattle or infusion of blood from different cattle, including Jersey. (Zinnatov et al., 2024).

2.3.4. Jersey

Among all the imported dairy breeds, Jersey was the minor. It was the breed that was known to have a variety of colors that range between dark brown and light brown, with strains exhibiting white spots. Light skin pigmentation and white spots on hair are essential to adapting to climates (Opoola Oluyinka et al., 2021).

2.4. Mixed Production Breeds

The most abundant breed found in Burundi was the local breed named Ankolé. This cow was found in most all East Africa. This name was from the Ankolé region of southern Uganda. Ankolé was a cross between a long-taurine and a short-horned zebu. The Ankolé has a fine skeleton and long, thin, white horns. Coats were usually uniform: mahogany, brown, dark red, or sometimes piebald.

2.5. Fodder Production and Management

Fodder production was the focus of projects in Sub-Saharan Africa and played a major role in livestock feeding. If no high-quality fodder was preserved, farmers observed the poor quality of the available fodder sources during the dry season. A scarcity of forage is another result of the lack of rainfall. This made farmers walk longer distances to fetch fodder from sites

with reasonable vegetation. In some regions, some farmers fed Banana stems to their livestock (Ndah et al., 2017). Green fodder played a major role in feeding livestock. It provided the required nutrients for milk production and the health of dairy animals. However, fodder production and animal feeding were aspects of the sustainability of products and productivity in animals. Forage availability was observed in the wet season, while feeds are scarce and of poor quality during the dry season. This resulted in poor feeding, and consequently, dairy cattle suffered severe nutritional stresses, which decreased productivity.

2.5.1 *Cenchrus Purpureus* Production

Cenchrus purpureus was the major feedstuff in the smallholder dairy production system. This fodder crop was grown alone or in a mixture with legumes, which could improve its quality. Dairy cattle prefer Napier grass in intensive and semi-intensive systems due to its high biomass (10-40t/ha). More than 70 percent of smallholder dairy farmers grow Napier grass, which is the major animal feed. In the case of smallholder dairy farms, it constituted 40-80 percent of the fodder. Also, there were many non-animal producers who produced fresh or preserved Napier grass fodder to be sold to dairy farmers. Napier grass is a quick growing perennial grass which has deep roots and whose height can attain as high as 4 meters. It is capable of propagating using ground stems to form a massive ground cover (Kabirizi, 2015).2.5.2. Importance of Napier Grass for Smallholder Farmers

Cenchrus purpureus played a central role to the smallholder dairy farmers. It is considered the main cattle food in the dairy production systems. Due to the population growth, farmers were landless, and animals are fed on *Cenchrus purpureus* under zero grazing. *Cenchrus purpureus* has the most promising and highest-yielding fodder(Orodho, 2006).

2.5.3. Characteristics of *Cenchrus purpureus*

The leaf of *Cenchrus purpureus* is wide and flat, measuring up to 3 cm wide and 30-90 cm in length. It can also form thick clumps. It was vegetatively established by using stem cuttings or division of a crown. *Cenchrus purpureus* is predicted to need more than 1000 mm of rainfall per year. Due to its large root system, *Cenchrus purpureus* is able to survive a light dry season (three to four months). Reduced growth was caused by low temperatures at high altitudes (above 2100m). Its best temperature and rainfall range is between 25 and 40 degrees Celsius. Fertile soils produced best growth and yield of *Cenchrus purpureus* (Orodho, 2006).

2.5.4. Maize Production

Across southern and Eastern Africa, maize was the main food, which provided a large amount of calories when it was supplied with sufficient nitrogen. *Zea mays* was produced throughout the world. It accounts for 30-50% of low-income household expenditures. Maize contained about 72% of starch, 10%of protein, 4%of fat, and about 365kcal/100g energy. the worldwide, maize is consumed as food. In Africa, most 30% of the population consumed maize as the main food. The production of maize was about 21% in Sub Saharan Africa. After rice and wheat, maize was said to be the third most important crop worldwide. Due to its maximum yield potential among the cereals, maize was referred to as the "queen of cereals" around the world (Adeniyi & Ariwoola, 2019). However, Snapp et al. (2014) found that during the dry season, maize stalks were the most accessible feed for the smallholder dairy industry.

2.5.5. Characteristics of *Zea mays*

Zea mays is a monocot of the grass family. The maize plant contains two different systems:

-The vegetative apparatus: included the stem with a height varying from 1.5-2.5 m, presented almost cylindrical internodes and with a diameter varying from 3-4cm. This constituted a selection parameter for resistance against drought. The leaves were alternate, and each had an embracing sheath provided with abundant hairs depending on the variety. There were generally between 8-20 leaves. The root system of corn was of the fascicle type, with the main root coming from the seminal roots, the secondary roots constituting the functional part, and the anchor roots, which help to consolidate the attachment of the plant to the ground.

-Reproductive system: The Maize plant was a plant with a sexual physiological gradient (the male character dominates at the top with a panicle grouping the male flowers. The female character was found in the middle third of the plant in the form of ears, generally made up of female flowers. *Zea mays* was a plant that had very high demand in terms of light. It was a plant that was very sensitive to variations in soil fertility. It responds well to fertilizer inputs, particularly nitrogen. The rainfall required for growing corn was greater than 700-800mm.

2.5.6. *Velvet Bean* Production

Velvet bean, a tropically adapted legume cover crop, is highly valued in sustainable farming systems globally due to its effectiveness as a green manure and potential as a protein-rich feed. It is a high-yielding leguminous forage crop, with a crude protein content of 26%. *Velvet bean* can be grown alone or mixed with other crops, offering grazing or fodder during

the dry season. It hays and silage serve as supplementary feed, enhancing the digestibility of low-quality roughages such as maize stalk.

2.5.7. Important *Velvet Bean* for Smallholders

Velvet bean is a higher productivity compared to many other leguminous and non-leguminous cover cop in Africa. It is also an effective legume in the small holder crop-livestock systems and can be grown individually or incorporated in the crop rotation, relay crop, intercrop with cereals, and other farming systems. Velvet bean is another plant that helps in the conservation and improvement of soil quality. Velvet beans were very good in improving the nutrition of smallholder livestock. It has been used as cow feed in the South-Eastern United States and has augmented N intake and N retention in the generation of milk and meat. It had a similar nutritional content as the soybean and other conventional stock feeds which are abundant in nutrients, lipids, minerals, and protein. Velvet beans provided the nitrogen which was needed during the effective fermentation of carbohydrates by the microbes into volatile fatty acids, which was a major energy source to the ruminant animals (Mubeen & Jabran, 2019).

2.5.8. Characteristic *Velvet Bean*

Velvet bean was found from live up to an altitude of 2100m. It required a hot and humid climate with an average rainfall of 650 to 2500mm/annual and a long growing period that would not experience frost during the rainy seasons. It is able to develop on light-textured soils that are well drained and have a perceptible acidity.

2.6. Fodder Conservation Strategy

When summer drought was too intense, and in situations where soils have too limited water reserves to ensure summer cultivation, the strategy that must be sought was the constitution of fodder stocks from plants that achieve most of their growth in periods when drought was limited. These forage stocks should ensure animal nutrition both during the dry period and during the wet period.

2.7. Fodder Conservation Practices

2.7.1. Silage Making

Silage production can be used to match feed requirements of a dairy head with producer supplies of feeds (forages, crop residues and agro-industrial byproducts). Silage production was mainly aimed at reducing the nutritional loss when storing and preserving the feed to be used at a later date (Wattiaux, 2000).

Three phases were observed when piling up cut green fodder that can be used as silage. These phenomena were particularly an increase in temperature, settling, and a flow of juice. The enzymatic activity of plant cells and that of bacteria is the basis of the biochemical and bacterial modifications of the treated fodder. The first phase which corresponded to the initial phase referred to the phase of enzymatic activity, where the cells of plant tissues continue to develop their metabolic activities.

The release of heat and the depletion of oxygen led to cellular disorganization. Proteolytic reactions continue which transform the proteins into peptides and then into amino acids. In the fodder mass, the micro-organisms came into action according to their possibility of development. and the characteristics of the environment. The second phase corresponds to the fermentation phase itself corresponding to bacterial activity. It was noted that, after harvest, the aerobic microflora present on the fodder continues to develop. The phase ended with the oxygen stopping.

This phase occurred when air enters the forage, during storage or when resuming silage. This phase was itself subdivided into the acetic and lactic butyric fermentation phases. The acetic fermentation phase corresponded to the phase where the enterobacteria carry out a fermentative was activity to the detriment of soluble carbohydrates, generating acetic acid, alcohol and carbon dioxide. These enterobacteria have the capacity to degrade nitrogenous matter into ammonia. The lactic fermentation phase followed the acetic fermentation phase. Note that the formation of silage was based on the sole presence of indigenous lactic bacteria on the substrate. The presence of a favorable environment (anaerobiosis, temperature between 10-40°C, enough fermentable sugars, pH lower than 6, the development of lactic acid bacteria will be explosive. This resulted in rapid acidification which will block the development of other species and stabilize the silage. It then followed butyric fermentation. Certain bacteria (butyric bacteria can germinate subject to sufficient humidity (greater than 70%) and low acidity (pH > 4.4). Their development was based on initial nutrients (sugars, amino acids, proteins, etc.) but also on the destruction of fermentation products. This fermentation induces consequences such as the loss of nutritional values, reduction in the acidity of the environment and deterioration of the organoleptic (appetence) and health quality of the fodder. The last phase is the post fermentation phase which corresponds to the phase of fungal activity. This is the phase of proliferation of molds and yeasts, and it is especially noticeable if the silo is insufficiently compacted but especially appears when opening the silo. Molds are aerobics and if the fodder is well packed, they cannot grow. Proliferation can be significant on the peripheries of the silo or air pockets can be noticed. The yeasts for their part are present on the surface of the plant

and are active in the unit phase of the silage only subject to having soluble sugar which it transforms into alcohol and carbon dioxide. The risk of proliferation existed in particular in silage with forage corn because the amylase activity of the yeasts provides the necessary glucose from the starch.

2.7.2. Advantages of Silage

The major constraint affecting livestock production was feed shortage during the dry season. However, silage making and its use as supplement in animal diets addressed the issue. Several advantages that can be derived from using this type of feed, first, it guaranteed feed availability throughout the whole year, ensuring animals maintain good body condition and health. Silage was a type of feed which animals efficiently utilize to their advantage, making it a superior supplementary feedstuff which any fodder bank must have.

2.7.3. Effect on Wilting on the Silage Quality

The sort of fermentation that occurred in the silo is significantly influenced by the DM concentration of the silage. When the DM concentration of silage is less than 25%, DM losses take place. Less lactic acid must be produced in wilted silage, and a high DM content raises the concentration of a soluble DM in the silage, raising osmotic pressure and preventing the growth of bacteria. The composition of the fodder changed as the DM was lost during the silage-making process. Fermentation and the forage's respiration process were the causes of the DM loss (Wattiaux, 2000).

2.7.4. Quality of Silage

The quality of silage that was palatable to animals and leads to better was influenced by many factors. The plant species, agro-technical techniques used, preparation time, inoculants used, and, most importantly, the stages of plant development at harvest were all included in these (Bijelic et al., 2015).

2.7.5. The Physical Aspect of Silage

The quality of silage can be analyzed in terms of its color, taste, smell and touch. At high grade, it was light yellow in colour. Silage fermentation was weak and thus the silage was of poor quality when the colour changed from dark brown to dark green. An acidic or sweet pleasant sweet-sour fragrance is a good quality. Otherwise, it is good provided the silage was sour and it tasted good to eat. Another indicator of good silage is when one squeezes his or her hand and the silage splits in half when the hand is released. It is low-moisture silage when it fragments into small particles. When there is dripping water, then the silage is too wet. According to Elferink et al. (2000), to keep silage, it should be below 4.5. In comparison to silage prepared without molasses, silage prepared with molasses received higher scores on

look (brownish/well pickled) and fragrance (typical silage smell and has no foul odor related to putrefaction).

2.8. Chemical Aspect of Silage

2.8.1. Maize stalk- *Velvet Bean* Silage

It is possible that the increased CP and reduced NDF of legumes, as compared to grasses, can affect digestibility. Hence, the corn-lablab bean combination silages could achieve significantly higher DM, CP, NDF, and ADF digestibility when compared to monoculture corn silage (up to 76.7 g/kg DM, 78.4 g/kg DM, 51.8 g/kg DM, and 85.4 g/kg DM respectively) because of the higher content of the latter (Qu et al., 2013).

2.8.2. Silage Fermentation

Ensiling was widely used as a technique to preserve the wet forage crop, which perhaps could raise its palatability and shelf life by the fermentation of lactic acids in an anaerobic environment. The dry matter level of the silage is one of the important factors that define the success of the ensiling material fermentation. The low levels of DM in the silage were an indicator of poor fermentation and both the silage contained high pH levels, low levels of lactic and acetic acids and often contained high quantities of butyric acid due to the proliferation of butyric bacteria. Also, DM was not allowed to excess, since ensiling material compaction is harder and increases the time of aerobic processes and leads to oxidative losses (Bijelic et al., 2015).

Clostridial fermentation is one of the most perverse fermentations, which is denoted by a high level of butyric acid (>0.5 per cent of DM) in the silage. Due to the breakdown of several of the soluble elements, silages containing a large portion of butyric acid are typically less nutritionally valuable and are found to contain a higher ADF and NDF. Too much protein degradation in the silo caused by slow decrease in pH or by the activity of the clostridium leads to high levels of ammonia (>12 to 15% of CP). Low PH inhibits the proliferation of the undesired anaerobic bacteria and decreases the activity of the plant enzymes. The prevention of clostridia bacteria was the most significant in the successful preservation of silage (Muck et al., 2020).

2.8.3. Factor Affecting Silage Quality

To maintain plant quality DM and energy in the silo, it is required to limit the plant respiration, plant proteolytic activity, clostridial, and aerobic microbial growth. A major

strategy that was critical in limiting these activities was the rapid colonization and preservation of anaerobic conditions in the silo. Production of high-quality silage using fermentation of the crop is a minor consideration when cropping wilted more than 55% DM. Fermentation required the presence of anaerobic conditions, adequate substrate, and adequate lactic acid bacteria to reduce the pH. The crop then established the quantity of substrate to be used in healthy fermentation that was augmented with buffering capacity and the content of moisture content.

2.8.4. Effect of Stage of Plants on the Quality of Silage

The early stages of plant development had an increased buffer capacity, reduced dry matter, and greater plant protein content, resulting in severe wastage of silage dry matter and occurrence of clostridial fermentation (Bijelic et al., 2015). Plants with later stages of growth had reduced buffering capacity and lower concentrations of easily soluble sugars. Also, they contain more lignin, structural carbohydrates and dry matter. When forage is compacted, these plants might yield lower-quality silage with a reduced lactic acid level, high pH and butyric acid levels, and lower digestibility (Bijelic et al., 2015).

2.8.5. Effect of Wilting on the Quality of Silage

Ensilage fermentation can be influenced by the temperature of the surrounding air and the moisture of the material in ensiling. Pre-ensile wilting was also common in most regions of the world since it is capable of reducing silo effluent and improving the quality of silage fermentation (Q. Liu et al., 2011).

2.8.6. Effect of the Silo Compacting on the Quality of Silage

Silage density decreases the amount of fodder that is lost due to oxidation and was a requirement to successful process fermentation. The silo contents were forced to a minimum dry matte density of 225 kg m3 which had to be plant material. The new layer of forage was spread out then compacted using legs. The efficiency of using silage density of the silo increases as the silage density increases. Technological factors that affected the silage density were the kind and plant, the harvesting time, the particle size, and the dry matter amount of the silage. To unsure best silage quality crops were harvested at the right maturity.

2. 8.7 Effect of Molasses on the Quality of Silage

Molasses is a thick, dark liquid with a syrupy consistency that was left over after extraction when it was no longer possible to obtain sucrose from the latter for simple

crystallization (Mordenti et al., 2021). Molasses was considered an active feed item due to its high concentration of easily fermentable mineral salts. According to reports, the WSC content of molasses was as high as 63.9%. According to some researches, adding molasses to silages lowers the amount of crude fiber (CF).

2.8.8. Silage Protein Utilization

The ability of dairy cows to utilize nitrogen in the form of urea and ammonium slats as the sole protein sources coupled with their special capacity to synthesize microbial protein allows them to survive and even grow. Also, good forage has a sufficient amount of CP concentration and is likely to satisfy dairy needs in nitrogen metabolism in dairy cows, and this can have a beneficial economic impact by reducing the use of expensive protein supplements (Pang, 2018).

2.8.9. Organization of the Dairy Sector in Burundi

Milk has a long been viewed as a key component of dietary element worldwide, primary because of the recognized nutritional benefits. According to Castellini et al. (2023), consumers are becoming more conscious of the nutritional value, lack of hazardous additives, and general health and environmental effects of the foods they eat. For the young of mammals, including humans, milk serves for an extended period, the sole source of nutrition. With the domestication of animals, the inclusion of milk in the diet of adult human became also feasible. In many parts of the world, especially in the West, milk derived from cattle (*Bos taurus*) constituted almost all the milk processed for human consumption. The dairy industry in the United States is mostly focused on cow's milk.

2.9. Milk Consumption

Milk was a complex blend of protein, carbohydrate, vitamins, minerals, and other constituents dispersed in water, making it one on the oldest foods. Its protein content is often considered nature’s nearly perfect food due to its rich profile, which contains more essential amino acids than any other nature food source. For humans, breast milk supplies all the necessary energy and nutrient for growth and development, especially during the first six months of life. Economically, milk is significant and consists of fat, protein, SNF, lactose and ash. Additionally, it includes water, amino acids, vitamins, lipids, fatty acids and mineral, each playing various functions and physiological role Palmio et al. (2022).

With milk and dairy products making up 62% of the overall value of livestock product imports, they were an important part of Burundi's economy. Non-governmental organizations and domestic consumption accounted for almost 70% of these imports. 5.6 million liters of milk and dairy products are imported annually, of which 72% are fresh milk, 20% are powdered milk, 9% are cheese, and 1% are yogurt. (Keringingo et al., 2022). Consumer preferences were influenced by taste, presentation, price and hygienic quality.

Taste was the main consideration for most consumers while making purchases. A number of factors affect the per capita consumption levels of dairy and other livestock products, including social and cultural characteristics, demographic changes like urbanization, and economic conditions like income levels and relative prices. In many emerging nations, the consumption of cattle products has increased due to economic growth and rising earnings. Particularly among low-income groups, dairy and other livestock products showed a high income-elasticity of demand, which means that even a small increase in income might lead to a large increase in expenditure on these goods. Also, when you compare dairy products to most other food items, especially to meat and fish, dairy products tend to have higher income elasticities of demand. This means that during periods of income growth, spending on dairy products increases at a disproportionate rate when compared to most other food items. In addition, there is a decline in demand elasticity for all food stuff, including dairy products, when income increases, especially in lower income and middle-income countries.

2.9.1. Quality of Raw Milk

The nutritional quality of milk is related to its composition of nutrients necessary for the growth and maintenance of vital functions in humans. Due to its richness in nutrients, cow's milk was an excellent food for humans at all ages. Its ease of absorption and the multiple forms in which it can be consumed make it a food and drink used in young people after birth. Physico-chemically, cow's milk was composed of proteins, fats, carbohydrates, vitamins and minerals Milk fat and carbohydrate supply energy for the activity of life (Zziwa, 2015). Dairy products were shown to contribute up to 20% of daily calorie intake and up to 60% of calcium intake.

2.9.2. The Role of Milk as a Source of Macronutrients

Providing an average daily contribution of 134 kcal, 8 g of protein, and 7.3 g of fat, milk constituted an appreciable source of dietary fat, protein, and energy. In Africa, milk accounted for only 3% of dietary energy and 6-7%, 6-8% of dietary protein, and fat, respectively. The predominant carbohydrate in milk, lactose, facilitates the intestinal

absorption of calcium, magnesium, and phosphorus and vitamin D. Moreover, lactose provided readily available energy to the infant.

2.10. Dairy Components

2.10.1. Milk Fat

Milk fat exhibits great complexity because it consists of many fatty acids and other lipid constituents which affect health in many ways. Milk fat has been found to contain more than 400 distinct fatty acids. Triacyl glycerides, which are made up of esterified fatty acids and contain a glycerol backbone, make up the majority of milk fat. These fatty acids can be obtained from the body's fat storage depots, produced from scratch in the mammary gland, or obtained through diet. A significant amount of mammary gland free fatty acid results from the metabolism of glucose and, more likely, amino acid precursors in mice which have been fed conventional rodent chow comprising around 8% of calories from fat. In order to support synthesis, the physiology of alveolar epithelial cells needs to be adequately 'programmed' to channel metabolic precursors toward the construction of milk proteins and milk fats (Anderson et al., 2007). Several anti-cancer bioactive compounds may be present in milk fats, including conjugated linoleic acid, sphingomyelin, butyric acid, ether lipid, β-carotene, and pro vitamins A and D. Moreover, it contained trans and saturated fatty acids, which had a negative correlation with illnesses. Milk fats contained the essential linoleic acid and only trace amounts of the omega-3 fatty acid, alpha-3 linolenic acid, which are both important to the human body in many ways.

2.10.2. Fat Synthesis

Rumen-derived triglycerides which are the fatty acids that constitute milk fat. Acetate and butyrate are partially responsible for the synthesis of milk fat. The synthesis of a triglyceride involves the combination of three fatty acids and glycerol, which can be procured through the synthesis of glucose. Acetate (17-45%) and butyrate (8-25%), which are generated in the rumen, were the sources of the milk fat. The ratio fed to the cow has a substantial effect on the composition of milk fat. In the absence of fiber, the rumen produces less acetate which causes the cow to produce low-fat milk (between 2 and 2.5%). Another source of acetate for milk-fat production is the mobilization of body lipids, which is especially important at the onset of lactation. The udder, in general, accounted for only half of the milk fat.

The cow's ration's long-chain fatty acids were mostly responsible for the other half. Therefore, the type of fat in the cow's feed can be changed to alter the composition of milk fatty acids.

2.10.3. Mammary Lipogenesis

Two key enzymes in the principal metabolic pathway are fatty acid synthetase (FAS) and acetyl-CoA carboxylase (ACC), which catalyze the condensation of malonyl-CoA and acetate and transform acetate into malonyl-CoA (Grigor and Warren, 1980). In milk, fatty acids (FAs) originate from two sources: 40% are synthesized de novo in the mammary gland and the remaining 60% are derived from blood plasma.

2.10.4. Protein Synthesis

Microorganisms in cow rumen created volatile fatty acids (VFA), including butyric, propionic, and acetic acids. The river virtually eliminated propionic acid from the portal blood. Propionate, which makes up 4560% of the glucose produced in ruminants, was a significant substrate for gluconeogenesis in the river. 40–55% of glucose is produced via gluconeogenesis from non-sugars, which occurs outside the mammary gland and involves the breakdown of proteins. According to Kittivachra et al. (2007), milk was isotonic in the blood. Amino acids extracted from the blood are used to create the caseins in milk. The range of casein level in cows was 2.4% to 2.6%, or almost 78% of milk protein. Prior to their release into the alveolar cavity, the proteins were coordinated into the formation of micelles. The casein fraction differs in molecular weight, number of polymorphic variants, amino acid composition, and phosphorus and milk content. The amount of α-lactalbumin produced by the secretory cells determines the genetic control of milk yield. This enzyme is significant in regulating lactose synthesis, thus influencing the total daily milk output (Zukiewicz et al., 2012).

2.10.5. Factor Regulating Milk Protein Expression

The anterior pituitary secreted the peptide hormone prolactin, which was also linked to the mammary gland, immunological system, and central nervous system. A prohormone, prolactin is made up of 227 amino acids. It was in charge of starting and sustaining lactation as well as the synthesis of the major ingredients in milk. Every level of the expression of milk protein genes was also influenced by prolactin (Zukiewicz et al., 2012).

2.10.6. Function of Protein Body

The main nutrients necessary for animal well-being, including humans. The importance of proteins was especially noted in various functions of the organism, among other things, the process of development, degradation, and transformation taking place constantly at the level

of the organism. Injected proteins were broken down into amino acids in the intestine. Once absorbed, amino acids circulate through the bloodstream to various parts of the body. The proteins incorporated from the diet significantly determines the construction of the muscles, organs, skin, hair, and various other tissues. These proteins are obtained from both plants (fruits, vegetables, legumes) and animals (meat, milk, eggs). Protein deficiency was especially noticeable in infants due to physical and intellectual development disorders. Decreased performance and resistance to infections can also result from protein deficiencies.

2.10.7. Factor Influencing Milk Composition

In general, it may be stated fat the breeds producing the larger amount of fat produce milk of a lot low fat percentage. Some researchers found that the average fat percentages for dairy cows were -Ayrshire :4.05%, Brown suiss:4.08%, Guernsey:4.96%, Holstei:3.4%, Jersey:5.28%. The stage of lactation, breed, parity, season, age, nutrition and health of the animals, and the general management of the herd all impact the quantity and quality of milk produced. One study found that weather, forage quality, and the minerals in forage accounted for 22% of the variation in dairy production (Chandra Naha, 2018).

-Breed: breed influences milk composition. The variation of interbreeds are high for butyric content, high protein and lactose. The impact of casei-genetic variants is twofold: on one hand, they modify the various caseins without altering the total and on the other hand they can modify the cheese-making aptitude of milk.

- Parity and lactation stage: According to some researches, the stage of lactation significantly affects the components of milk. They discovered that the day of lactation affected the levels of protein, fat, and total solids. Kuchtík et al.,(2008) found the total solid changes from 15,5% to 20.68%, fat changed from 4.96 % to 7.80% and protein changed from 4.69% to 6.66% depending on the stage of lactation. Parity influences the total solids and fat.

-Animal health: health can impact milk production and composition. Milk retention can be attributed the animal stress, udder injury, faulty milking, interrupted milking or suckling. The change in milk composition depends on the extent of retention. Mastitis is a pathological factor that affects milk production and composition. Within the dairy industry, mastitis is regarded as the costliest condition affecting the herd. As identified by Fallis (2013), mastitis is an inflammation of the mammary gland principally caused by an intramammary bacterial infection, and it entails an array of mastectomy-associated costs, including the costs of veterinary intervention, treatment and culling of the affected animal, lost production due to rejected or reduced milk, and chronic depreciation in milk quality. The cumulative losses from

mastitis include lower milk production, additional labor costs, and an increased attrition of the herd due to shorter lifespans.

- **Seasonal variation:** seasonal variation affects milk production and composition. It has been noted that milk production rises in the rainy season and falls in the dry. This is explained by the fact that animal feed is scarce during the dry season and readily available during the wet season.

- -**Feed and management effect:** The management of animals was also important for better production and product composition. This concerned all management that farmers do to make their livestock to be in good health and produce more. This came from the housing itself, where it was required to be safety to animals. Control of feed and disease was also an important role to take into consideration when expecting to have quantity and quality production. It was then important to prevent animal stress, and this was possible due to the management of the farmers to animals. In addition to the fact that milk ejection is a neuro-endocrine reaction required to allow for the full evacuation of milk from the mammary gland, the rise or fall in milk production was a crucial consideration when assessing the technique employed during milking. It is then required an elevation of oxytocin during the entire milking. As in developing country, milking was done, it was observed by some research that many countries use hand milking. This method appeared to be the earliest that farmers employed to extract milk for human consumption from nursing animals. When farmers lack access to machine milking technology, the technique is employed. The technique required the presence of a calf for suckling and stimulated initial ejection, then calf suckles immediately after milking (Millogo et al., 2012).

2.10.8. Feeding and Watering Practice for Dairy Cows

Dairy cows were fed according to their physiological stage. Dairy cows' diet was essentially composed of fodder (green or preserved as hay or silage) and a concentrated feed whose composition varies according to the raw material available on the market. Water distributed to animals comes from rivers or public water distribution networks for farms.

2. 10.9. Barn, Health, Hygiene

The livestock building was a construction of great importance intended to be used as a shelter, housing. Most farms have enclosed housing, while other housing units are designed in the open air. Health and hygiene on farms make it possible to meet the expectations of the farmer and the consumer. Some pathologies in dairy cows could lead to a reduction in the

quantity of milk, while others can be harmful to the health of consumers or, even less seriously, reduce the commercial life of milk when it is distributed raw. To do this, hygiene in the barns and during milking must be taken care of as well as the health of the dairy cows. As far as milking is concerned, it is done manually.

2.11. Physicochemical and Microbiological Quality of Milk

2.11.1. Raw Milk

An important component of any diet that is wholly beneficial to the growth of humans is milk. It is produced by several different species, humans included. Milk contains a variety of nutrients including protein, fat, carbohydrates, vitamins, minerals, and essential amino acids. Milk can serve as a habitat for microorganisms. The primary types of bacteria present in milk are those of the lactic acid group which are *Lactococcus*, *Leuconostoc*, *Streptococcus*, and *Enterococcus*. As stated by Quigley et al. (2013), in addition to lactate production, bacteria influence several of the sensory, textural, taste, and overall organoleptic properties of milk.

2.11.2. Pasteurized Milk

To obtain this type of milk, heat treatment is applied for 15 to 30 seconds at 72-75°C. The temperature reduces classical flora, destroys pathogenic germs such as Koch's bacillus (*Mycobacterium tuberculosis*) and inactivates alkaline phosphatase. Heating the milk has little impact on its constituents, apart from a slight loss of thiamine (vit B1) and vitamin C (7-10%). Pasteurized milk can be stored in refrigerator for several days.

2.11.3. Sterilized Milk

As a result of sterilization for 20 min in closed bottles, the milk constituents undergo changes due to heating to 118-120°C. Milk browning is due to protein-lactose interactions. The Ca/P mineral balance is shifted towards the insoluble form. The surface layer of micelles is modified and their stability decreases.

2.11.4. Fermented Milk: Yoghurt

Yogurt is a dairy product for which demand has seen the highest increase in many parts of the world. Yoghurts were characterized by the existence of high concentration of viable lactic acid bacteria. Yoghurt has been associated with several benefits for the consumers' health. These have a higher lactose tolerance, a beneficial balance of the internal microflora, high antimicrobial activity, high stimulation of immune system, and anti-tumoral and cholesterolemic effect (Birollo et al., 2000).

2.11.5. The Dry Extract of Concentrated Skimmed Milk

The dry extract of concentrated skimmed milk is between 35 and 50%. Concentrated skimmed milk was dried by spraying it with a stream of hot air at 140-150°C, using various techniques such as fogging, spraying or atomization and it was between 35 and 50%. The water evaporated instantly, and by the end of the process the temperature has dropped to around 90°C. The resulting white powder contains just 4% water, and is virtually unchanged in composition, apart from a few vitamins and enzymes. Dry whole milk, i.e. milk not skimmed with lipids, is difficult to preserve due to lipid oxidation.

The only way to preserve it was to vacuum-pack it in a hermetically sealed container. There is a problem with the stability of lactose with respect to water (lactose in its amorphous state is not stable), so crystallization must be encouraged after drying. In this way, the powder's particulate structure ensures solubility, absence of caking, and easy flow.

2. 12. Feed Analysis Methods

2. 12.1. Dry Matter Determination

Dry matter is the material that is left over after the water has been extracted. For maintenance, growth, pregnancy, and lactation, an animal required a portion of the dry matter from the meal. The dry matter composition of the feed dictated how much was required to provide the animal with a particular quantity of nutrients. Dry matter of the feed was determined in the laboratory by using equipment which can help in drying feed and removing water content. This equipment could be, a forced-air oven, microwave, vortex dryer (Nennich & Chase, 2007).

AOAC (930.15) was used to assess the samples' DM (Mutayoba et al., 2011), whereas Kjeldahl-method AOAC (984.13) was used to determine the samples' CP. The AOAC technique (973.18) was used to test NDF, ADF, and lignin.

2. 12.2. Crude Protein Determination

Determining the amount of crude protein in the diet can be done in two different ways. In the first instance, different ways of nitrogen estimation were used. For example, AOAC990.03 describes how nitrogen is quantified by burning nitrogenous compounds, oxidizing, transforming them into nitrogen, and then detecting the nitrogen. In AOAC 2001.11, nitrogen was estimated in the classical Kjeldahl acid digestion process where nitrogenous compounds were converted into ammonia. This ammonia was later distilled, then titrated and crude protein was determined as %N times 6.25 (Thiex et al., 2002). CP was determined using the Kjeldahl method AOAC (984.13) (Mutayoba et al., 2011)

2.12.3. Crude Fiber Determination

Five step guided the determination of Crude Fiber. Fiber could be defined as the vegetative part found in cell walls of the plant (lignin, cellulose, hemicellulose, and pectin) that cannot be digested and assimilated by the gastrointestinal tract but mentioned as fundamental parameter for assessment of feed's quality. The determination of crude Fiber was important in estimation of indigestible carbohydrate in animal feed. The step of Crude Fiber determination started the digestion of the sample in sulfuric acid for sugar and starch extraction. This step was possible due to boiling and filtration. It by boiling and filtration. This step was followed by the alkali digestion with potassium or sodium hydroxide to remove protein, some hemicellulose and lignin. It was important to wash again with water and then defatting with the sample and wash with acetone (VELP, 2019)**.**

2.12.4. Ash

The estimation of total organic matter through crude ash helped interpret the value of feeds regarding all chemical forms of energy, which highlighted the contributory value of ash to nutrients. Measurement of crude ash in animal feeds is achieved through the AOAC method 942.05 (Quirino et al., 2023).

CHAPTER THREE

MATERIALS AND METHODS

3. 1. Description of the Study Areas

The study covered the eastern and northeastern parts of Burundi, located between 2°48'30" and 4°20'43" S latitudes and 29°93'63" E longitudes. On the Imbo plain, the primary crops cultivated are rice and maize. Over a duration of seven to eight months, the Imbo plain ecological region of Burundi received 800 to 1,100 mm of rain. The average annual temperature of the region was 25°C, with maximum and minimum yearly temperatures of 30°C and 15°C, respectively. The relative humidity was 70%.

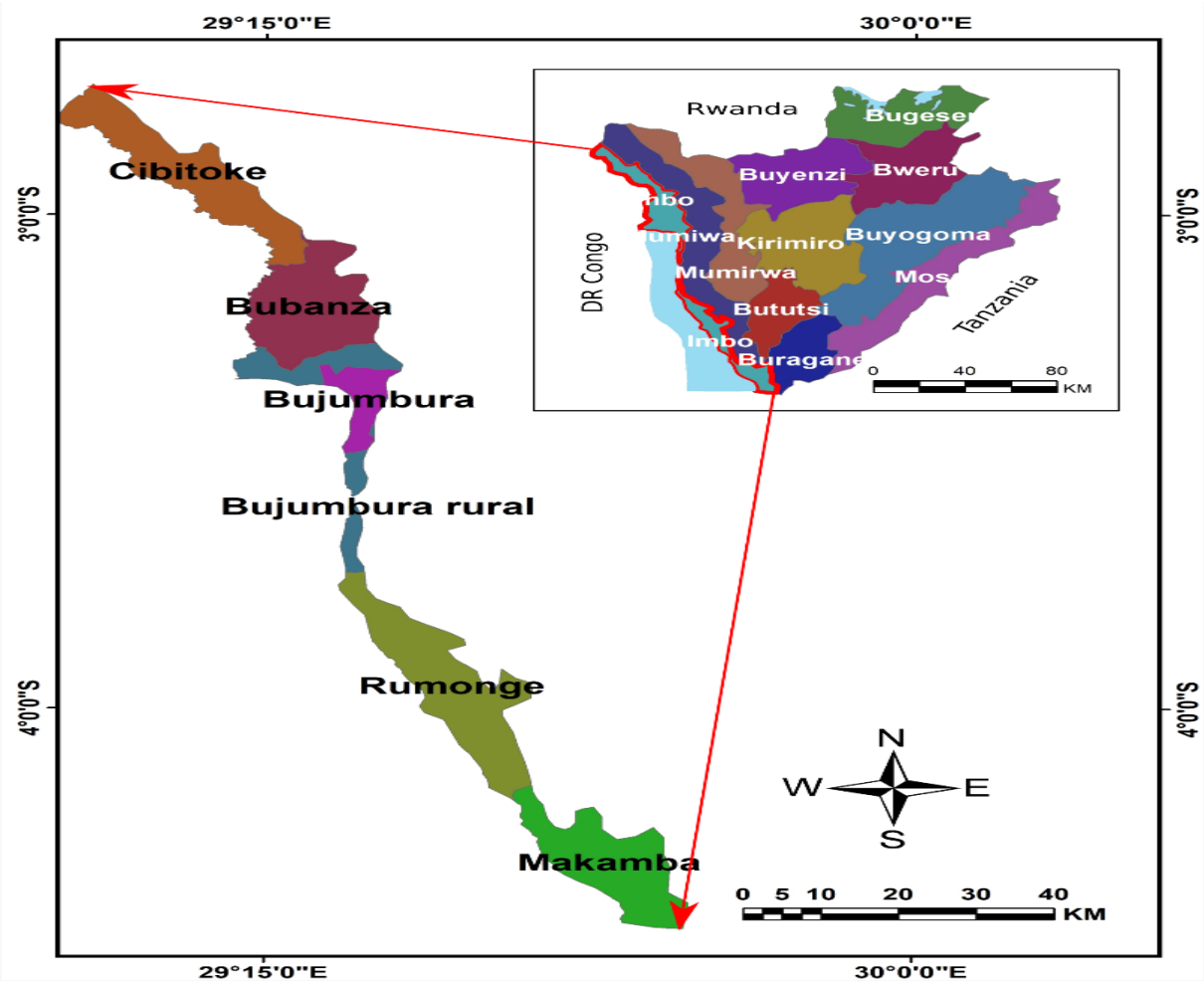

Figure 1:Map of the study area(Nkurunziza et al., 2024)

3.2. Survey Design

A survey questionnaire consisted of 40 closed questions divided into five sections. The following general information included details on fodder producers and fodder production, fodder conservation, feeding management, feed resources, and information on milk production and marketing. To assess fodder production availability in smallholder farms, a field visit was

done for each farmer. Fodder production and conservation practices were assessed to record the level of improvement of feed technology for animals. Data were collected on household characteristics such as sex, age, family size, and education level, and economic variables such as landholding, livestock population, and fodder production situation of the farmers were collected. Farmers' indigenous knowledge and practices in harvesting time, post-harvest management, and feeding, were also recorded.

3.3. Survey Distribution and Data Collection

The survey was conducted in the Imbo Plain region in five provinces: CIBITOKE, BUBANZA, BUJUMBURA, RUMONGE, and MAKAMBA. In each province, two sub-counties were randomly selected, depending on the number of sub-counties to provide a total of 10 communes. Additionally, having at least one dairy cow and being a PRDAIGL project partner were requirements for household enrollment in the study. Therefore, using the dairy farmers list that was available in each of the five provinces and was received from the government offices, households that met the requirements were chosen at random. A maximum of 384 homes could be enlisted. In each province, two sub-Counties were randomly selected, depending on the number of sub-Counties, to provide a total of 10 sub-Counties**.**

3.4. Household Survey

In this study, which used a cross-sectional methodology, 384 households selected from the five provinces of Burundi's Imbo plain were given a structured questionnaire (appendix). The questionnaire was evaluated in ten smallholder dairy farming homes before the real household survey. A total of 4 personnel were selected to conduct the household interviews. Interviews were conducted in the Kirundi language; answers were translated into English by enumerators. To prevent other household representatives from influencing survey replies, interviews were done in-person with a household representative. To facilitate activities in the survey, smartphones were used, and the Kobo Collect tool containing questionnaires was also used by the enumerator. All survey answers were collected and entered into Microsoft Excel 2010.

3.5. Sample Size and Sampling Methods

The farmers were sampled randomly, selected from 5 provinces of the Imbo plain with the highest population of improved stall-fed dairy cows. A list of 3000 smallholder dairy farmers were used to randomly select the dairy farmers. The number of farmers interviewed was 384. This number was determined using the formula:

$$n = \frac{z^2 pq}{e^2}$$

where:

n: sample size

z: confidential interval (value 1.96 at 95%)

p:0.5(the expected proportion of household beneficiating of the PRDAIGL)

q:1-0.5, and e:5% (the allowable margin of error)

3.6. Fodder Establishment

Cenchrus purpureus was the major fodder used by smallholder farmers in Burundi. It was estimated to form about 40% of the total dry matter intake in the diet of dairy cattle. Fodder used in the experiment was established at Randa Public Farm. These constituted of grass and legumes made such as *Cenchrus purpureus* Maize stalk, and *Velvet bean*.

***Figure 2:Zea mays* crops**

Figure 3:Velvet bean crop

Figure 4:*Cenchrus purpureus* crop

3.7. Silage Preparation

3.7.1 Harvesting

Factors such as the seasonal accumulation of carbohydrates, the growth of the forage plant, the level of inflorescence development, and the response to defoliation all contribute to the plant response. Throughout the study, the velvet bean was harvested during its early flowering stage, maize stalks were harvested at the grain's ripening stage, and *Cenchrus purpureus* was harvested at a height of one meter (prior to the formation of internodes). After being harvested in the morning and allowed to wilt in the field for a full day, *Cenchrus purpureus* and maize stalks were moved to a forage cutter machine. The legumes were harvested in the morning, allowed to wilt for six hours, and then sliced in the same way. *Cenchrus purpureus*, maize stalks, and velvet beans were harvested using machetes.

3.7.2. Chopping

A forage chopper machine was used to cut the fodder into lengths of less than 2.5 cm for stems and much longer for leaves. The legumes (*velvet beans*) were picked in the morning, wilted for six hours, and then sliced similarly.

Figure 5:fodder chopping

3.7. 3. Filling and Packing

One day was used to fill the silo. Before ensiling, the fodder was manually collected and pre-wilted for a day. Forages were chopped on the second day and delivered right away to the silo. A plastic sheet was placed on the walls and the silo's exterior edges and hung over the sides prior to filling. The silo was soon filled with chopped fodder. *Cenchrus purpureus* and maize stalks were manually combined with legumes. Eighty percent of the mixture was made up of grass and twenty percent of legumes. The forage was swiftly packed and moved to the silo in order to keep oxygen out and encourage the start of fermentation. Forage that was chopped was transferred immediately to the silo. The silo measured 1.5m x 1.5m x 1.5m, and the silo with a capacity of 3.375m3 was filled with fodder. Silage was compacted with legs in a stepwise fashion.

3.7.4. Addition of Molasses

1.5% molasses was added to the silage while it was being compacted. A watering can was used to sprinkle 5 kg of molasses diluted in 10 liters of water onto the silo's feed, which improved the silage's flavor and aroma and encouraged more consumption. Because of Burundi's sugarcane industry, molasses was accessible.

3.7.5. Compacting

During the silo filling, forage was compacted by trampling with legs (Fig. 6) to get out the air as much as possible. The dilution was applied at intervals during the process of filling the silo by spreading them over the chopped forage.

Figure 6:Filling and compacting the silo

3.7.6. Covering

As soon as the filling and compacting were finished, the silo was covered. The silage was covered with a plastic sheet after dry fodder was added. In order to secure the plastic sheet, dirt was finally piled on top of it.

3.8. Sampling and Sample Preparation

One kg sample was taken from fresh chopped fodder and silage. All the samples were hand mixed before taking a sample. Samples of freshly mixed *Cenchrus purpureus: Velvet bean* or Maize stalk: *Velvet-bean* material were taken.

Figure 7:Silo opening

3.9. Experimental Procedures and Samples Analysis

Nine lactating cows were fed on green forage with an addition of 12kg of silage per day. Silage samples were collected both immediately after the silo was filled and after the fermentation process was completed (during silo opening). During both instances, silage samples were stored at -8°C. The analyses preformed included determination of dry matters, crude proteins,

ashes, crude fibers, and crude fats for both fresh and ensiled samples. The analyses were executed by the Laboratory of Soil Analysis and Food Products (LASPA).

The DM content in the feed was determined using AOAC (930.15), whereas CP was determined using the Kjeldahl method (984.13) of the AOAC (1990). Ash was also determined using the AOAC (942.05) method, and crude fat was determined using the AOAC (920.29) method.

3.10. Management of Experimental Animals

Nine nursing Friesian cross cows weighing 400 kg (±100 kg) early to mid-lactation (about 5–8 weeks after calving) were chosen from the Randa public farm for the feeding trial in order to achieve the goal of this study. The selection of dairy animals was based on the average amount of milk they produced. Internal and external parasites were treated in cows who were in second or third parity. An overview of the cow was completed at the start of the trial. Prior to the 28 days of the experiment which involved the continuous feeding of the treatment diets to the cows under the randomized complete block design (RCBD), a 14 days covariate phase took place. The initial and final milk yields of each animal were recorded.

3.11. Housing

To avoid interaction among the trial animals in a common housing facility, each was allocated an individual pen. The trial cows, differentiated by weight and lactation yield, were assembled into three uniform triplet blocks. From each block, the trial cows were randomly allocated into three different dietary treatments, comprising the combinations of the protein and energy supplements of rice bran, wheat bran, cottonseed cake, and palm seed cake. The trial cows had ad libitum access to water. The number of replicates for each treatment is displayed in Table 1.

Table 1:Replicate treatments

	Treatments			Total
BLOCS	A	B	C	
PEN1	C206	C135	C397	3
PEN2	C248	C234	C387	3
PEN3	CB289	C285	C212	3
Total	3	3	3	9

3.12. Experimental Diets

After 14 days of adaption, the cows were fed three meals a day for 28 days at 8:00, 13:00, and 17:00. Diets were fresh Maize stalk –*Velvet bean* silage(T1), *Cenchrus purpureus-Velvet bean(T2)*, and fresh mixed grass-legume forage(T3), except for cows in T3, each cow received 12kg of silage per day. During milking. Two kilograms of concentrate were distributed for all cows at each milking time (8:00 and 16:00).

3.13. Feeding Design

The diet consisted of two ratios of the mixture of grass: legumes silage (80:20). Concentrates were made of Rice bran, Maize bran, palm seed cake, and cottonseed cake. Each cow had access to a mineral lick block at all times. All cows had an adaptation period of 7 days. Data collection was done for 28 days. Cows were housed in three blocks in the same house. They were all group-fed and had all the time access to trace-mineral salt blocks. The daily feed allocation was given in three portions per day at an interval of 4 hours. The amounts of feed offered were measured (12 kg silage/cow/day). Refusals for each day were removed in the morning before the next day's feeding. Water was distributed and available *ad libitum*. Cows were assigned into the block according to the average weight and milk yield. Treatments were allocated randomly to the cows within a block and each block had three (3) cows. The control diet consisted of a fresh grass-legume mixture. Silage was weighted and transported using a basket. Picture 8 illustrate the method used for silage weighting and transporting.

Figure 8:Basket for silage weighing and transporting

3.14. Milking and Recording

Every cow's milk production was measured twice a day for the length of the experiment. Every cow's daily milk outputs were monitored and documented between 8:00 AM and 16:00 PM.

Figure 9:milking

Figure 10:milk measuring and recording

3.15. Milk Sample

For the purpose of analyzing milk composition, milk samples were collected both at the start and finish of the study. Samples of milk were taken to the National Veterinary Laboratory for analysis after being put in a clean cup and stored in the icebox. LACTOSCAN (milk analyzer) was used to measure the amount of fat, protein, lactose, and solid-not-fat in the milk sample. Throughout the entire experiment and at each milking time, the milk output was promptly recorded. Samples of milk were taken at the start of the trial (before to the adaption phase) and on day 25.

3.16. Statistical Analysis

Data collected were recorded and input in excel (Microsoft office 16). Data was analyzed using R software (R.4.4.1). SPSS version 20 was used to analyze the survey data. Quantitative data was analyzed using descriptive statistics. Data from the survey helped to make an inventory of the forage resources that are used by small-scale dairy farmers and the feeding systems. It also helped to identify limitations in the seasonal supply of fresh and conserved forage. At the end of the experiment, an assessment of the importance of grass and legume silage on milk production and quality was done.

In R4.4.1, the analysis of variance (ANOVA) was positioned the same as for a randomized complete block design (RCBD). For the one way of variance (ANOVA) in R, comparisons were made for dry matter, crude protein, ash, crude fiber, and crude fat of freshly

mixed *Cenchrus purpureus*. Also, as for maize stalk. Oneway ANOVA was used in measuring the influence of *Cenchrus purpureus* addition: *Velvet bean* and Maize stalk: Velvet bean silage ration. For weight gain, milk production, and milk composition, the means of the blocks were compared. To ascertain whether adding *Cenchrus purpureus* significantly altered the mean of weight increase, milk output, and composition: Maize stalk and *Velvet bean*: ration of *Velvet bean* silage.

At the $P<0.05$ level, the significant difference was identified. According to Snedecor and Cochran (1989), significantly distinct means were differentiated for linear expressions using the models outlined below.

Yijkl, or milk yield, is equal to μ + covi + Ti + Bj + Sk + Fl + Eijkl.

μ is the general mean.

covi is the cow's covariate measure.

Ti = The treatment's impact,

Bj = The block's effect

Sk = The impact of the lactation stage.

Eijkl is the random error term, and Fl is the interaction's effect (Tix Bj).

CHAPTER FOUR

RESULTS

4.1. Farmer's Characteristics (%)

The result in Table 2 shows that among respondents, 43.2% were female, and 56.70% were male. A total of 42.4% had no formal education, 34.6% had primary level, and only 1% (from Cibitoke Province) had university-level education. Young farmers were fewer than adult farmers at 28.7 and 58.3% respectively.

Table 2: Smallholder dairy farmers' characteristics

	Gender		**Education**				**category of age**		
Provinces	Male	Female	None	Primary	Secondary	University	Young	Adult	Old
Bubanza	11.70	8.60	9.10	7.80	3.40	0.00	8.10	9.90	2.30
Bujumbura	12.20	8.90	9.90	7.60	3.60	0.00	5.70	13.30	2.10
Cibitoke	11.70	7.30	8.90	4.70	4.40	1.00	8.10	9.40	1.60
Makamba	9.90	9.60	8.10	7.30	4.20	0.00	3.40	12.80	3.40
Rumonge	11.20	8.90	6.50	7.30	6.30	0.00	3.40	13.00	3.60
TOTAL	56.70	43.30	42.50	34.70	21.90	1.00	28.70	58.40	13.00

4.2. Wet Season Fodder Availability

In Burundi, seasons affect the availability of fodder. In the results of the study, 96.4% of the respondents reported the availability of natural fodder, 94.5% reported the availability of established fodder, and only 22.4 % reported the availability of crop residues in the wet season. About 68% of the respondents reported that there was low crop residue availability during the wet season.

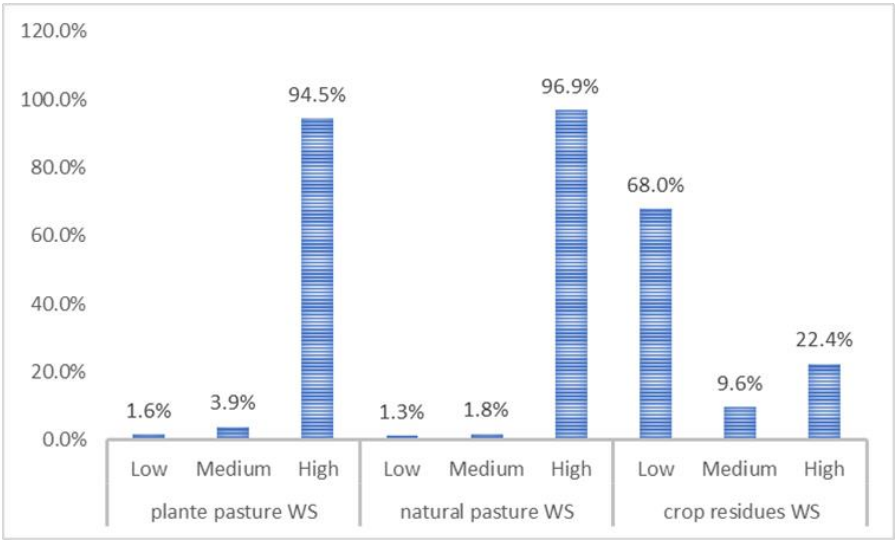

Figure 13: Wet season fodder availability

4.3. Dry Season Fodder Availability

More than 80% of smallholder dairy farmers reported dry season fodder scarcity as a major challenge in the Imbo plain of Burundi. Results from the survey showed a very low green fodder availability during the dry season: 87.2% reported poor availability of planted pasture availability, and 85.7% reported poor availability of natural pasture. On the other hand, high availability of crop residues during the dry season was reported by about 65.4% of the respondents.

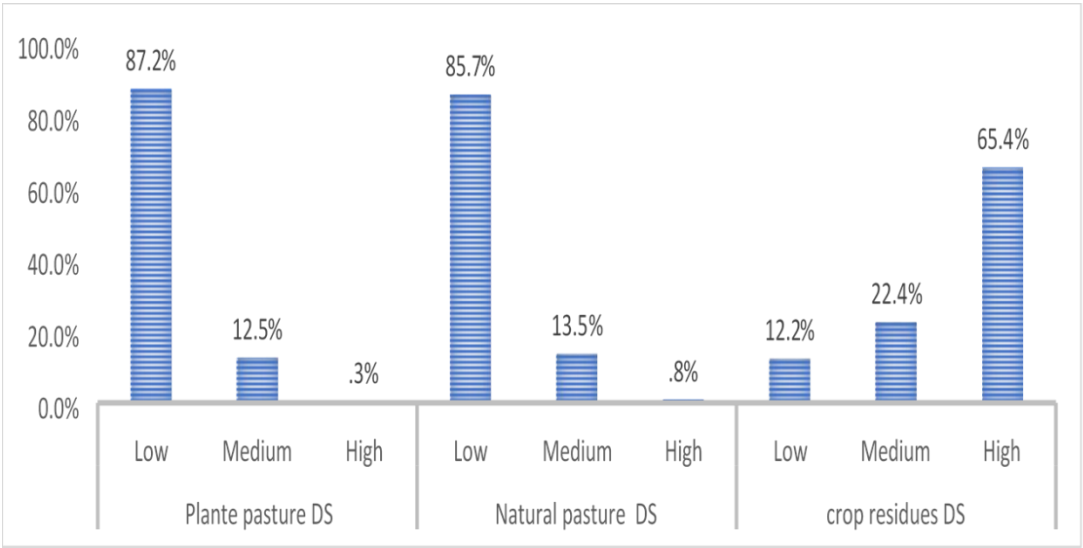

Figure 14: Dry season fodder availability

4.4. Fodder Production, Conservation, Sale Practices, and Access to Credit

Results in Table 3 showed a very low level of adoption of fodder conservation in the Imbo plain of Burundi. In the total number of 154 dairy farmers, 99% did not make silage. The main reason for not making silage was a lack of knowledge and scarcity of fodder due to the scarcity of arable land for forage and crop production. In five provinces of the Imbo Plain, the lack of arable land was the main challenge limiting smallholder dairy farmers' fodder production. This resulted in feed scarcity, consequently reducing milk production. The lack of financial means was also observed among smallholder dairy farmers. This issue could be solved by selling fodder, but the results indicated that 99.4% of respondents reported that low fodder production was the main reason that smallholder dairy farmers do not sell fodder. Table 3 shows the production, conservation for smallholder dairy farmers in the Imbo plain.

Table 3: Fodder production, conservation practices

Activity		PROVINCES					
		Bubanza	Bujumbura	Cibitoke	Makamba	Rumonge	Total
Fodder production (%)	No	5.70	3.10	3.40	3.60	1.30	17.10
	yes	14.60	18.00	15.60	15.90	18.80	82.90
Fodder conservation practice (%)	No	13.00	15.10	9.90	11.20	12.80	62.00
	yes	7.30	6.00	9.10	8.30	7.30	38.00
Silage making practice (%)	No	20.30	20.80	18.80	19.00	20.10	99.00
	yes	0.00	0.30	0.20	0.50	0.00	1.00
Fodder sale practice (%)	No	20.30	20.60	19.00	19.50	20.10	99.50
	yes	0.00	0.50	0.00	0.00	0.00	0.50

The study assessed the reasons for poor fodder conservation and sale adoption. It also assessed farmers' access to credit. Results from the study showed that 60.7% did not have access to credit. Only 39.3% had access to credit. The table 4 showed reasons

for poor fodder conservation and sale practices, and the accessibility of farmers to credit.

Table 4: Reasons for poor adoption of conservation, sales practices, and accessibility to credit

		Buban-za	Bujumbu-ra	Cibitoke	Makam-ba	Rumonge	Total
	Lack of arable land	4.70	2.30	2.60	2.10	0.30	12.00
	Lack of financial means	0.30	0.50	0.50	1.60	0.80	3.70
	lack of forage seeds	0.30	0.30	0.30	0.00	0.30	1.20
Reason for poor fodder sales (%)	Low fodder production	19.90	20.70	18.90	19.70	20.20	99.40
	Lack of a fodder sale market	0.30	0.00	0.30	0.00	0.00	0.60
Access to credit (%)	No	12.2	13.8	11.1	10.9	12.0	60.3
	Yes	7.6	7.3	7.8	8.6	8.1	39.7

4.5. Fodder Varieties and Fodder Sources

Different varieties of fodder were identified in the Imbo plain of Burundi. These included grass and leguminous fodder. The level of production depends on many factors such as land size, seed availability, and the type of soil. For the smallholder dairy farmers interviewed, fodder production also depends on the palatability to livestock.

The main fodder forages established in the Imbo plain were *Cenchrus purpureus, Caliandra calothyrsus, Desmodium intortum, Tripsacum laxum, and Velvet bean*. Natural forages were available during the wet season and were characterized by a mixture of spontaneous fodder *Cynodon dactylon (couch grass), Commelina benghalensis (*tropical spiderwort*) (Macrotyloma axillare (*Macrotyloma*), Digitaria abyssinica (*Africa couch grass*)* while Crop residues (stalks, cereals straws such as millet, sorghum, Maize stalk, and haulms of leguminous crops such as beans and groundnut, and rice straw) were abundant in the dry season.

Table 5: Fodder Varieties

Fodder type	Common name	Percentage
Cenchrus purpureus	Napier grass	65.9%
Caliandra calothyrsus	Red Calliandra	12.5%
Desmodium intortum	Green leaf desmodium	11.5%
Tripsacum laxum	Guatemala grass	7.0%
Velvet bean	Mucuna Pruriens	2.5%

It was observed that *Cenchrus purpureus* was the main grass established in the Imbo Plain of Burundi at the level of 65.9%. Leguminous fodder had a very low level of establishment. *Calliandra calothyrsus was established at 12.5% while Desmodium intortum* was established at 11.5%.

4.6. Seasonal Variation of Fodder

Almost 85% of responders identified insufficient feed during the dry season (May to September) as a serious issue. The availability of both natural and created pastures was found to become increasingly limited throughout the dry season. The importance of crop leftovers, particularly rice straw, as dry season animal feed during the dry season was noted. There were claims that both natural and created meadows supplied on-farm feeds during the rainy season

(October to April). Nevertheless, 68.0% of respondents indicated that the wet season had the lowest availability of crop residue. It was reported that due to dry season feed scarcity, farmers were compelled to search for forage near rivers and lakes. As a consequence, during the dry season, dairy animals were given less forage, which ultimately impacted milk output.

4.7. Quality and Chemical Composition of Experimental

4.7.1. Aspect of the Silage Quality

In general, the result of the experiment demonstrated that silage prepared from Maize stalk-*Velvet bean* silage was acceptable to livestock than silage made on *Cenchrus purpureus* - *Velvet bean*. The high DM intakes were recorded in Maize stalk -*Velvet bean* silage.

4.7.2. Nutrient Composition of the Mixture of Grass-Legumes

The composition of the *Cenchrus purpureus* - *Velvet bean* and Maize stalk - Velvet bean silage is shown in Table 5. The crude fiber content of the ensiled grass-legumes was 24.8% for maize stalk - Velvet bean silage and 28.1% for *Cenchrus purpureus* - *Velvet bean*. The *Cenchrus* purpureus - *Velvet bean* silage had the highest amount of crude protein (CP) at 7.07% and the Maize stalk - *Velvet bean* silage had the least at 5.37%.

Table 6: Nutrient composition of the mixture of grass-legumes (%)

Nutrient /Parameter	DM	CP	CF	Ash	Crude fat
Fresh *Cenchrus purpureus*-*Velvet bean*	45.1	9.76	29.4	12.0	1.78
Fresh mays stalk-*Velvet bean*	22.7	11.6	24.8	7.19	1.34
Ensiled Maize stalk-*velvet bean*	17.6	5.37	33.9	12.6	2.51
F value	3.811	4.254	0.99	0.013	2.646
Pr(>F)	0.19	0.175	0.425	0.921	0.245

DM: Dry Matter; CP: Crude protein; CF: Crude Fiber

Table 7: Statistical description of the forage composition

Nutrients	Min.	Median	Mean ± SD	Max.
DM	17.60	26.40	28.88 ±11.97	45.10
CP	5.370	8.415	8.450 ± 2.77	11.600
CF	24.80	28.75	29.05 ± 3.76	33.90
Ash	7.190	9.600	9.748 ± 2.95	12.600
Fat	1.340	1.885	1.905 ± 0.48	2.510

4.8. Effect of Feeding *Cenchrus Purpureus- Velvet Bean*, or Maize Stalk- *Velvet Bean* Silage on Body Weight Change

There was a difference in body weight change between blocks, according to Table 7's results ($P<0.05$). Cows fed *Cenchrus purpureus-Velvet bean* silage (4.66 ± 0.57 kg) and fresh mixed fodder (2.33 ± 0.57 kg) had lower mean body weights than cows fed maize stalk-*Velvet bean* silage (11.66 ± 3.21 kg).

Table 8: Means and standard deviation of body weight change

Diets	Weight gain(kg)
Maize stalk-*Velvet bean* silage	11.66±3.21
Cenchrus purpureus -*Velvet bean* silage	4.66±0.57
fresh mixed fodder	2.33±0.57
F test	19.3
P-value	0.002

4.9. Impact on Milk Production of Feeding *Cenchrus Purpureus-Velvet Bean* or Maize Stalk-Velvet Bean Silage

The mean milk output varied between the blocks ($P < 0.05$), according to the results shown in Table 8. Cows fed *Cenchrus purpureus-Velvet bean* silage (5.36±1.07l) and fresh mixed grass-legume feed (4.29l±1.07l) produced less milk on average than cows fed Maize Stalk-*Velvet bean* silage (7.53±1.52l).

Table 8: Means milk production

Diet	MILK (l/d)
Maize stalk-*Velvet bean* silage	7.53±1.52
Cenchrus purpureus: *Velvet bean* silage	5.36±1.07
Fresh mixed fodder	4.29±1.07

f test	234.213
p-value	<0.05

4.10. Impact on Milk Composition of Feeding *Cenchrus Purpureus- Velvet Bean* or Maize Stalk *Velvet Bean* or Silage

The mean milk content of fat and protein did not differ significantly. Table 9. SNF (P-value=0.019), lactose (P-value=0.020), and salt (P-value=0.0007) showed a significant variation in milk composition. In comparison to cows fed *Cenchrus purpureus-Velvet bean* silage, cows fed maize stalk-*Velvet bean* silage had higher levels of SNF, lactose, and salt. The mean milk composition for the experimental cows is displayed in Table 9.

Table 9: mean milk composition

DIET	Maize stalk-*V.Bean* silage	*Cenchrus purpureus Velvet bean* silage	fresh mixed	F test	P-value
Fat	4.62± 4.82	7.85± 1.28	6.67±4.06	0.58	0.58
Protein	3.26± 0.51	3.22± 0.51	3.24±0.16	0.016	0.98
SNF	8.94±0.15	8.04±0.21	8.77	8.1	0.019
Lactose	4.88± 0.16	4.35± 0.11	8.77±0.43	7.99	0.020
Salt	0.76±0.001	0.62±0.002	0.73±0.003	2.52	0.0007

CHAPTER FIVE

DISCUSSIONS

5. 1. Fodder Production and Conservation Practices

The following were the main causes of smallholder dairy producers in Burundi's Imbo plain's limited adoption of fodder technology and practices: i) farmers' limited knowledge of fodder production and conservation practices; ii) the lack of arable land for establishing fodder; iii) the limited access to investment capital; iv) lack of fodder/seeds producer groups (cooperative); v) lack of fodder sale market. This has also been reported by (Mapiye et al., 2006) When evaluating the constraints to the adoption of forage and browse legumes by smallholder dairy farmers in Zimbabwe.

Poor adoption of improved fodder production and conservation was also associated with low levels of education among the farmers. Results from the study showed that 77.2% had a low education level (non-formal). This may have negatively affected the adoption of fodder production and conservation technologies. It has been observed that farmers with a high education level have better access to information and knowledge that is beneficial to farming operations. (Balkaya & Akkucuk, 2021). The study found that only 21.90% had the secondary level, and they were exposed to rapid adoption technologies of fodder management, as cited by some researchers. According to Duguma and Janssens (2016), "Farmers with high education levels typically adopt new technologies more rapidly than lower education levels."

The mean age of smallholder dairy farmers was 43.7. While in Burundi the average retirement age is 60, Young smallholder dairy farmers were less (28.7%) compared to adult smallholder dairy farmers (58.4%). The likelihood of adoption declines with household age because they become less engaged in the process of disseminating new technology, probably as a result of cultural influences (Dehinenet et al., 2014). The majority of the interviewees were men, the majority of whom had no formal education, and their primary occupation was farming. The key decision-makers and owners of vital resources required for the pursuit of economic activity are men. This may have affected the economy and increased poverty, which was largely linked to low agricultural productivity.

The availability of both natural and established fodder was observed only in the wet season. This may have resulted in the lack of the tradition of conserving the excess forage for the dry season when there was a shortage of feed. About 22.4% of smallholder dairy farmers reported the availability of crop residue in the wet season. These may be the rice producers located in some irrigated parts of the Imbo plain. In this region, rice straw was the most abundant feed. Its

storage and treatment (urea/molasses treatment) could solve the feed scarcity issues. Indeed, crop residues were reported to be the main livestock feed during the dry season. Due to the scarcity of arable land, fodder production was not adopted. Most farmers tend to favor crop production (94.5%) to improve food security. Animals were fed crop residues obtained after harvesting. To prevent feeding scarcity problems, it was possible to improve the current situation by conserving surplus fodder in the form of hay, straw, and silage during the wet season and treating crop residues during the dry season. It was also important to train farmers on feed management to prevent low income and poverty. Some researchers found that Maize stalk fodder could be fed safely at all physiological stages of animals without any danger (Sun et al., 2018).

5. 2. Chemical Composition of Experimental Feeds

The composition of *Cenchrus purpureus*-*Velvet* bean silage and Maize stalk-*Velvet* bean silage did not differ significantly. When fresh samples were compared to ensiled samples, dry matter and crude protein both dropped. Variety, the environment, and post-harvest treatment are some of the elements that affect the chemical makeup of feeds. The combination of *Cenchrus purpureum* and *Velvet bean* silage showed a decrease in crude fiber and ash content, but the mixing of maize stalk and *Velvet bean* silage showed an increase. The quality of the fodder used, which varies greatly according to the species, variety, and harvest stage, may account for this discrepancy. A drop in crude fiber could mean that the leaf's cellulose enzyme converted crude fiber to glucose. Fresh *Cenchrus purpureus*-*Velvet bean* silage had a greater proportion of dry matter and crude protein (DM=30.1, CP=7.07, Ash=7.20) than maize stalk-*Velvet bean* silage (DM=17.6, CP=5.37, Ash=12.6). *Cenchrus purpureus*-*Velvet bean's* DM value (30.1) was nearly identical to that of maize stalk at the dough stage (DM=30.38) (Zhao et al., 2007). In this investigation, the crude protein was limited to 6.8. On the other hand, compared to *Cenchrus purpureus*-*Velvet bean* silage, maize stalk-*Velvet bean* silage had higher levels of crude fiber, crude fat, and ash.

5. 3. Effect of Feeding Grass-Legume Silage on Milk Production

Cows fed Cenchrus purpureus-Velvet bean silage (5.36±1.07l/d) and fresh mixed grass-legume (4.29l±1.07l/d) produced less milk on average than cows fed Maize stalk-Velvet bean silage (7.53±1.52l/d). This could be because maize stalk silage has a different dry matter content, which could significantly affect the digestion of the meal. According to some researchers, the distribution of high-quality feed, which enhances rumen function and the efficiency of milk production synthesis, may be the cause of the rise in milk output (S. Liu et al., 2016). Terefe et al. (2021) found that the dietary treatments had a substantial ($P<0.01$)

impact on the cow's daily milk yield, with cows on the silage-based diet (50% concentrate mixture, 50% maize stalk silage) producing more milk each day than cows on the control diet. The means of milk production for T2 (70% maize stalk silage: 30% concentrate mixture) in his study were nearly identical to this study's (9.46l/d). The mixture of maize stalk and velvet bean was close to the ratio of 80% to 20%, and concentrate was added during the feeding period (2 kg of concentrate/cow/day). The enhanced fermentation characteristics and increased palatability of maize stalk-Velvet bean silage may account for the greater quantity of silage consumed by cows. Moreover, there is an increased quantity of milk produced when cows are fed a diet containing legume silage and silage made from maize stalks, or a mixture of the two. Nevertheless, as noted by Dewhurst (2013), legumes and grasses contain, on average, an adequate proportion of crude protein. Here again, increased output may, in part, be attributable to an increase in the frequency of milking.

Increased milk output may also be impacted by increased milking frequency. Some researchers claim that milking twice a day produces at least 40% more milk than milking only once. According to Vijayakumar et al. (2017), the most plausible explanation for the increase in milk production with increased milking frequency could be the reduction of intramammary pressure, an increase in the stimulation of hormone activity of milk production, and a decrease in the negative feedback on the secretory cells caused by the accumulation of milk components.

Throughout the trial, differences in milk output ($P < 0.01$) across different treatments were considerable. Block 1 (7.53±1.52l/day) produced more milk than Blocks 2 (5.36±1.07l/day) and 3 (4.29±1.07l/day), which may, in part, be attributed to the differences in the feeds' glucose and amino acid concentrations. Also, the productivity of ruminants is significantly influenced by the quantity of feed. This, in turn, determines the nutritional value of the diet and its comparison to the ruminant needs, which ultimately determines the diet's digestibility and availability of nutrients. The increase in milk production may also be induced by the increase in mammary gland activity. In cows fed mixed forages (26,3 kg/day, corn stalk diet 1:22,62 kg/day, corn stalk diet 2:17,41 kg/day) (Ruppert et al., 2003), high corn silage (32,3 to 33,4 kg/day), and high alfalfa silage (33,3 to 34,2 kg/day), the results of this study were lower than those reported by S. Liu et al. (2016). According to Zhao et al. (2007), the high oil content of dry maize stalk, maize stalk silage, and maize stalk silage sustained milk yields of up to 28, 25, and 23 kg/d, respectively. An increase or decrease in milk output could also be explained by the animal's genetics. This may be related to the breed that is employed, which has a greater capacity for producing milk.

5. 4. Effect of Feeding Grass-Legume Silage on Milk Composition

The fat and protein contents for cows on T1 were 7.85±1.28 and 3.22±0.51, respectively. For cows in T2, the milk's fat and protein contents were 4.62±4.82 and 3.26±0.51, respectively, but for cows in T3, they were 6.67±4.06 and 3.24±0.16. According to the current results, milk fat and protein contents did not differ significantly ($p \geq 0.05$). Fatty acids from meals, adipose tissue, or newly synthesized fatty acids in the gland could be the cause of this discrepancy. Free fatty acids produced in the mammary gland from glucose and most likely precursors to amino acids could influence the composition of milk fat. According to some researchers, the physiology of alveolar epithelial cells must be significantly programmed to direct metabolic precursors to the synthesis of both lactose and milk lipids to sustain their synthesis (Anderson et al., 2007). According to Bauman and Griinari (2003), a decrease in rumen acetate and butyrate limits milk fat production. The concentration of milk protein and/or fat has frequently decreased as a result of legume silages. The decrease in milk protein concentration is most consistent with the decrease in milk fat concentration with silages. When clover silages with very high intake characteristics were fed, the concentration of milk protein increased, usually a little but occasionally significantly (Dewhurst, 2013). The kind of breed and the stage of lactation can also affect the amount of fat in milk. Our findings are different from those of several researchers who concluded that the average milk fat level of the Holstein Friesian breed ranged from 3.61 to 3.80 percent (Budimir et al., 2011). The cows' stage of lactation may also contribute to the decrease in milk fat and protein. Our findings differ from those of some studies that discovered that while milk's fat and total solid content rose, its lactose content dropped, and its protein content declined as breastfeeding progressed (Palmio et al., 2022).

SNF, lactose, and milk salt varied significantly ($p<0.05$) depending on the therapy. The animals in T1 (8.95±0.15) had a greater SNF concentration than those in T2 (8.04±0.21) and T3 (8.77±0.43). In T1, T2, and T3, the lactose concentration was 4.88 ±0.16, 4.35 ±0.11, and 4.85 ±0.23, and the milk salt content was o.76±0.001, 0.62±0.002, and o.73±0.003, respectively. All of the experimental cows' milk SNF content is comparable to what previous researchers have discovered. These outcomes also met the standards set by the Food Safety and Standards Authority of India (FSSAI). According to these regulations, the proportion of SNF in cow's raw milk should be between 8.5 and 9.0 (Garg et al., 2016). Research into the constituents of raw milk reported lactose levels that were comparable with the milk described

as ‘low’ in (Kittivachara et al., 2007), where the average lactose content was 4.68%. This is congruent with the results of our investigation.

In T1, T2, and T3, the salinity of the milk produced by the animals was recorded at 0.76±0.001%, 0.62±0.002%, and 0.73±0.003. The addition of a lick block may have contributed to the milk composition changes. The lick block was included during our experimental feeding. Numerous factors affect the composition of milk. Animal-related intrinsic factors, such as age, health, breed, parity, and lactation stage, need to be included. The composition of milk is also influenced by extrinsic factors, which are the environment, such as housing, nutrition, climate, and hygiene (especially during milking), and the milking procedure.

5. 5. Effect of Feeding Grass-Legume Silage on Body Weight Change

Results from the different treatments on Animal body weight gain were significant ($P<0.05$). Cows on *Cenchrus purpureus-Velvet bean* silage (4.66 ± 0.57 kg) and fresh mixed fodder (2.33 ± 0.57 kg) recorded lower mean weights compared to those on maize stalk-Velvet bean silage (11.66 ± 3.21 kg). For the *Cenchrus purpures-velvet bean* silage and fresh mixed grass-legume (Control), the correlation was significant at the $P<0.05$ level. For the cows on maize stalk-velvet bean silage, the link was shown to be very highly significant at the $P<0.01$ level. Increased weight gain observed in experimental cows could be explained by rumen microbes transforming the grains consumed into the fatty acids butyric, acetic, and propionic acids. (Kittivachra et al., 2007).

CHAPTER SIX
CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

The study discovered that the two biggest issues facing smallholder dairy farmers in Burundi's Imbo plain were a shortage of arable land and low levels of education. The author concluded that the adoption of innovations and technology related to animal nutrition and production problems remained prevalent, particularly during the dry season. This led to low milk production and reduced; consequently, animals suffered from malnutrition, an increase in animal health issues, and decreased production.

Due to the findings of this study, the other researchers concluded that the mixture of grass-legumes (80%-20%) contributed to increasing the nutritive value of the feed. The author also concluded that the increase in nutritive value of fodder affected its DM, CP, CF, ash, and Crude Fat composition. The author also concluded that the incorporation of grasses and legumes and their conservation in the form of silage increased milk production, affected milk composition, and body weight change for dairy cows.

6.2. Recommendations

Based on the study conclusions, the author suggests to recommend the government of Burundi reorganize fodder production and conservation practice, and organize training on the utilization of locally available feed resources to increase livestock production. Our recommendation is addressed to partners involved in livestock development sectors in Burundi to strengthen livestock nutrition innovation. Our recommendations are also addressed to researchers, to analyze the chemical composition of existing feed and its impact on milk production, milk quality, and body weight change, and to farmers to change their behavior and collaborate with all partners involved in the development of the livestock sector (extension agents, public and private, and researchers) and to improve the nutritive value of the grasses feed by mixing it with feed of high protein value, such as legume.

6.3. Further research

1. An investigation into total milk production and consumption in Burundi.

2. Assessment of the nutritive composition of existing animal feed in Burundi and its impact on dairy production.

3. Ratio formulation based on available feed resources in Burundi.

4. Assessment of household income from dairy animal products in Burundi.

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APPENDICES

Appendix A : **Questionnaire for Fodder Producers**

Questionnaire No……

Section I: General information

I.1. Date of interview:/……./…...… Name of enumerator: …….

I.2. Country …… Province …….…….

Commune ……colline……village…….

Section II: Fodder Producer Information

II.1. Name of respondent .....Age (years)..... Phone number……

II.2. Gender: a) Male……b) Female ……

II.3. Relationship of the respondent to the fodder producer: a) Himself… b) Spouse…….

II.4. Education level of the fodder producer a) None…..... b) Primary……c) Secondary…… d) university…….

II.5. What livelihood options do you have? a) Livestock… b) Crop production…c) Trade

(specify)……. d) other……

II.6. Which one of the above is your MAIN source of livelihood?.....

II.7. What is the total size of the land you own?... ha

II.8. what livestock species do you own? Please fill in the table below:

Livestock species	Number of mature	Number of young<12 month	Purpose of keeping s

	Male	Female	Male	Female	
Cattle					
Sheep					
Goats					
Pigs					
Total					

Section III: Fodder Production

III.1. Do you produce fodder a) Yes… b) No…

III.2. If no, why? a) lack of arable land…… b) lack of financial means…… c) poor knowledge of fodder production methods…. d) lack of forage seeds …e) other(specify)….

III.3. If yes, what is the objective of producing fodder? a) feed my livestock… b) soil improvement

…. c) Leasing out for income……d) Erosion control … e) marching ……other

III.4. what is the main objective to produce fodder?.....

III.5. Have you ever learned how to produce fodder? a) yes ……. b) no….

- If yes, where did you learn about fodder production? a) ISABU… b) Extension services…. c) NGOs……d) Neighboring…e) Farmer groups… f) Others (specify)…….

-If yes, in which practice have you been trained? a) Land preparation…b) Planting…….c)

Harvesting……. e) processing……f) Others (specify)……

III.6. a) Do you belong to any fodder producer marketing group? a) Yes……b) No……

- If yes, what is the name of the group……

- what is the year of formation……

b) Do you belong to any seed producer marketing

- If yes, what is the name of the group……

- what is the year of formation……

III.7. a) What fodder species do you grow, and which one do you collect

Grown fodder	Quantity estimated Per day(kg)	Collected fodder	Quantity pe estimated day
I		i	
Ii		ii	
Iii		*iii*	
Iv		iv	
v Others (specify)		v Others (specify)	

III.8. What factors influence the choice of fodder species that you grow? a) Availability of seeds b) Cost of production …… c) Palatability…. d) Marketability…. e) short production period…..... f) Adaptability to the area…….. g) Others (specify) ……. III.9. a) In which area do you grow fodder?.....(ha)

b) own area……. b) rent area……

III.10. Did you have access to credit for fodder production? 1) Yes…….…… 0) No……. a) If yes where a) bank…. b) neighbor… c)microfinance… d) other…

b) if no, why……

Section IV: FODDER CONSERVATION PRACTICES

IV.1. Do you know any fodder conservation practices? a) yes… b) no…….

If yes, which ones

a) silage making…. b) hay making…c) other

-if not, why?.....

b) Have you heard or seen how to make silage? a) Yes…. b) No….

IV.2. Do you make silage? a) Yes…… b) No….

-If yes, what method do you use in silage making

a) Silos ……. b) Plastic bags…….c) others

- what forage do you use in silage making a) *Tripsacum laxum*…b) Napier grass…

c) legumes…. (name)……. d)other grass ……..… -if not, why don't you make it?

a) lack of knowledge…… b) scarcity of fodder…… c) scarcity of land…. d)other

…

IV.3. a) what do you mix with forage during the ensiling process?

TYPE	Quantity(kg)	Fresh material(kg)
Urea		
Molasses		
Salt		
Other		

b) which quantity of silage do you get……(kg) **Section V. FEED AVAILABILITY**

V.1. Is fodder available all year round? a) Yes…… b) No…

V.2. How is available fodder in the dry and wet seasons?.....

	planted pastures			natural pasture			crop residues		
Period	Low	medium	high	low	medium	High	low	medium	high
Dry season									

wet season									

V. 3.Do you supplement your animals? a) Yes…… b) Non…….

V.4. Which type of supplement do you use?

Type of supplement	Quantity/cow/day

Section VI. PRODUCTION AND MARKETING

VI.1. Do you sell fodder? 1) Yes……0) No……

if yes which type of fodder, do you sell

Type	Quantity/year
Fresh fodder	
Hay	
ensiled fodder	

-If not, why?.....

a) lack of fodder sales market…… b) low forage productivity……c) other……

GPS: Latitude …… Longitude ……. Altitude…

B. ANOVA STATISTICAL OUTPUT

Rcmdr> numSummary(milk1[,"MILK", drop=FALSE], statistics=c("mean", "sd", "IQR",
Rcmdr+ "quantiles"), quantiles=c(0,.25,.5,.75,1)) mean sd IQR 0% 25% 50%
75% 100% n

5.73254 1.835173 2.325 1.5 4.375 5.5 6.7 10 252

Table de statistique

Rcmdr> Tapply(MILK ~ DIET, mean, na.action=na.omit, data=milk1) # mean by groups

Cenchrus purpureus -Velvet bean silage fresh mixed fodder

5.369048 4.291667

maize stalk-*Velvet bean* silage

7.536905

Rcmdr> Tapply(MILK ~ DIET, median, na.action=na.omit, data=milk1)

Rcmdr+ # median by groups

Cenchrus purpureus -Velvet bean silage fresh mixed fodder

5.50 4.00

maize stalk-*Velvet bean* silage

7.75

rcmdr> tapply(milk ~ diet, sd, na.action=na.omit, data=milk1) # sd by groups

Cenchrus purpureus -Velvet bean silage fresh mixed fodder

1.078595 1.078845

maize stalk-*Velvet bean* silage

1.525666

Rcmdr> Tapply(MILK ~ DIET, var, na.action=na.omit, data=milk1) # var by groups

Cenchrus purpureus- Velvet bean silage fresh mixed fodder

1.163368 1.163906

maize stalk-*Velvet bean* silage

2.327658

Rcmdr> Tapply(MILK ~ DIET, CV, na.action=na.omit, data=milk1) # CV by groups

Cenchrus purpureus -Velvet bean silage fresh mixed fodder

0.2008914 0.2513813 maize stalk-*Velvet bean* silage
0.2024261

Rcmdr> Tapply (MILK ~ DIET, IQR, na.action=na.omit, data=milk1) # IQR by groups

Cenchrus purpureus -Velvet bean silage fresh mixed fodder

1.5 1.5

maize stalk -*Velvet bean* silage

2.5

Test de normalité/ normality test

Rcmdr> normalityTest(~MILK, test="shapiro.test", data=milk1)

Shapiro-Wilk normality test data: MILK
W = 0.95872, p-value = 0.00000129

Test d'homogénéité / test of homogeneity of variances

1. Test de Bartlett

Rcmdr> bartlett.test(MILK ~ DIET, data=milk1) Bartlett test of homogeneity of variances
data: MILK by DIET
Bartlett's K-squared = 14.033, df = 2, p-value = 0.0008968

Test de levenn

Rcmdr> Tapply(MILK ~ DIET, var, na.action=na.omit, data=milk1) # variances by group

Cenchrus purpureus -Velvet bean silage fresh mixed fodder

1.163368 1.163906

maize stalk-*Velvet bean* silage

2.327658

Rcmdr> leveneTest(MILK ~ DIET, data=milk1, center="mean")

Levene's Test for Homogeneity of Variance (center = "mean") Df F value Pr(>F) group 2 9.9956 0.00006675 ***
249

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

RcmdrMsg: [18] NOTE: Avis dans leveneTest.default(y = y, group = group, ...) :

ANOVA

Rcmdr> AnovaModel.1 <- aov(MILK ~ DIET, data = milk1)

Rcmdr> summary(AnovaModel.1)

Df Sum Sq Mean Sq F value Pr(>F)

DIET 2 459.0 229.49 147.9 <2e-16 ***

Residuals 249 386.4 1.55

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Rcmdr> with(milk1, numSummary(MILK, groups = DIET, statistics=c('mean', 'sd'))) mean sd data:n
Cenchrus purpureus -Velvet bean silage 5.369048 1.078595 fresh mixed fodder 4.291667 1.078845 maize stalk-*Velvet bean* silage 7.536905 1.525666

I. Data-Forage

```
Rcmdr> summary(data_forage)
```

DM	CP	CF
Min. :17.60	Min. : 5.370	Min. :24.80
1st Qu.:21.43	1st Qu.: 6.645	1st Qu.:27.27 Median :26.40 Median : 8.415 Median :28.75
Mean :28.88	Mean : 8.450	Mean :29.05
3rd Qu.:33.85	3rd Qu.:10.220	3rd Qu.:30.52
Max. :45.10	Max. :11.600	Max. :33.90

Ash	Fat
Min. : 7.190	Min. :1.340
1st Qu.: 7.197	1st Qu.:1.670
Median : 9.600	Median :1.885
Mean : 9.748	Mean :1.905
3rd Qu.:12.150	3rd Qu.:2.120
Max. :12.600	Max. :2.510

Statistique descriptve

```
Rcmdr> numSummary(data_forage[,"Ash", drop=FALSE], statistics=c("mean", "sd",
Rcmdr+ "IQR", "quantiles"), quantiles=c(0,.25,.5,.75,1)) mean sd IQR 0%
25% 50% 75% 100% n 9.7475 2.957537 4.9525 7.19 7.1975 9.6 12.15 12.6 4
Rcmdr> numSummary(data_forage[,"CF", drop=FALSE], statistics=c("mean", "sd", "IQR",
Rcmdr+ "quantiles"), quantiles=c(0,.25,.5,.75,1)) mean sd IQR 0% 25% 50%
75% 100% n 29.05 3.768731 3.25 24.8 27.275 28.75 30.525 33.9 4
Rcmdr> numSummary(data_forage[,"CP", drop=FALSE], statistics=c("mean", "sd", "IQR",
Rcmdr+ "quantiles"), quantiles=c(0,.25,.5,.75,1)) mean sd IQR 0% 25% 50%
75% 100% n
8.45 2.770644 3.575 5.37 6.645 8.415 10.22 11.6 4
```

Rcmdr> numSummary(data_forage[,"DM", drop=FALSE], statistics=c("mean", "sd", "IQR", Rcmdr+ "quantiles"), quantiles=c(0,.25,.5,.75,1)) mean sd IQR 0% 25% 50% 75% 100% n 28.875 11.97229 12.425 17.6 21.425 26.4 33.85 45.1 4

Rcmdr> numSummary(data_forage[,"Fat", drop=FALSE], statistics=c("mean", "sd", Rcmdr+ "IQR", "quantiles"), quantiles=c(0,.25,.5,.75,1)) mean sd IQR 0% 25% 50% 75% 100% n

1.905 0.4858326 0.45 1.34 1.67 1.885 2.12 2.51 4

Test de normalité/normality test

Rcmdr> normalityTest(~Ash, test="shapiro.test", data=data_forage) Shapiro-Wilk normality test data: Ash

W = 0.77737, p-value = 0.06744

Rcmdr> normalityTest(~CF, test="shapiro.test", data=data_forage) Shapiro-Wilk normality test data: CF

W = 0.98252, p-value = 0.9167

Rcmdr> normalityTest(~CP, test="shapiro.test", data=data_forage) Shapiro-Wilk normality test data: CP

W = 0.97112, p-value = 0.8484

Rcmdr> normalityTest(~DM, test="shapiro.test", data=data_forage) Shapiro-Wilk normality test data: DM

W = 0.94241, p-value = 0.6691

Rcmdr> normalityTest(~Fat, test="shapiro.test", data=data_forage) Shapiro-Wilk normality test data: Fat

W = 0.99417, p-value = 0.9777

ANOVA

> > one.way= aov (DM~`TYPE OF FEED`, data=data_forage)

> summary(one.way)

Df Sum Sq Mean Sq F value Pr(>F)

`TYPE OF FEED` 1 282 282 3.811 0.19

Residuals 2 148 74

> one.way= aov (CP~`TYPE OF FEED`, data=data_forage)

> summary(one.way)

Df Sum Sq Mean Sq F value Pr(>F)

`TYPE OF FEED` 1 15.664 15.664 4.254 0.175

Residuals 2 7.365 3.682

> one.way= aov (CF~`TYPE OF FEED`, data=data_forage)

> summary(one.way)

Df Sum Sq Mean Sq F value Pr(>F)

`TYPE OF FEED` 1 14.11 14.11 0.99 0.425

Residuals 2 28.50 14.25

> one.way= aov (Ash~`TYPE OF FEED`, data=data_forage)

> summary(one.way)

Df Sum Sq Mean Sq F value Pr(>F)

`TYPE OF FEED` 1 0.164 0.164 0.013 0.921

Residuals 2 26.077 13.039

> one.way= aov (Fat~`TYPE OF FEED`, data=data_forage)

> summary(one.way)

Df Sum Sq Mean Sq F value Pr(>F)

`TYPE OF FEED` 1 0.4033 0.4033 2.646 0.245

Residuals 2 0.3048 0.1524

II. Data Milk component

Statistique descriptive

Rcmdr> summary(milk2)

COW DIET WEIGHT.GAIN FAT

Length:9 Length:9 Min. : 2.000 Min. :0.02

Class :character Class :character 1st Qu.: 3.000 1st Qu.:4.20

Mode :character Mode :character Median : 5.000 Median :6.96

Mean : 6.222 Mean :6.05

3rd Qu.: 8.000 3rd Qu.:9.20

Max. :14.000 Max. :9.65

SNF LACT SALT PROTEIN

Min. :7.810 Min. :4.240 Min. :0.6100 Min. :2.890

1st Qu.:8.230 1st Qu.:4.470 1st Qu.:0.6500 1st Qu.:3.060

Median :8.790 Median :4.700 Median :0.7500 Median :3.300

Mean :8.586 Mean :4.698 Mean :0.7089 Mean :3.243

3rd Qu.:8.930 3rd Qu.:4.940 3rd Qu.:0.7600 3rd Qu.:3.360

Max. :9.140 Max. :5.030 Max. :0.7700 Max. :3.810

Rcmdr> numSummary(milk2[,"FAT", drop=FALSE], statistics=c("mean", "sd", "se(mean)",

Rcmdr+ "var", "IQR", "quantiles", "CV", "skewness", "kurtosis"), quantiles=c(0, Rcmdr+ .25,.5,.75,1), type="2") mean sd se(mean) var IQR CV skewness kurtosis 0% 25% 6.05 3.523691 1.174564 12.4164 5 0.5824283 -0.8177144 -0.6415156 0.02 4.2 50% 75% 100% n

6.96 9.2 9.65 9

Rcmdr> numSummary(milk2[,"LACT", drop=FALSE], statistics=c("mean", "sd",

Rcmdr+ "se(mean)", "var", "IQR", "quantiles", "CV", "skewness", "kurtosis"), Rcmdr+ quantiles=c(0,.25,.5,.75,1), type="2") mean sd se(mean) var IQR CV skewness kurtosis

4.697778 0.3005735 0.1001912 0.09034444 0.47 0.06398207 -0.2832032 -1.600446

0% 25% 50% 75% 100% n

4.24 4.47 4.7 4.94 5.03 9

Rcmdr> numSummary(milk2[,"PROTEIN", drop=FALSE], statistics=c("mean", "sd",

Rcmdr+ "se(mean)", "var", "IQR", "quantiles", "CV", "skewness", "kurtosis"), Rcmdr+ quantiles=c(0,.25,.5,.75,1), type="2")

mean sd se(mean) var IQR CV skewness kurtosis 0%

3.243333 0.2750909 0.09169696 0.075675 0.3 0.08481734 0.8607557 1.358837 2.89 25% 50% 75% 100% n

2.06 3.3 3.36 3.81 9

Rcmdr> numSummary(milk2[,"SALT", drop=FALSE], statistics=c("mean", "sd",

Rcmdr+ "se(mean)", "var", "IQR", "quantiles", "CV", "skewness", "kurtosis"), Rcmdr+ quantiles=c(0,.25,.5,.75,1), type="2") mean sd se(mean) var IQR CV skewness

0.7088889 0.06584915 0.02194972 0.004336111 0.11 0.09289066 -0.6446814

kurtosis 0% 25% 50% 75% 100% n

-1.572259 0.61 0.65 0.75 0.76 0.77 9

Rcmdr> numSummary(milk2[,"SNF", drop=FALSE], statistics=c("mean", "sd", "se(mean)",

Rcmdr+ "var", "IQR", "quantiles", "CV", "skewness", "kurtosis"), quantiles=c(0, Rcmdr+ .25,.5,.75,1), type="2") mean sd se(mean) var IQR CV skewness kurtosis 0%

8.585556 0.4860841 0.162028 0.2362778 0.7 0.0566165 -0.3914126 -1.506983 7.81

25% 50% 75% 100% n

8.23 8.79 8.93 9.14 9

Rcmdr> numSummary(milk2[,"WEIGHT.GAIN", drop=FALSE], statistics=c("mean", "sd",

Rcmdr+ "se(mean)", "var", "IQR", "quantiles", "CV", "skewness", "kurtosis"), Rcmdr+ quantiles=c(0,.25,.5,.75,1), type="2") mean sd se(mean) var IQR CV skewness kurtosis 0% 25% 6.222222 4.521553 1.507184 20.44444 5 0.7266782 1.02378 -0.3725632 2 3

50% 75% 100% n

5 8 14 9

Rcmdr> Tapply(FAT ~ DIET, mean, na.action=na.omit, data=milk2) # mean by groups cenchrus purpureus *Velvet bean* silage fresh mixed fodder

4.623333 5.673333

maize stalk-*Velvet bean* silage

7.853333

Rcmdr> Tapply(LACT ~ DIET, mean, na.action=na.omit, data=milk2) # mean by groups

cenchrus purpureus *Velvet bean* silage fresh mixed fodder

4.886667 4.850000

maize stalk-*Velvet bean* silage

4.356667

Rcmdr> Tapply(PROTEIN ~ DIET, mean, na.action=na.omit, data=milk2) # mean by groups

cenchrus purpureus *Velvet bean* silage fresh mixed fodder

3.266667 3.243333

maize stalk-*Velvet bean* silage

3.220000

Rcmdr> Tapply(SALT ~ DIET, mean, na.action=na.omit, data=milk2) # mean by groups

cenchrus purpureus *Velvet bean* silage fresh mixed fodder

0.7633333 0.7366667

maize stalk-*Velvet bean* silage

0.6266667

Rcmdr> Tapply(SNF ~ DIET, mean, na.action=na.omit, data=milk2) # mean by groups

Cenchrus purpureus- Velvet bean silage fresh mixed fodder

8.940000 8.776667

maize stalk-*Velvet bean* silage

8.040000

Rcmdr> Tapply(WEIGHT.GAIN ~ DIET, mean, na.action=na.omit, data=milk2)

Rcmdr+ # mean by groups

Cenchrus purpureus- Velvet bean silage fresh mixed fodder

4.666667 2.333333 maize stalk-*Velvet bean* silage

11.666667

Rcmdr> Tapply(FAT ~ DIET, median, na.action=na.omit, data=milk2) # median by groups

Cenchrus purpureus- Velvet bean silage fresh mixed fodder

4.20 6.60

maize stalk-*Velvet bean* silage

7.28

Rcmdr> Tapply(LACT ~ DIET, median, na.action=na.omit, data=milk2)

Rcmdr+ # median by groups

Cenchrus purpureus- Velvet bean silage fresh mixed fodder

4.93 4.94 maize stalk-*Velvet bean* silage

4.36

Rcmdr> Tapply(PROTEIN ~ DIET, median, na.action=na.omit, data=milk2)

Rcmdr+ # median by groups

Cenchrus purpureus- Velvet bean silage fresh mixed fodder

3.30 3.31

maize stalk-*Velvet bean* silage

2.96

Rcmdr> Tapply(SALT ~ DIET, median, na.action=na.omit, data=milk2) Rcmdr+ # median by groups *cenchrus purpureus- Velvet bean* silage fresh mixed fodder

0.77 0.75

maize stalk-*Velvet bean* silage

0.62

Rcmdr> Tapply(SNF ~ DIET, median, na.action=na.omit, data=milk2) # median by groups cenchrus purpureus *Velvet bean* silage fresh mixed fodder

8.93 8.89

maize stalk-*Velvet bean* silage

8.08

Rcmdr> Tapply(WEIGHT.GAIN ~ DIET, median, na.action=na.omit, data=milk2) Rcmdr+ # median by groups *cenchrus purpureus* -*Velvet bean* silage fresh mixed fodder

5 2

maize stalk-*Velvet bean* silage

13

rcmdr> tapply(fat ~ diet, sd, na.action=na.omit, data=milk2) # sd by groups *cenchrus purpureus* -*Velvet bean* silage fresh mixed fodder

4.828937 4.069906 maize stalk-*Velvet bean* silage

1.280208

Rcmdr> Tapply(LACT ~ DIET, sd, na.action=na.omit, data=milk2) # sd by groups

Cenchrus purpureus- *Velvet bean* silage fresh mixed fodder

0.1692139 0.2381176 maize stalk-*Velvet bean* silage

0.1150362

Rcmdr> Tapply(PROTEIN ~ DIET, sd, na.action=na.omit, data=milk2) # sd by groups

Cenchrus purpureus- *Velvet bean* silage fresh mixed fodder

0.1137248 0.1607275

maize stalk-*Velvet bean* silage

0.5121523

Rcmdr> Tapply(SALT ~ DIET, sd, na.action=na.omit, data=milk2) # sd by groups

Cenchrus purpureus- *Velvet bean* silage fresh mixed fodder

0.01154701 0.03214550

maize stalk-*Velvet bean* silage

0.02081666

Rcmdr> Tapply(SNF ~ DIET, sd, na.action=na.omit, data=milk2) # sd by groups

Cenchrus purpureus- Velvet bean silage fresh mixed fodder

0.1552417 0.4313158 maize stalk-*Velvet bean* silage
0.212838

rcmdr> tapply(weight.gain ~ diet, sd, na.action=na.omit, data=milk2) # sd by groups

Cenchrus purpureus- Velvet bean silage fresh mixed fodder

0.5773503 0.5773503 maize stalk-*Velvet bean* silage
3.2145503

Rcmdr> Tapply(FAT ~ DIET, var, na.action=na.omit, data=milk2) # var by groups

Cenchrus purpureus- Velvet bean silage fresh mixed fodder

23.318633 16.564133

maize stalk-*Velvet bean* silage

1.638933

Rcmdr> Tapply(LACT ~ DIET, var, na.action=na.omit, data=milk2) # var by groups cenchrus purpureus *Velvet bean* silage fresh mixed fodder
0.02863333 0.05670000

maize stalk-*Velvet bean* silage

0.01323333

Rcmdr> Tapply(PROTEIN ~ DIET, var, na.action=na.omit, data=milk2) # var by groups cenchrus purpureus *Velvet bean* silage fresh mixed fodder
0.01293333 0.02583333

maize stalk-*Velvet bean* silage

0.26230000

Rcmdr> Tapply(SALT ~ DIET, var, na.action=na.omit, data=milk2) # var by groups

Cenchrus purpureus- Velvet bean silage fresh mixed fodder

0.0001333333 0.0010333333 maize stalk-*Velvet bean* silage

0.0004333333

Rcmdr> Tapply(SNF ~ DIET, var, na.action=na.omit, data=milk2) # var by groups

Cenchrus purpureus- Velvet bean silage fresh mixed fodder

0.0241000 0.1860333

maize stalk-*Velvet bean* silage

0.0453000

Rcmdr> Tapply(WEIGHT.GAIN ~ DIET, var, na.action=na.omit, data=milk2) Rcmdr+ # var by groups *cenchrus purpureus -Velvet bean* silage fresh mixed fodder

0.3333333 0.3333333

maize stalk-*Velvet bean* silage

10.3333333

Rcmdr> Tapply(FAT ~ DIET, CV, na.action=na.omit, data=milk2) # CV by groups

Cenchrus purpureus- Velvet bean silage fresh mixed fodder

1.0444709 0.7173747

maize stalk-*Velvet bean* silage

0.1630146

Rcmdr> Tapply(LACT ~ DIET, CV, na.action=na.omit, data=milk2) # CV by groups

Cenchrus purpureus- Velvet bean silage fresh mixed fodder

0.03462767 0.04909642

maize stalk-*Velvet bean* silage

0.02640464

Rcmdr> Tapply(PROTEIN ~ DIET, CV, na.action=na.omit, data=milk2) # CV by groups

Cenchrus purpureus- Velvet bean silage fresh mixed fodder

0.03481372 0.04955627

maize stalk-*Velvet bean* silage

0.15905352

Rcmdr> Tapply(SALT ~ DIET, CV, na.action=na.omit, data=milk2) # CV by groups *Cenchrus purpureus- Velvet bean* silage fresh mixed fodder

0.01512708 0.04363643

maize stalk-*Velvet bean* silage

0.03321807

Rcmdr> Tapply(SNF ~ DIET, CV, na.action=na.omit, data=milk2) # CV by groups

Cenchrus purpureus- Velvet bean silage fresh mixed fodder

0.01736485 0.04914347

maize stalk-*Velvet bean* silage

0.02647238

Rcmdr> Tapply(WEIGHT.GAIN ~ DIET, CV, na.action=na.omit, data=milk2) # CV by groups

Cenchrus purpureus -Velvet bean silage fresh mixed fodder

0.1237179 0.2474358

maize stalk-*Velvet bean* silage

0.2755329

Rcmdr> Tapply(FAT ~ DIET, IQR, na.action=na.omit, data=milk2) # IQR by groups

Cenchrus purpureus -Velvet bean silage fresh mixed fodder

4.815 3.990

maize stalk-*Velvet bean* silage

1.180

Rcmdr> Tapply(LACT ~ DIET, IQR, na.action=na.omit, data=milk2) # IQR by groups

Cenchrus purpureus -Velvet bean silage fresh mixed fodder

0.165 0.225 maize stalk-*Velvet bean* silage

0.115

Rcmdr> Tapply(PROTEIN ~ DIET, IQR, na.action=na.omit, data=milk2) # IQR by groups

Cenchrus purpureus -*Velvet bean* silage fresh mixed fodder

0.11 0.15

maize stalk-*Velvet bean* silage

0.46

rcmdr> tapply(salt ~ diet, iqr, na.action=na.omit, data=milk2) # iqr by groups

Cenchrus purpureus -*Velvet bean* silage fresh mixed fodder

0.01 0.03

maize stalk-*Velvet bean* silage

0.02

Rcmdr> Tapply(SNF ~ DIET, IQR, na.action=na.omit, data=milk2) # IQR by groups

Cenchrus purpureus -*Velvet bean* silage fresh mixed fodder

0.155 0.420

maize stalk-*Velvet bean* silage

0.210

Rcmdr> Tapply(WEIGHT.GAIN ~ DIET, IQR, na.action=na.omit, data=milk2)

Rcmdr+ # IQR by groups

Cenchrus purpureus -*Velvet bean* silage fresh mixed fodder

0.5 0.5

maize stalk-*Velvet bean* silage

3.0

Test de normalité

Rcmdr> normalityTest(~FAT, test="shapiro.test", data=milk2) Shapiro-Wilk normality test data: FAT

W = 0.8803, p-value = 0.1582

Rcmdr> normalityTest(~LACT, test="shapiro.test", data=milk2) Shapiro-Wilk normality test data: LACT

W = 0.90495, p-value = 0.2821

Rcmdr> normalityTest(~PROTEIN, test="shapiro.test", data=milk2) Shapiro-Wilk normality test data: PROTEIN

W = 0.92148, p-value = 0.4046

Rcmdr> normalityTest(~SALT, test="shapiro.test", data=milk2) Shapiro-Wilk normality test data: SALT

W = 0.82707, p-value = 0.0414

Rcmdr> normalityTest(~SNF, test="shapiro.test", data=milk2) Shapiro-Wilk normality test data: SNF

W = 0.90584, p-value = 0.2878

Rcmdr> normalityTest(~WEIGHT.GAIN, test="shapiro.test", data=milk2) Shapiro-Wilk normality test data: WEIGHT.GAIN W = 0.8394, p-value = 0.05687

Test d'homogénéïté

rcmdr> tapply(fat ~ diet, var, na.action=na.omit, data=milk2) # variances by group

Cenchrus purpureus -*Velvet bean* silage fresh mixed fodder

23.318633 16.564133

maize stalk-*Velvet bean* silage

1.638933

Rcmdr> bartlett.test(FAT ~ DIET, data=milk2) Bartlett test of homogeneity of variances data: FAT by DIET

Bartlett's K-squared = 2.3437, df = 2, p-value = 0.3098

Rcmdr> Tapply(LACT ~ DIET, var, na.action=na.omit, data=milk2) # variances by group

Cenchrus purpureus -Velvet bean silage fresh mixed fodder

0.02863333 0.05670000

maize stalk-*Velvet bean* silage

0.01323333

Rcmdr> bartlett.test(LACT ~ DIET, data=milk2) Bartlett test of homogeneity of variances data: LACT by DIET

Bartlett's K-squared = 0.82027, df = 2, p-value = 0.6636

Rcmdr> Tapply(PROTEIN ~ DIET, var, na.action=na.omit, data=milk2)

Rcmdr+ # variances by group

Cenchrus purpureus -Velvet bean silage fresh mixed fodder

0.01293333 0.02583333

maize stalk-*Velvet bean* silage

0.26230000

Rcmdr> bartlett.test(PROTEIN ~ DIET, data=milk2) Bartlett test of homogeneity of variances data: PROTEIN by DIET

Bartlett's K-squared = 4.0012, df = 2, p-value = 0.1353

Rcmdr> Tapply(SALT ~ DIET, var, na.action=na.omit, data=milk2) # variances by group

Cenchrus purpureus -Velvet bean silage fresh mixed fodder

0.0001333333 0.0010333333 maize stalk-*Velvet bean* silage 0.0004333333

Rcmdr> bartlett.test(SALT ~ DIET, data=milk2) Bartlett test of homogeneity of variances data: SALT by DIET

Bartlett's K-squared = 1.526, df = 2, p-value = 0.4663

Rcmdr> Tapply(SNF ~ DIET, var, na.action=na.omit, data=milk2) # variances by group

Cenchrus purpureus -Velvet bean silage fresh mixed fodder

0.0241000 0.1860333

maize stalk-*Velvet bean* silage

0.0453000

Rcmdr> bartlett.test(SNF ~ DIET, data=milk2) Bartlett test of homogeneity of variances data: SNF by DIET

Bartlett's K-squared = 1.819, df = 2, p-value = 0.4027

Rcmdr> Tapply(WEIGHT.GAIN ~ DIET, var, na.action=na.omit, data=milk2) Rcmdr+ # variances by group cenchrus purpureus *Velvet bean* silage fresh mixed fodder

0.3333333 0.3333333

maize stalk-*Velvet bean* silage

10.3333333

Rcmdr> bartlett.test(WEIGHT.GAIN ~ DIET, data=milk2)

Bartlett test of homogeneity of variances

data: WEIGHT.GAIN by DIET

Bartlett's K-squared = 6.1522, df = 2, p-value = 0.04614

Rcmdr> leveneTest(FAT ~ DIET, data=milk2, center="median")

Levene's Test for Homogeneity of Variance (center = "median")

Df F value Pr(>F) group 2 0.8765 0.4635

Rcmdr> Tapply(LACT ~ DIET, var, na.action=na.omit, data=milk2) # variances by group

Cenchrus purpureus -Velvet bean silage fresh mixed fodder

0.02863333 0.05670000

maize stalk-*Velvet bean* silage

0.01323333

Rcmdr> leveneTest(LACT ~ DIET, data=milk2, center="median")

Levene's Test for Homogeneity of Variance (center = "median") Df F value Pr(>F) group 2 0.2297 0.8015

RcmdrMsg+ group coerced to factor.

Rcmdr> Tapply(PROTEIN ~ DIET, var, na.action=na.omit, data=milk2)

Rcmdr+ # variances by group

Cenchrus purpureus -Velvet bean silage fresh mixed fodder

0.01293333 0.02583333

maize stalk-*Velvet bean* silage

0.26230000

Rcmdr> leveneTest(PROTEIN ~ DIET, data=milk2, center="median")

Levene's Test for Homogeneity of Variance (center = "median") Df F value Pr(>F) group 2 0.5951 0.5811

Rcmdr> Tapply(SALT ~ DIET, var, na.action=na.omit, data=milk2) # variances by group

Cenchrus purpureus -Velvet bean silage fresh mixed fodder

0.0001333333 0.0010333333 maize stalk-*Velvet bean* silage

0.0004333333

Rcmdr> leveneTest(SALT ~ DIET, data=milk2, center="median")

Levene's Test for Homogeneity of Variance (center = "median")

Df F value Pr(>F) group 2 0.375 0.7023

RcmdrMsg: [48] NOTE: Avis dans leveneTest.default(y = y, group = group, ...) :

RcmdrMsg+ group coerced to factor.

Rcmdr> Tapply(SNF ~ DIET, var, na.action=na.omit, data=milk2) # variances by group

cenchrus purpureus *Velvet bean* silage fresh mixed fodder

0.0241000 0.1860333 maize stalk-*Velvet bean* silage

0.0453000

Rcmdr> leveneTest(SNF ~ DIET, data=milk2, center="median")

Levene's Test for Homogeneity of Variance (center = "median") Df F value Pr(>F) group 2 0.6849 0.5396

RcmdrMsg: [49] NOTE: Avis dans leveneTest.default(y = y, group = group, ...) :

RcmdrMsg+ group coerced to factor.

Rcmdr> Tapply(WEIGHT.GAIN ~ DIET, var, na.action=na.omit, data=milk2)

Rcmdr+ # variances by group

Cenchrus purpureus -Velvet bean silage fresh mixed fodder

0.3333333 0.3333333

maize stalk-*Velvet bean* silage

10.3333333

Rcmdr> leveneTest(WEIGHT.GAIN ~ DIET, data=milk2, center="median")

Levene's Test for Homogeneity of Variance (center = "median")

Df F value Pr(>F) group 2 1.087 0.3955

RcmdrMsg: [50] NOTE: Avis dans leveneTest.default(y = y, group = group, ...) :

RcmdrMsg+ group coerced to factor.

comparaison of the means : One way ANOVA Rcmdr> AnovaModel.5 <- aov(FAT ~ DIET, data = milk2)

Rcmdr> summary(AnovaModel.5)

Df Sum Sq Mean Sq F value Pr(>F)

DIET 2 16.29 8.144 0.588 0.584 Residuals 6 83.04

Rcmdr> with(milk2, numSummary(FAT, groups = DIET, statistics=c('mean', 'sd')))

Cenchrus purpureus -Velvet bean silage 4.623333 4.828937 3 fresh mixed fodder 5.673333 4.069906 3 maize stalk-*Velvet bean* silage 7.853333 1.280208 3

RcmdrMsg+ Variable(s) 'DIET' of class 'character' is/are not contained as a RcmdrMsg+ factor in 'model'.

Rcmdr> oneway.test(FAT ~ DIET, data = milk2) # Welch test One-way analysis of means (not assuming equal variances) data: FAT and DIET

F = 0.77851, num df = 2.0000, denom df = 3.0612, p-value = 0.5329

Rcmdr> AnovaModel.6 <- aov(LACT ~ DIET, data = milk2)

Rcmdr> summary(AnovaModel.6)

Df Sum Sq Mean Sq F value Pr(>F)

DIET 2 0.5256 0.26281 7.999 0.0203 *

Residuals 6 0.1971 0.03286

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Rcmdr> with(milk2, numSummary(LACT, groups = DIET, statistics=c('mean', 'sd')))

		mean	sd
data:n cenchrus purpureus *Velvet bean*	silage	4.886667	0.1692139
3 fresh mixed fodder		4.850000	0.2381176
3 maize stalk-*Velvet bean*	silage	4.356667	0.1150362
3			

RcmdrMsg: [37] ERREUR:

RcmdrMsg+ Variable(s) 'DIET' of class 'character' is/are not contained as a RcmdrMsg+ factor in 'model'.

Rcmdr> oneway.test(LACT ~ DIET, data = milk2) # Welch test One-way analysis of means (not assuming equal variances) data: LACT and DIET

F = 10.58, num df = 2.0000, denom df = 3.7009, p-value = 0.02946

Rcmdr> AnovaModel.7 <- aov(PROTEIN ~ DIET, data = milk2)

Rcmdr> summary(AnovaModel.7)

Df	Sum Sq	Mean Sq	F value	Pr(>F)
DIET	2 0.0033	0.00163	0.016	0.984 Residuals 6
0.6021 0.10036				

Rcmdr> with(milk2, numSummary(PROTEIN, groups = DIET, statistics=c('mean', 'sd')))

		mean	sd	data:n
Cenchrus purpureus -Velvet bean	silage	3.266667	0.1137248	
3 fresh mixed fodder		3.243333	0.1607275	
3 maize stalk-*Velvet bean*	silage	3.220000	0.5121523	
3				

RcmdrMsg: [38] ERREUR:

RcmdrMsg+ Variable(s) 'DIET' of class 'character' is/are not contained as a RcmdrMsg+ factor in 'model'.

Rcmdr> oneway.test(PROTEIN ~ DIET, data = milk2) # Welch test One-way analysis of means (not assuming equal variances) data: PROTEIN and DIET

F = 0.024733, num df = 2.0000, denom df = 3.5051, p-value = 0.9757

Rcmdr> AnovaModel.8 <- aov(SALT ~ DIET, data = milk2)

Rcmdr> summary(AnovaModel.8)

Df Sum Sq Mean Sq F value Pr(>F)

DIET 2 0.03149 0.015744 29.52 0.000785 ***

Residuals 6 0.00320 0.000533

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Rcmdr> with(milk2, numSummary(SALT, groups = DIET, statistics=c('mean', 'sd')))

mean sd data:n

Cenchrus purpureus -Velvet bean silage 0.7633333 0.01154701 3 fresh mixed fodder 0.7366667 0.03214550 3 maize stalk-*Velvet bean* silage 0.6266667 0.02081666 3

RcmdrMsg: [39] ERREUR:

RcmdrMsg+ Variable(s) 'DIET' of class 'character' is/are not contained as a RcmdrMsg+ factor in 'model'.

Rcmdr> oneway.test(SALT ~ DIET, data = milk2) # Welch test One-way analysis of means (not assuming equal variances) data: SALT and DIET

F = 41.501, num df = 2.0000, denom df = 3.4668, p-value = 0.003789

Rcmdr> AnovaModel.9 <- aov(SNF ~ DIET, data = milk2)

Rcmdr> summary(AnovaModel.9)

Df Sum Sq Mean Sq F value Pr(>F)

DIET 2 1.3794 0.6897 8.1 0.0197 *

Residuals 6 0.5109 0.0851

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Rcmdr> with(milk2, numSummary(SNF, groups = DIET, statistics=c('mean', 'sd')))

mean sd data:n

Cenchrus purpureus -Velvet bean silage 8.940000 0.1552417 3 fresh mixed fodder 8.776667 0.4313158 3 maize stalk-*Velvet bean* silage 8.040000 0.2128380 3

RcmdrMsg: [40] ERREUR:

RcmdrMsg+ Variable(s) 'DIET' of class 'character' is/are not contained as a RcmdrMsg+ factor in 'model'.

Rcmdr> oneway.test(SNF ~ DIET, data = milk2) # Welch test One-way analysis of means (not assuming equal variances) data: SNF and DIET

F = 14.928, num df = 2.0000, denom df = 3.6261, p-value = 0.01777

Rcmdr> AnovaModel.10 <- aov(WEIGHT.GAIN ~ DIET, data = milk2)

Rcmdr> summary(AnovaModel.10)

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
DIET	2	141.6	70.78	19.3	0.00243 **
Residuals	6	22.0	3.67		

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Rcmdr> with(milk2, numSummary(WEIGHT.GAIN, groups = DIET, statistics=c('mean', Rcmdr+ 'sd')))

mean sd data:n

Cenchrus purpureus -Velvet bean silage 4.666667 0.5773503 3 fresh mixed fodder 2.333333 0.5773503 3 maize stalk-*Velvet bean* silage 11.666667 3.2145503 3

RcmdrMsg: [41] ERREUR:

RcmdrMsg+ Variable(s) 'DIET' of class 'character' is/are not contained as a RcmdrMsg+ factor in 'model'.

Rcmdr> oneway.test(WEIGHT.GAIN ~ DIET, data = milk2) # Welch test One-way analysis of means (not assuming equal variances) data: WEIGHT.GAIN and DIET

F = 18.369, num df = 2.0000, denom df = 3.5927, p-value = 0.01299

III. Data_survey

Statistique descriptive

Rcmdr> numSummary(Data_survey[,"Age", drop=FALSE], statistics=c("mean", "sd",
Rcmdr+ "se(mean)", "var", "IQR", "quantiles", "CV"), quantiles=c(0,.25,.5,.75,1)) mean
sd se(mean) var IQR CV 0% 25% 50% 75% 100% n 43.69531 13.81917
0.7052068 190.9696 18.25 0.3162622 14 35 43 53.25 81 384
Rcmdr> numSummary(Data_survey[,"Area..ha.", drop=FALSE], statistics=c("mean", "sd",
Rcmdr+ "se(mean)", "var", "IQR", "quantiles", "CV"), quantiles=c(0,.25,.5,.75,1)) mean
sd se(mean) var IQR CV 0% 25% 50% 75% 100% n 1.132812 0.3398147 0.0173411
0.1154741 0 0.2999744 1 1 1 1 2 384
Rcmdr> numSummary(Data_survey[,"Area.ha.", drop=FALSE], statistics=c("mean", "sd",
Rcmdr+ "se(mean)", "var", "IQR", "quantiles", "CV"), quantiles=c(0,.25,.5,.75,1)) mean
sd se(mean) var IQR CV 0% 25% 50% 75% 100% n NA 1.497258 1.325342
0.06772183 1.756533 1.5 0.8851794 0 0.5 1 2 11 383 1
RcmdrMsg: [9] NOTE: Avis dans CV(X) : not all values are positive

Test de normalité

Rcmdr> normalityTest(~Age, test="shapiro.test", data=Data_survey) Shapiro-Wilk normality test data: Age
W = 0.98691, p-value = 0.001546

Rcmdr> normalityTest(~Area..ha., test="shapiro.test", data=Data_survey) Shapiro-Wilk normality test data: Area..ha.
W = 0.40001, p-value < 2.2e-16

Rcmdr> normalityTest(~Area.ha., test="shapiro.test", data=Data_survey) Shapiro-Wilk normality test data: Area.ha.
W = 0.75991, p-value < 2.2e-16

C.ETHICAL APPROVAL

EGERTON UNIVERSITY

TEL: (051) 2217808 P. O. BOX 536 FAX: 051-2217942
EGERTON

EGERTON UNIVERSITY INSTITUTIONAL SCIENTIFIC AND ETHICS REVIEW COMMITTEE

EU/RE/DIR/009

Approval No. EUISERC/APP/278/2023 ***11th August*** **2023**

Francine Ahimpera

Department of Animal Sciences

Egerton University

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Dear Francine,

ETHICAL APPROVAL

This is to inform you that ***Egerton University Institutional Scientific and Ethics Review Committee*** has reviewed and approved your above research proposal. Your application approval number is ***EUISERC/APP/278/2023.*** The approval period is ***11th August, 2023 – 12th August,***

2024

This approval is subject to compliance with the following requirements;

i. Only approved documents including (informed consents, study instruments, MTA) will be used.

ii. You are required to adhere Institutional Experimental Animals use and Care policy.

iii. All changes including (amendments, deviations, and violations) are submitted for review and approval by ***Egerton University Institutional Scientific and Ethics Review Committee***.

iv. Death and life-threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to ***Egerton University Institutional Scientific and Ethics Review Committee*** within 72 hours of notification

v. Any changes, anticipated or otherwise that may increase the risks or affect safety or welfare of study participants and others or affect the integrity of the research must be reported to

Egerton University Institutional Scientific and Ethics Review Committee within 72 hours.

vi. Clearance for Material Transfer of biological specimens must be obtained from relevant institutions.

vii. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal. viii.

Submission of an executive summary report within 90 days upon completion of the study to ***Egerton University Institutional Scientific and Ethics Review Committee***.

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) https://oris.nacosti.go.ke and also obtain other clearances needed.

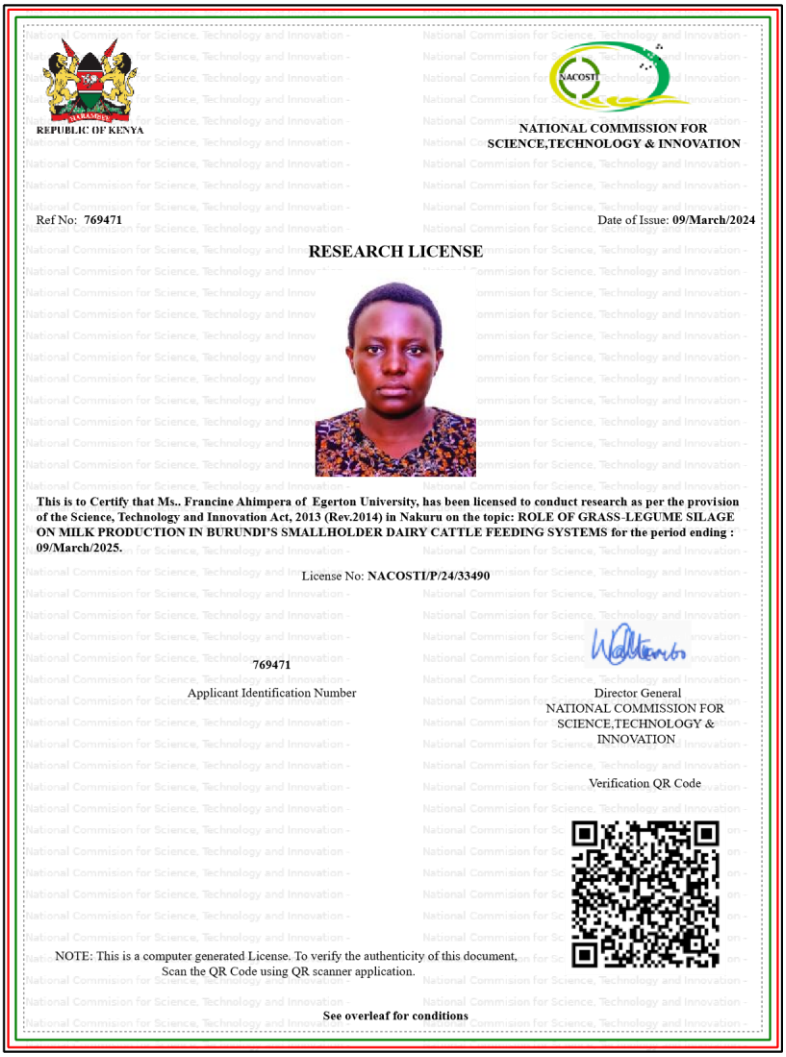
Yours sincerely.

Prof. Raphael M. Ngure

CHAIRMAN, EGERTON UNIVERSITY INSTITUTIONAL SCIENTIFIC AND ETHICS REVIEW CTTEE

RMN/BK/

D.NACOSTI PERMIT



REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

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RESEARCH LICENSE

This is to Certify that Ms.. Francine Ahimpera of Egerton University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Nakuru on the topic: ROLE OF GRASS-LEGUME SILAGE ON MILK PRODUCTION IN BURUNDI'S SMALLHOLDER DAIRY CATTLE FEEDING SYSTEMS for the period ending : 09/March/2025.

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E. PUBLICATIONS

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Fodder production and conservation practices for smallholder dairy farmers in the Imbo plain of Burundi

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Abstract: The study was conducted on 384 smallholder dairy farms located in five Provinces of the Imbo Plain of Burundi. It assessed the status of livestock feeding and identified potential dry season feed interventions by smallholder dairy farmers. A survey using a structured questionnaire was used to collect information on fodder production, fodder conservation, feeding management, feed resources, and marketing. The Kobo collect tool was used to

facilitate the activity. Data were analyzed using IBM SPSS Statistics 20 software. Quantitative data were analyzed using descriptive statistics while qualitative data were analyzed using the association of some variables by using cross-tabulations. Results from the study showed a high level of availability of natural fodder (96.9%) and established fodder (94.5%) during the wet season with scarcity during the dry season (87.2% and 85.7% respectively). It was observed that there was a low level of adoption of fodder conservation and marketing. The study concluded that the low adoption level of fodder production, conservation, and marketing practices may be a result of the low education level and consequently increased poverty among smallholder dairy farmers. To prevent dry season feed scarcity, smallholder dairy farmers, were encouraged to adopt new technologies of conservation of surplus fodder available in the wet Season. They were also inducted to new technologies of treating crop residues for use as animal feed during the dry season period.

Keywords: Livestock, feed scarcity, milk production, season, smallholder income, Burundi.