Journal of Veterinary Science and Animal Husbandry
Volume 12 | Issue 2
ISSN: 2348-9790

Research Article Open Access

Nutritional Value and Chemical Composition of Selected Fodders; Feed Intervention in Smallholder Dairy Farms in Kenya

Caleb Wanyiri Oktoto[*], **James Ombiro Ondiek**

Egerton University, Department of Animal Science, Nakuru, Kenya

[*]**Corresponding Author:** Caleb Wanyiri Oktoto, Egerton University, Department of Animal Science, Nakuru, Kenya, Tel.: 0713228915, E-mail: calebwanyiri8@gmail.com

Citation: Caleb Wanyiri Oktoto, James Ombiro Ondiek (2024) Nutritional Value and Chemical Composition of Selected Fodders; Feed Intervention in Smallholder Dairy Farms in Kenya, J Vet Sci Ani Husb 12(2): 201

Received Date: April 27, 2024 **Accepted Date:** May 27, 2024 **Published Date:** May 31, 2024

Abstract

This study evaluated the nutritional value and chemical composition of five selected fodder; Boma Rhodes, lucerne, greenleaf Desmodium, chicory, and sweet potato vines which were collected from three geographically distinct regions: Bomet, Nyandarua, and Nyeri, and taken for chemical analysis in the Animal Nutrition laboratory in Animal Science department at Egerton University. These fodder species were analysed for their proximate composition, metabolisable energy, and van Soest composition. All these analyses were done on a dry matter basis. All these results were analysed at $P<0.05$. The results revealed significant variations in the nutritional profiles of these diets across the three regions. Bomet exhibits specific trends in crude protein and dry matter, while Nyandarua showcases variability in ether extract and total ash content. Nyeri emphasises differences in crude protein and ash content. These findings provide valuable insights into the regional variations in the chemical composition of fodder, highlighting the importance of tailoring dietary strategies for livestock based on the local environment. The study contributes to the existing literature by offering a comprehensive analysis of the nutritional value of common livestock diets in diverse regions, aiding farmers and researchers in optimizing animal nutrition and enhancing overall agricultural practices.

Keywords: Boma Rhodes; lucerne; greenleaf Desmodium; chicory; sweet potato vines

Introduction

The livestock industry in Kenya is vital to the country's economy, providing jobs, income, and food security. The livestock industry generates 12% of the GDP, while the dairy industry, which has been expanding at a rate of 4%, contributes 4-8% of the gross domestic product (GDP) [1]. In Kenya, smallholder dairy farmers generate around 1.8 million jobs along the value chain and produce 80% of the nation's milk. The high cost of producing milk, which is mostly caused by the poor quality of animal feed, and the limited availability of high-quality forages throughout the year limit the growth of the dairy industry [2]. In Kenya, tropical grasses supplemented with legumes and residues from crops make up the majority of the forages used in livestock diets.

The goal of this study is to thoroughly investigate the nutritional makeup of the chosen fodders listed below. The principal aim is to acquire a comprehensive comprehension of the ways in which these particular fodders influence the amount and quality of milk produced. By comparing the income over feed cost linked with the use of these particular fodders, the study also explored the economic side. This study aims to offer important insights that can guide and improve feeding procedures within the context of dairy farming through a thorough analysis of their nutritional content and their consequent effect on milk production efficiency.

Only 25 per cent of dairy cows in Kenya produces over 8 litres of milk per day. In comparison, 60 per cent which produces between 1 to 4 litres, and 15 per cent that produces 4 to 8 litres of milk per day based on a study that was done. Nutritional constraints in dairy cow farming have been cited as the primary cause of low milk productivity: inadequate feeds, high feed costs, lack of supplements, poor feeding practices and low-quality feedstuffs have all contributed to low milk productivity. Feed factors are major obstacles to dairy cow production for more than 70 per cent of small-scale dairy farm holders. The solution to the aforementioned issue may lie in the development and utilization of high-quality non-conventional feedstuffs to formulate a feeding model that is economically affordable and readily available, such as a total mix ratio of Boma Rhode hay, lucerne, greenleaf Desmodium, chicory and sweet potato vine

Lucerne or Alfalfa (Medicago sativa L)

Figure 1 presents a visual depiction showcasing the morphological characteristics of alfalfa (Medicago sativa). This image provides a detailed glimpse into the distinctive features of the alfalfa plant, including its leaves, stems, and any other relevant structures. The visual representation serves as a valuable resource for understanding the physical attributes of alfalfa, contributing to a comprehensive insight into the plant's morphology.

Figure 1: Flowered Lucerne leaves (Medicago sativa L.)

Source: https://www.namibian.com.na/

For years, lucerne has been pivotal in animal production, but changing climate dynamics necessitate a reassessment of its role. Understanding the drawbacks of existing systems and realizing the potential of lucerne as a ruminant food source is essential [3]. The frequency of leaf defoliation emerges as a critical factor influencing the quality, yield, and persistence of lucerne grasslands, impacting forage biomass and pasture longevity [4]. Considering these factors can optimize forage harvesting and pasture preservation [5]

Lucerne's Versatility in Human Nutrition and Medicine

Lucerne acknowledged for its acquired taste, has secured a place in diverse human recipes, such as puree sauté, tortilla, tea, croquettes, soufflé, pudding, and both raw and cooked salads [6]. Despite its distinctive flavour, it is recommended to persevere due to its nutritional value. In traditional medicine across regions like Iraq, Turkey, America, and even in traditional Chinese medicine, lucerne has been recognized for its nutritional benefits. It has been used to stimulate appetite, alleviate boils and abscesses, promote healthy blood circulation, and enhance resistance to diseases [7, 8]. Lucerne's leaves contain essential nutrients, including ß-carotene, calcium, iron, phosphorus, potassium salts, and vitamins B, C, D, E, and K. Notably, its chlorophyll content contributes to its anticarcinogenic and detoxifying properties, particularly in the gastrointestinal tract [9].

Beyond its traditional applications, lucerne's aerial parts contain plant protein, sugars, mineral salts, and vitamins [8]. In a comparative study, ruminants fed lucerne pasture showed higher concentrations of vitamin E, essential omega-3 fatty acids, and carcass weight compared to those on a feedlot diet or grazing yearly pastures with concentrate supplements [10]. This underscores lucerne's potential to enhance the nutritional profile of animal products in agricultural settings. Thus, lucerne stands as a versatile resource, benefiting both human nutrition and animal husbandry. The timing of when forage is available is affected by a plant variety's degree of dormancy, which causes the plant to grow later in the spring and finish earlier in the autumn [11].

Sweet Potato Vines (*Ipomoea batatas* L.) Background Information

After wheat, rice, corn, potato, barley and cassava, sweet potatoes (Ipomoea batatas L.) are the most significant crop [12]. It is an important staple that is widely grown throughout many parts of Nigeria and is a member of the Morning Glory family, Convolvulaceae. Due to their enormous starchy, sweet-tasting storage roots that can be used as human food, animal feed, and seed vines for commercial root production, sweet potatoes are well-established in savanna and rainforest regions as shown in Figure 2 [13].

Figure 2: Sweet Potato Vines(Ipomoea batatas L.)

Source: https://kilimonews.co.ke/

Sweet potato leaves, constituting 27% real protein, 8% starch, 4% sugar, and 10% ash on a dry weight basis, are rich in pro-vitamin A, vitamins B and C, calcium, potassium, and sodium, with variations in vegetative morphology and leaf shapes [13]. The diminishing agricultural land for forage production has led to the exploration of dual-purpose crops like sweet potatoes, which thrive in semi-arid environments. Research by the International Potato Centre (C1P) in 2008 highlighted the preference for dual-purpose sweet potato varieties among farmers, offering both human consumption and livestock feed. These cultivars, harvestable throughout the growing season, hold promise for enhancing the nutritional and food security of resource-limited households in rural areas [14]. Despite concerns about genetic selection for high storage root yield in sweet potatoes, additional efforts are underway to release varieties like Kenspot 1-5, addressing the gap in research on biomass production and nutritional value for farm animals [15, 16].

Greenleaf Desmodium (Desmodium intortum)

The robust tropical forage legume, Greenleaf Desmodium, exhibits perennial growth with branched, decumbent stems measuring 1.5 to 7.5 m long and 7 mm in diameter. Featuring trifoliate leaves with ovate reddish-brown to purple leaflets (2-7 cm long by 1.5-5.5 cm wide), it has climbing pubescent stems rooting at the nodes. Terminal compact racemes bear flowers in deep lilac to deep pink hues. Pods, 5 cm long, contain 8–12 kidney-shaped seeds (1.5 mm wide, 3 mm long) that cling to clothing. Notably, Greenleaf Desmodium, in contrast to Silverleaf Desmodium, is characterized by its rounder leaflets as shown in figure 3.

Figure 3: Green Leaf Desmodium(Desmodium uncinatum)

Source: www.Fedipedia.com

Greenleaf Desmodium, originating from Central and North-Western America, is a versatile fodder legume with applications in cutting for hay, silage, fresh feeding, or as a long-term fodder option [17]. Thriving in subtropical regions between 30°N and 30°S, it exhibits adaptability to various elevations and regions with heavier rainfall [18]. Resilient to diverse soil types, except those excessively saline or extremely acidic, it proves valuable in agriculture [17]. Boasting a notable 24% protein content [19], Greenleaf Desmodium serves as a valuable plant protein source with no reported cases of toxicity. Beyond its agricultural applications, certain Desmodium species are employed in herbal medicine for treating conditions like rheumatism and wounds [17, 20].

Chicory (*Cichorium intybus L.*) Background Information

Cichorium intybus L., commonly known as chicory or kasni in Hindi, is a significant medicinal herb belonging to the Asteraceae family. The aerial parts, flowers, seeds, and roots of this plant are extensively utilized for their medicinal properties as shown in Figure 4 [21]. Rich in essential compounds such as lactones, volatile oil, fatty acids, coumarins, alkaloids, unsaturated sterols, cardiac glycosides, sesquiterpene, anthocyanins, and phenols, each part of the plant contributes to its overall medicinal value [22].

Figure 4: Chicory Commander (Cichorium intybus L.)

Source: www.agricom.co.nz

Cichorium intybus, commonly known as chicory, is a valuable medicinal herb with uses in various parts, including aerial parts, flowers, seeds, and roots. Rich in compounds such as lactones, volatile oil, fatty acids, coumarins, alkaloids, sterols, glycosides, sesquiterpene, anthocyanins, and phenols, the plant exhibits medicinal properties across its entirety. Chicory roots, containing inulin with a minimal impact on blood sugar, are beneficial for diabetics. Traditionally, it has been employed to address conditions like gallbladder stones, jaundice, diarrhoea, and high fever. Additionally, *C. intybus* demonstrates a range of pharmacological activities, including antibacterial, anthelmintic, antimalarial, liver-protective, antidiabetic, gastroprotective, antioxidant, anti-inflammatory, analgesic, tumor-inhibitory, and antiallergic properties, as reported by [23, 24].

Boma Rhodes (*Chloris gayana*)

Rhodes grass is a versatile tropical grass that can be annual or perennial, growing 1-2 meters tall. Its diverse features include culms that can be decumbent or erect, tufted or creeping, and roots that extend up to 4.5 meters below the surface. The glabrous linear leaves are 12–50 cm long and 10–20 mm wide, with a tapering tip. The seed head resembles an open hand with two to ten racemes, maturing from light greenish-brown to darker brown. The spikelets, numbering more than 32, are strongly imbricated and feature two awns. The fruit is a caryopsis with longitudinal grooves as shown in figure 5 [25].

Figure 5: Boma Rhodes Grass(Chloris gayana)

Source: www.Fedipedia.com

Rhodes grass, a versatile fodder, is used for grazing, hay, and deferred feed. Cultivars cater to different environments, and their deep roots make them valuable for soil enhancement [25]. Thriving in temperatures of 25–30°C, Rhodes grass tolerates climates with lows of 16.5°C and highs of 26°C, with ideal annual rainfall from 600 to 750 mm [18]. Drought-tolerant, it endures up to 6 months of dry spells, with a yield range of 10 to 16 T DM/ha [18]. Adaptable to various soils, it prefers well-structured ones with pH levels of 5.5–7.5 [25]. Both vegetative and seed propagation are possible, with seeds sown in autumn and rapid germination on well-prepared seedbeds [25, 26].

Material and Methods

Description of the Study Area

The first experiment, fodder samples were obtained from Olubutyo Dairy Cooperative demonstration farm which is found in Tagiamin village, in Kongasis ward, Chepalungu sub-county in Bomet County-0.7942421° 47' 8.0196" S, 35.3478951° 20' 20.8968" E, 223 Km from Nairobi In according to Latlong. In 2019, its population was 875,689, and its total area was 1,630.0 square kilometres. Bomet Town is the county seat of Bomet County as shown in Figure 6. As the country's centre, the capital is easily accessible from across all corners and districts of the area. The Narok-Kisii road, where the town is situated, is very busy.

Bomet experiences brief, warm, and cloudy summers and long, cool, mostly clear winters. The average yearly temperature ranges from 11.67°C to 26.11°C, with only a few exceptions when it drops below 10°C or rises above 28.89°C. There is an average daily temperature of 25.56°C during the warm season, lasting from January 13th to March 21st. With an average maximum temperature of 26.11°C and low temperature of 12.22°C, the month of February is the hottest of the year in Bomet. The summer season, with a mean daily maximum temperature of 22.78°C or less, runs from April 29 to August 29. With an average minimum temperature of 11.67°C and high temperature of 22.22°C, July is the coldest month in Bomet [27].

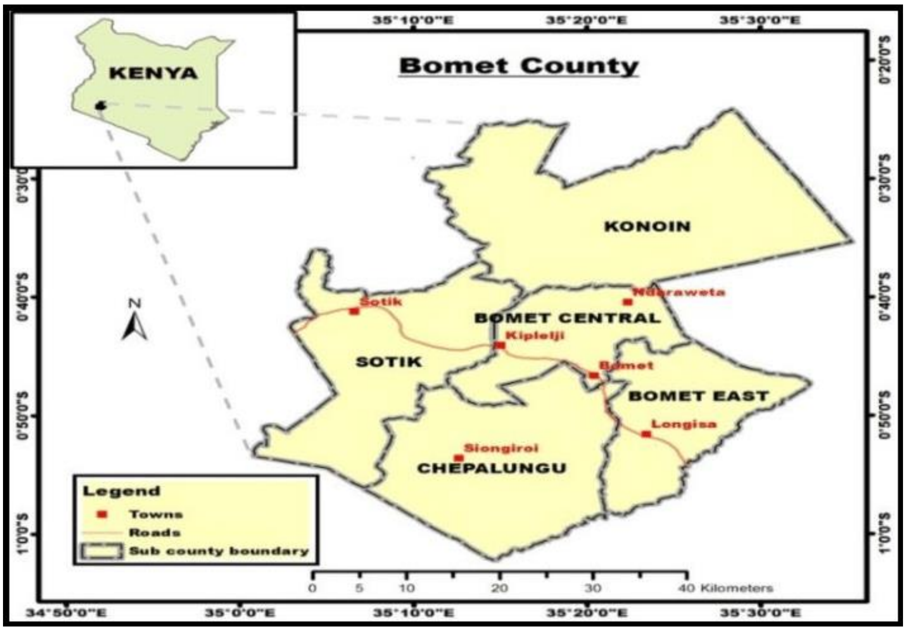

Figure 6: Map of Bomet County showing the study area for objective one

Source: Kenya Independent Electoral and Boundaries Commission (2012).

The second comparing experiment fodder samples were obtained from Ndaragwa Central constituency, Ngamini Ward, Kahothia Village in Nyandarua County located between geographical coordinates -0.480098611S, and 36.54974917E as shown in Figure 7. Kenya's Nyandarua County was formerly part of the Central Province. Ol Kalou is its largest town and capital. Nyahururu, which is now a part of Laikipia County, served as the capital once. Nyandarua County is 3,304 km2 in size and home to 596,268 people.

The Aberdare Ranges are located in the county, which is situated in the northwest of the former Central Province.

3,107.7 km2 makes up its whole area (1,199.9 sq mi). 638289 people call it home, according to the 2019 general census. Farming, including potato, dairy, and crop cultivation, is the primary economic activity in Nyandarua. According to the Köppen-Geiger classification, this area has a Cfb climate. Here, the average temperature is 15.8 °C. This area receives about 2276 mm, or 89.6 inches, of rainfall annually. The Aberdare Ranges are located in the northwest of the county, which was once part of the Central Province. The road distance between Nyandarua and Nakuru is 295.4 km, while the distance between the two towns is 48 km. Nitosols, andosols, leptosols, luvisols, phaezems, and planosols are the most common types of soils.

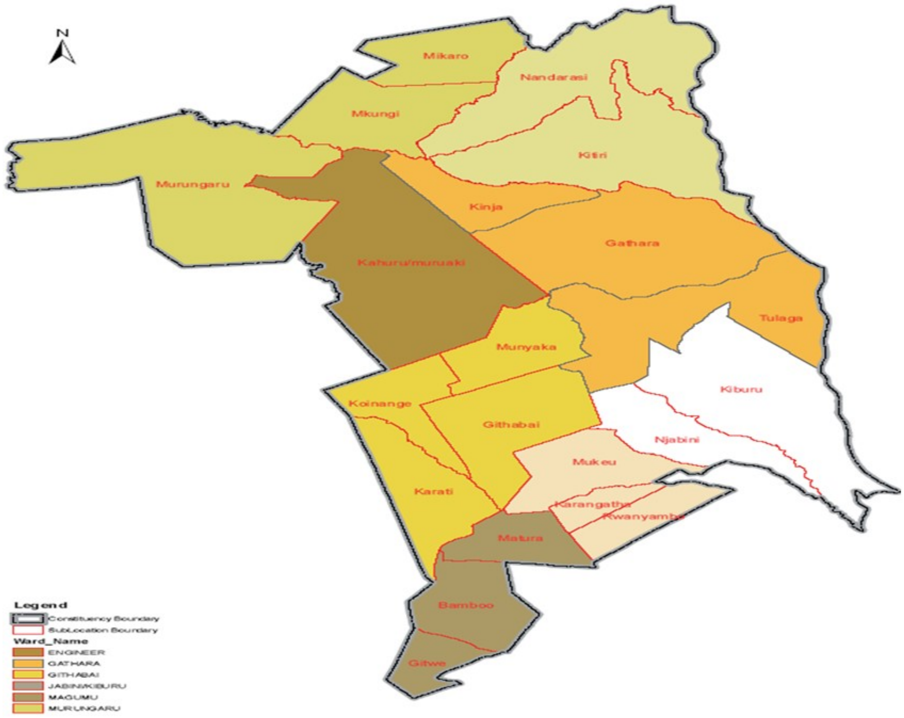

Figure 7: Map of Kinangop sub-county in Nyandarua county showing the administrative boundaries and wards for objective one

Source: The guide.org

Nyeri County provided the fodder samples for the third comparison experiment. The two Sub-Counties—Mathira West, Ngandu location, and Kieni East—were chosen for this research based on the number of dairy farmers in each Sub-County as shown in Figure 8. The Kenya National Bureau of Statistics (KNBS) estimated the population in 2019 to be 759,164 people living in 207.8/km2. Its common borders are with five counties: Meru to the north, Laikipia to the north, Nyandarua to the west, Murang'a to the south, and Kirinyaga to the east. It is located between latitudes 0°25′12″ S and 36°56′51″ E. It has become a premier centre for agricultural innovation as a result. The county is situated between 3,076 and 5,199 metres above sea level, about 150 kilometres north of Nairobi. In the hot months of January through March and September through October, the county's average temperature is 20.8°C, and in the cold months of June and July, it is 12.80°C. 500–1600 millimetres of precipitation fall there annually, with April and May seeing the heaviest amounts.

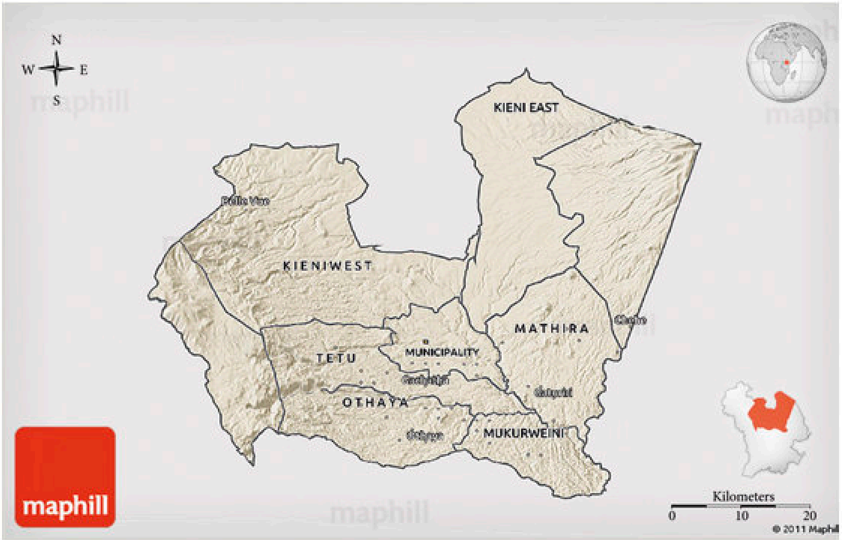

Figure 8: For goal one, a map of Nyeri County with the various sub-counties indicated (the municipality represents Nyeri Central)

Map provided by Maphill.(Kieni East and Mathra)

Sampling

Fodders for laboratory analysis were collected using a systematic random sampling technique and packed in well-labelled khaki bags.

Proximate Analysis

The samples were examined at the Animal Nutrition Laboratory in the Department of Animal Science at Egerton University in Kenya. The following techniques were employed to evaluate the selected fodder samples' proximate chemical composition: ether extracts by continuous extraction performed on a dry sample in a Soxhlet extractor without previous acid hydrolysis (EE; AOAC Official method 934.01); crude protein was computed by multiplying the nitrogen content by 6.25 and determining the amount of nitrogen using the Kjeltec 2300 Foss Tecator apparatus (Hanganäs, Sweden). The AOAC standard procedures [28] were employed to determine crude ash (Ash; AOAC Official Method 942.05) and crude fibre (CP; Kjeldahl method, AOAC Official method 984.1); additionally, crude fibre was determined in accordance to the Henneberg-Stohmann method by hydrolyzing animal fodder samples with acid and base solution using a Fibertec Tecator (Haganäs, Sweden) apparatus (CF; AOAC Official method 978.10). Samples of dry matter were dried using the weight method and dried in a forced air oven at 105oC (DM; AOAC Official method 934.01).

The fibre component was analysed using an apparatus made by Fibertec Tecator (Haganäs, Sweden) and the [29] method for acid detergent lignin (ADL; method 973.18 of AOAC), neutral detergent fibre (NDF; method 2002.04 of AOAC), and acid detergent fibre (ADF; method 973.18 of AOAC) [30]. Also, the metabolizable energy levels of the feed were determined using the bomb calorimeter. Before feeding, this was done to know how much to feed the animal in terms of its daily nutrient requirement and to have an impression of their contribution to the milk yield per experimental animal.

Statistical Analysis

All variables were subjected to analysis of variance (ANOVA) in a completely randomised design utilizing the SAS (2002) version 9.4. Statistical Package's General Linear Model Procedures (proc glm). The New Duncan's multiple range test was used to declare significant means at the 5% confidence level [31]. The linear model for the completely randomised design (CRD) was:

$Y_{ij}= \mu + T_i+ e_{ij}$

where Y_{ij}= dependent variables (nutrient composition/digestibility/ME).

μ= overall mean due to all observations.

T_i= effect of i^{th} treatment diet {i=1,2,3,4}

e_{ij} = Random error effect.

Results

Bomet

Table 6 shows the compounded chemical composition (% DM basis) of selected fodder species in Bomet County, from proximate analysis to van Soest analysis to metabolizable energy.

No significant difference in dry matter % was found between lucerne, green leaf Desmodium, and boma Rhodes at P>0.05. Similarly, the dry matter content of sweet potato vines, green leaf Desmodium, and chicory showed no significant difference at P>0.05. However, a significant difference was observed between lucerne's dry matter % and that of sweet potato vine and chicory at P <0.05. There was a significant difference in crude protein % across all five experimental fodders—lucerne, green leaf Desmodium, sweet potato vines, chicory, and boma Rhodes at P<0.05. Ether extract % showed no significant difference between sweet potato vine, green leaf Desmodium, chicory, and boma Rhodes at P>0.05. However, ether extract % of lucerne differed significantly from all four fodders at P<0.05.

A significant difference in ash content was observed across all five fodders—lucerne, green leaf Desmodium, sweet potato vines, chicory, and boma Rhodes at P<0.05. Crude fibre % also showed a significant difference across all five fodders at P<0.05. Neutral detergent fibre content level had no significant difference between sweet potato vine and chicory at P>0.05, while lucerne, green leaf Desmodium, and boma Rhodes differed significantly at P<0.05. Green leaf Desmodium and boma Rhodes also showed a significant difference in neutral detergent fibre content level from sweet potato vine and chicory at P<0.05. Lucerne had a significant difference in neutral detergent fibre content level from sweet potato vine and chicory at P<0.05. No significant difference was found in acid detergent fibre % among sweet potato vines, green leaf Desmodium, and chicory at P>0.05, while lucerne and boma Rhodes differed significantly at P<0.05. Lucerne also differed significantly in terms of acid detergent fibre % with sweet potato vines, green leaf Desmodium, and chicory at P<0.05. Boma Rhodes had a significant difference in acid detergent fibre % from sweet potato vines, green leaf Desmodium, and chicory at P<0.05.

There was a significant difference in acid detergent lignin% across all five fodders—lucerne, green leaf Desmodium, sweet potato vines, chicory, and boma Rhodes at P<0.05. However, no significant difference was observed between the metabolizable energy (J/kg) of lucerne and that of boma Rhodes at P<0.05. Sweet potato vine, green leaf Desmodium, and chicory exhibited a significant difference in metabolizable energy (J/kg) at P>0.05. Sweet potato vine differed significantly in terms of metabolizable energy (K/kg) from lucerne and boma Rhodes at P<0.05. Similarly, green leaf Desmodium differed significantly in terms of metabolizable energy (K/kg) from lucerne and boma Rhodes at P<0.05, as did chicory, which differed significantly in terms of metabolizable energy (K/kg) from lucerne and boma Rhodes at P<0.05.

Table 1: Compounded chemical composition (% DM basis) of selected fodder species in Bomet County

Sample	DM	CP	EE	Ash	CF	NDF	ADF	ADL	ME (J/Kg)
Lucerne	2.87[a]	14.20[a]	1.73[a]	13.35[a]	19.22[a]	32.89[a]	27.41[a]	5.02[a]	12.72[a]
Sweet Potato Vines	4.15[b]	16.21[b]	2.76[b]	14.82[b]	16.27[b]	28.33[b]	38.13[b]	14.57[b]	12.05[b]
Greenleaf Desmodium	3.59[ab]	15.63[c]	2.87[b]	9.67[c]	27.03[c]	44.79[d]	40.39[b]	6.00[c]	13.27[c]
Boma Rhodes	3.45[ab]	4.30[d]	2.72[b]	12.35[d]	36.61[d]	68.61[c]	47.73[c]	18.96[d]	12.73[a]
Chicory	4.10[b]	17.55[e]	2.53[b]	19.47[e]	14.54[e]	29.08[b]	40.85[b]	2.09[e]	11.64[d]
P	0.0337	<.0001	0.0431	<.0001	<.0001	<.0001	0.0005	<.0001	<.0001
SEM	0.261	0.131	0.2401	0.111	0.155	0.481	1.985	0.265	0.046

DM= dry matter; CP=crude protein; EE= Ether extract; CF=crude fibre; NDF=neutral detergent fibre; ADF=acid detergent fibre; ADL=acid detergent lignin; ME= Metabolisable energy;

[a, b, c, d, e]: means with the same superscripts in the same column are not significantly different at (P<0.05)

Nyandarua

Table 7 shows the Compounded chemical composition (% DM basis) of selected fodder species in Nyandarua County, from proximate analysis to van Soest analysis to metabolizable energy.

No significant difference in dry matter % was observed across all five fodders-lucerne, green leaf Desmodium, sweet potato vines, chicory, and boma Rhodes at P>0.05. Sweet potato vines and chicory showed no significant difference in crude protein % at P>0.05. However, there was a significant difference in crude protein % among lucerne, green leaf Desmodium, and boma Rhodes at P<0.05. Lucerne also differed significantly in crude protein % from sweet potato vines and chicory at P<0.05. Similarly, green leaf Desmodium and boma Rhodes exhibited a significant difference in crude protein % from sweet potato vines and chicory at P<0.05. A significant difference in ether extract % was observed between lucerne and sweet potato vines, green leaf Desmodium, chicory, and boma Rhodes at P<0.05. However, there was no significant difference in ether extract % between sweet potato vines, green leaf Desmodium, chicory, and boma Rhodes at P>0.05. All five fodders-lucerne, sweet potato vines, green leaf Desmodium, chicory, and boma Rhodes—differed significantly at P<0.05 in terms of ether extract content.

All five fodders-lucerne, sweet potato vines, green leaf Desmodium, chicory, and boma Rhodes—differed significantly at P<0.05 in terms of ash content. Similarly, all five fodders differed significantly at P<0.05 in terms of neutral detergent fibre content. A significant difference in acid detergent fibre content was observed among sweet potato vines, green leaf Desmodium, and boma Rhodes at P<0.05. However, chicory and sweet potato vines showed no significant difference in acid detergent fibre content level at P>0.05. Chicory and sweet potato vines had a significant difference in acid detergent fibre content level compared to sweet potato vine, green leaf Desmodium, and boma Rhodes at P<0.05.

All five fodders—lucerne, sweet potato vines, green leaf Desmodium, chicory, and boma Rhodes—differed significantly at P<0.05 in terms of acid detergent lignin. There was no significant difference in metabolizable energy (J/kg) between lucerne and boma Rhodes at P>0.05. Green leaf Desmodium, sweet potato vines, and chicory exhibited a significant difference in metabolizable energy (J/kg) at P<0.05. However, each of these three fodders—green leaf Desmodium, sweet potato vines, and chicory-differed significantly in metabolizable energy (J/kg) from both lucerne and boma Rhodes.

Table 2: Compounded Chemical composition (% DM basis) of selected fodder species in Nyandarua County

Sample	DM	CP	EE	Ash	CF	NDF	ADF	ADL	ME (J/Kg)
Lucerne	97.13[a]	12.55[a]	1.67[a]	12.86[a]	19.03[a]	32.07[a]	23.53[a]	5.02[a]	12.72[b]
Sweet Potato Vines	95.85[a]	16.19[b]	2.67[b]	14.29[b]	16.10[b]	28.02[b]	40.47[b]	14.57[b]	12.05[c]
Greenleaf Desmodium	96.41[a]	13.99[c]	2.97[b]	9.62[c]	26.21[c]	44.87[c]	38.01[c]	6.00[c]	13.24[a]
Boma Rhodes	96.55[a]	4.63[d]	3.14[b]	12.13[d]	34.57[d]	68.01[d]	49.97[d]	18.96[d]	12.73[b]
Chicory	95.90[a]	16.35[b]	2.81[b]	18.63[e]	14.39[e]	29.07[e]	38.77[b]	2.09[e]	11.63[d]
P	0.6192	<.0001	0.0005	<.0001	<.0001	<.0001	0.0005	<.0001	<.0001
SEM	0.5295	0.1661	0.1585	0.2281	0.1482	0.2934	0.4395	0.1602	0.0461

DM= dry matter; CP=crude protein; EE= Ether extract; CF=crude fibre; NDF=neutral detergent fibre; ADF=acid detergent fibre; ADL=acid detergent lignin; ME= Metabolisable energy;

[a, b, c, d, e]: means with the same superscripts in the same column are not significantly different at (P<0.05)

Nyeri

Table 8 shows the Compounded chemical composition (% DM basis) of selected fodder species in Nyeri County, from proximate analysis to van Soest analysis to metabolizable energy.

There was no statistically significant difference in dry matter % between lucerne and boma Rhodes at P<0.05. Additionally, lucerne, sweet potato vine, green leaf Desmodium, and chicory did not exhibit a significant difference in terms of dry matter % at P>0.05. However, the latter three fodders—sweet potato vine, green leaf Desmodium, and chicory—each showed a significant difference in dry matter % compared to both lucerne and boma Rhodes at P<0.05. All five fodders—lucerne, sweet potato vines, green leaf Desmodium, chicory, and boma Rhodes—differed significantly at P<0.05 in terms of crude protein %. Sweet potato vines, green leaf Desmodium, and chicory did not show a significant difference in ether extract % at P>0.05, while lucerne and boma Rhodes differed significantly in ether extract content at P<0.05. Each of the former three fodders—sweet potato vines, green leaf Desmodium, and chicory—differed significantly in terms of ether extract from both lucerne and boma Rhodes at P<0.05.

There was no significant difference in ash content between Boma Rhodes and lucerne at P>0.05. However, sweet potato vines, green leaf Desmodium, and chicory each exhibited a significant difference in ash content at P<0.05. Each of the latter three fodders—sweet potato vines, green leaf Desmodium, and chicory—differed significantly in terms of ash content from the former two fodders—boma Rhodes and lucerne at P<0.05. All five fodders—lucerne, sweet potato vines, green leaf Desmodium, chicory, and boma Rhodes—differed significantly at P<0.05 in terms of crude fibre %. There was no significant difference in neutral detergent fibre % between sweet potato vines and chicory. However, lucerne, sweet potato vines, green leaf Desmodium, and boma Rhodes each showed a significant difference in neutral detergent fibre % at P<0.05. Lucerne, green leaf Desmodium, and boma Rhodes each differed significantly in terms of neutral detergent fibre % from sweet potato vines and chicory at P<0.05.

There was no significant difference in acid detergent fibre % between sweet potato vines, green leaf Desmodium, and chicory. Additionally, green leaf Desmodium, chicory, and boma Rhodes did not show a significant difference in terms of acid detergent fibre % at P>0.05. Lucerne differed significantly from each of the other four fodders—sweet potato vines, green leaf Desmodium, chicory, and boma Rhodes. All five fodders—lucerne, sweet potato vines, green leaf Desmodium, chicory, and boma Rhodes—differed significantly at P<0.05 in terms of acid detergent lignin %. There was no significant difference in metabolizable energy (J/kg) between sweet potato vines and boma Rhodes at P>0.05. However, lucerne, green leaf Desmodium, and chicory differed significantly at P<0.05 in terms of metabolizable energy (J/kg). The latter three fodders—lucerne, green leaf Desmodium, and chicory—each had a significant difference in metabolizable energy (J/kg) compared to sweet potato vines and boma Rhodes at P<0.05.

Table 3: Compounded Chemical composition (% DM basis) of selected fodder species in Nyeri County

Sample	DM	CP	EE	Ash	CF	NDF	ADF	ADL	ME (J/Kg)
Lucerne	96.57^{ab}	14.04^{a}	1.8^{a}	11.70^{a}	19.27^{a}	32.50^{a}	25.50^{a}	4.7^{a}	12.60^{a}
Sweet PotatoVines	95.72^{a}	16.09^{b}	2.75^{b}	13.79^{b}	15.99^{b}	28.32^{b}	39.47^{b}	14.57^{b}	12.20^{b}
Greenleaf Desmodium	96.24^{a}	15.51^{c}	2.96^{cb}	9.62^{c}	25.31^{c}	44.54^{c}	41.52^{bc}	6.07^{c}	13.44^{c}
Boma Rhodes	97.40^{b}	4.06^{d}	2.11^{d}	11.37^{a}	36.67^{d}	68.32^{d}	44.69^{c}	18.70^{d}	12.20^{b}
Chicory	95.94^{a}	17.25^{e}	2.50^{b}	19.24^{d}	13.81^{e}	28.04^{b}	41.98^{bc}	2.36^{e}	11.27^{d}
P	0.0122	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
SEM	0.2767	0.0199	0.0951	0.2090	0.1135	0.4648	1.510	0.1640	0.0973

DM= dry matter; CP=crude protein; EE= Ether extract; CF=crude fibre; NDF=neutral detergent fibre; ADF=acid detergent fibre; ADL=acid detergent lignin; SEM = standard error of the mean.

$^{a, b, c, d, e}$: means with the same superscripts in the same column are not significantly different at (P<0.05)

Discussion

The meticulous analysis of forage composition across the distinct regions of Bomet, Nyandarua, and Nyeri offers a nuanced understanding of the inherent similarities and intriguing discrepancies. These variations are reflective of multifaceted interactions involving environmental conditions, agricultural practices, and regional peculiarities influencing forage growth and nutritional content.

The evaluation reveals a notable commonality in dry matter content across all three regions. The absence of significant differences suggests potential similarities in environmental conditions, harvesting practices, or forage management strategies that collectively contribute to consistent moisture levels. A shared aspect emerges in the realm of crude fibre content, showcasing significant differences in all regions. This could indicate a commonality in the impact of plant maturity or similar processing methods affecting the fibre composition of forage as clearly elaborated in the finding of Moore [32], on how various factors affect fodder nutrient composition.

While Bomet exhibits pronounced differences in crude protein content across fodders, Nyandarua and Nyeri showcase uniformity in certain fodders. This disparity hints at potential variations in soil fertility, fertilization practices, or the inherent genetic makeup of forage plants specific to each region. Notably, Bomet displays significant differences in ether extract content for Lucerne, whereas Nyandarua and Nyeri do not. This discrepancy could be rooted in variations in lipid synthesis influenced by sunlight exposure, soil conditions, or the genetic composition of forage plants. The results of [33] on plant factors that contribute to diversity in plant nutrient composition are consistent with this finding.

Nyandarua and Nyeri present significant differences in total ash content, contrasting with Bomet. These disparities may be linked to variations in soil mineral composition, fertilization practices, or regional geographical influences shaping the nutritional makeup of forage. Bomet exhibits distinctive differences in NDF, ADF, and ADL across fodders, while Nyandarua and Nyeri display variations in specific fodders. These discrepancies may be attributed to regional differences in forage plant genetics, growth conditions, or processing methods employed, these findings concur with the work of Jangra & Madan [34].

Bomet and Nyeri manifest significant differences in metabolizable energy, whereas Nyandarua does not. This discrepancy may be related to differences in the composition of carbohydrates, plant metabolism, or regional climatic conditions influencing forage quality. In delving deeper into the observed discrepancies, several factors warrant consideration. Geographical and climatic variances stand out as influential determinants, as the three regions encompass diverse climates, soil types, and altitudes. These factors collectively impact plant growth, nutrient absorption, and forage composition. Agronomic practices also contribute to the observed variations. Differences in fertilization practices, crop management, or harvesting techniques may introduce discrepancies in forage composition. The genetic makeup of forage plants can play a pivotal role, with regional variations influencing nutrient content and composition, as it is with the findings of López-Angulo [35].

Furthermore, processing methods, such as drying or chopping, may introduce variations in nutritional content. Soil fertility emerges as a critical factor, with differences in nutrient levels potentially contributing to variations in mineral content across regions. The observed variations in forage composition across the regions of Bomet, Nyandarua, and Nyeri are intricately linked to the subsequent impact on the milk output of Friesian cows, as discussed earlier. The nutritional content of forage directly influences the dietary intake and, consequently, the performance of dairy cows.

Conclusion

In conclusion, the nutritional analysis of the diverse forages comprising lucerne, green leaf Desmodium, sweet potato vines, chicory, and boma Rhodes grass in Bomet, Nyandarua, and Nyeri Counties reveals significant variations in their composition. The variations in total ash, crude fibre content, ether extract, dry matter content, crude protein, and Van Soest composition show how these forages have different nutritional profiles depending on the region. The results emphasise how crucial it is to comprehend and modify dietary plans in accordance with the local availability of forage and nutritional composition. Overall, the nutritional analysis provides a foundation for informed decision-making in optimizing dairy cow diets for enhanced milk production in smallholder farming systems.

Scope and Limitation of the Study

The study aimed to find out the qualitative and quantitative effect of feeding Friesian dairy cows with a mixture of lucerne, greenleaf desmodium, sweet potato vine and chicory supplemented to Boma Rhodes on dairy performance in smallholder dairy farms in Bomet County. It also focused on the cost-benefit profile of utilizing the experimental diets. The study was prone to suffer from some limitations like the occurrence of diseases affecting the dairy cows and fodders as well as weather conditions challenges affecting fodder establishment.

Recommendation

Based on our nutritional analysis of various forages in Bomet, Nyandarua, and Nyeri Counties, we highly recommend farmers consider incorporating homegrown fodders into their cattle diets. Homegrown fodders, when properly cultivated and managed, can offer cost-effective and nutritionally balanced alternatives for livestock feeding. Furthermore, we suggest conducting additional studies on a broader range of leguminous and grass fodders. This expanded research would provide a more comprehensive understanding of locally available forages, enabling farmers to make informed decisions regarding the optimal composition of cattle diets. By exploring a diverse array of forages, we can identify additional options that may enhance milk production efficiency and overall economic viability for farmers in these regions.

Funding

This research was made possible through the generous financial support of the RUFORUM -TAGDev program at Egerton University and the Milk Africa project. Both initiatives provided critical funding for the design, execution, and analysis of the study.

Conflict of Interest

The authors, C. W. Oktoto, J. O. Ondiek, and O. A. Ndambi, collectively declare that there is no conflict of interest influencing the publication of this manuscript. The research was conducted with utmost integrity and objectivity.

Data Availability

The datasets supporting the findings of this study are available upon reasonable request. Interested parties may contact any of the authors, CW Oktoto, JO Ondiek, or OA Ndambi, for access to the data sets used in this research.

Author's Contribution

All authors, CW Oktoto, JO Ondiek, and OA Ndambi, contributed significantly to all aspects of this manuscript. Specific contributions include:

Conceptualization: CW Oktoto, JO Ondiek, OA Ndambi

Methodology: CW Oktoto, JO Ondiek, OA Ndambi

Data Collection: CW Oktoto

Analysis and Interpretation: CW Oktoto,

Writing – Original Draft Preparation: CW Oktoto

Writing – Review and Editing: CW Oktoto, JO Ondiek, OA Ndambi

Funding Acquisition: CW Oktoto, JO Ondiek, OA Ndambi

References

1. Bebe BO, Rademaker CJ, van der Lee J, Kilelu CW, Tonui C (2017) Sustainable growth of the Kenyan dairy sector: a quick scan of robustness, reliability and resilience: executive summary. (Report /Wageningen Livestock Research; No. 1021). Wageningen Livestock Research.

2. Mawa LI, Kavoi MM, Baltenweck I, Poole J (2014) Profit efficiency of dairy farmers in Kenya: An application to small-holder farmers in Rift Valley and Central Province. Journal of Development and Agricultural Economics, 6: 455.

3. Bouton JH (2012) An overview of the role of lucerne (Medicago sativa L.) in pastoral agriculture. Crop and Pasture Science, 63: 734-8.

4. Chen JS, Tang FL, Zhu RF, Gao C, Di GL et al. (2012) Effects of cutting frequency on alfalfa yield and yield components in Songnen Plain, North-East China. African Journal of Biotechnology, 11: 4782.

5. Teixeira RF, Proenca V, Crespo D, Valada T, Domingos T (2015) A conceptual framework for the analysis of engineered biodiverse pastures. Ecological Engineering, 77: 85-97.

6. Mielmann A (2013) The utilisation of lucerne (Medicago sativa): a review. British Food Journal, 115: 591-4.

7. Bora KS, Sharma A (2011) Phytochemical and pharmacological potential of Medicago sativa: A review. Pharmaceutical Biology, 49: 211-20.

8. Gaweł E, Grzelak M, Janyszek M (2017) Lucerne (Medicago sativa L.) in the human diet—Case reports and short reports. Journal of Herbal Medicine, 10: 8-16.

9. Iqbal Y, Ponnampalam EN, Suleria HA, Cottrell JJ, Dunshea FR (2021) LC-ESI/QTOF-MS profiling of chicory and lucerne polyphenols and their antioxidant activities. Antioxidants, 10: 932.

10. Ponnampalam EN, Hopkins DL, Giri K, Jacobs JL, Plozza T et al. (2017) The use of oxidative stress biomarkers in live animals (in vivo) to predict meat quality deterioration post-mortem (in vitro) caused by changes in muscle biochemical components. Journal of Animal Science, 95: 3012-24.

11. NSW-DPI (2013) Prime fact 1306 First edition Mary-Anne Lattimore District Agronomist Yanco, lucerne varieties, June 2013, NSW Department of Primary Industries.

12. Gundadhur S (2012) Increasing Productivity of Sweet Potato Through Clonal Selection of Ideal Genotypes from Open Pollinated Seedlings Population. International Journal of Farm Sciences, 2: 17-27.

13. Nwankwo II M, Bassey EE (2021) Evaluation of some Advanced Breeder Lines of Sweet potato for Root and Fodder Yields in Umudike, South Eastern Nigeria. Nigerian Journal of Agricultural Technology, 18: 1-5.

14. Nyathi MK, Du Plooy CP, Van Halsema GE, Stomph TJ, Annandale JG (2019) The dual-purpose use of orange-fleshed sweet potato (Ipomoea batatas var. Bophelo) for improved nutritional food security. Agricultural Water Management, 217: 23-37.

15. Urgessa T, Umer D, Sida A, Hayilu A (2014) On-farm demonstration and evaluation of sweet potato (Ipomoea batatas (L.)) varieties. The case of Kellem and West Wollega Zones, West Oromia, Ethiopia. Journal of Education and Practice, 5: 111-6.

16. Kenana RS, Hoka AI, Ondabu N, Ondabu F, Mercy J (2021) Evaluation of Yields and Nutritive Composition of Dual-Purpose

Sweet Potato Vine Cultivars for Forage Use. UKnowledge- University of Kentucky Libraries, 24: 1-4.

17. Heuzé V, Tran G, Hassoun P (2017) Greenleaf desmodium (Desmodium intortum): Feedipedia, a programme by INRAE, CIRAD, AFZ and FAO. Animal feed resources information system, 17: 32.

18. EcoCrop FAO (2014) Capsicum annum L, Eco-Crop Online Database. Land and Water Development Division, Food and Agricultural Organization of the UN (FAO).

19. Heinritz SN, Hoedtke S, Martens SD, Peters M, Zeyner A (2012) Evaluation of ten tropical legume forages for their potential as pig feed supplement. Livestock Research for Rural Development, 24.

20. Rahman MK, Barua S, Islam MF, Islam MR, Sayeed MA et al. (2013) Studies on the anti–diarrheal properties of leaf extract of Desmodium puchellum. Asian Pacific Journal of Tropical Biomedicine, 3: 639-43.

21. Shad MA, Nawaz H, Rehman T, Ikram N (2013) Determination of some biochemicals, phytochemicals and antioxidant properties of different parts of Cichorium intybus L.: A comparative study. Animal and Plant Science, 23: 1060-6.

22. Abbas ZK, Saggu S, Sakeran MI, Zidan N, Rehman H et al. (2015) Phytochemical, antioxidant and mineral composition of Hydroalcoholic extract of chicory (Cichorium intybus L.) leaves. Saudi Journal of Biological Sciences, 22: 322-6.

23. Street RA, Sidana J, Prinsloo G (2013) Cichorium intybus: Traditional uses, phytochemistry, pharmacology, and toxicology. Evidence-Based Complementary and Alternative Medicine, 2013: 1-13.

24. Al-Snafi AE (2016) The medical importance of Cichorium intybus–A review. IOSR Journal of Pharmacy, 6: 41-56.

25. Heuzé V, Tran G, Boudon A, Lebas F (2016) Rhodes grass (Chloris gayana). Feedipedia, a programme by INRAE, CIRAD, AFZ and FAO. Last updated on, 15.

26. FAO (2014) Impact of mastitis in small-scale dairy production systems. Animal Production and Health Working Paper. No. 13. Rome.

27. Weatherspark (2016) Climate and Average Weather Year-Round in Bomet-Kenya.

28. AOAC (Association of Official Analytical Chemists) (2012) Official Methods of Analysis of the Official Analytical Chemists, 19th Edition, AOAC, Washington, DC, USA.

29. Van Soest PJ (1994) Nutritional Ecology of the Ruminant. 2nd Edition, Cornell University Press-Ithaca, 476.

30. AOAC (2005) International Official Methods of Analysis, 18th edition; AOAC International: Arlington, Texas, USA.

31. Steel RG, Torrie JH (1980) Principles and Procedures of Statistics, a Biometrical Approach 2: 137-9.

32. Moore KJ, Lenssen AW, Fales SL (2020) Factors affecting forage quality. Forages: The Science of Grassland Agriculture, 2: 701-17.

33. Elgersma A, Søegaard K (2018) Changes in nutritive value and herbage yield during extended growth intervals in grass-legume mixtures: effects of species, maturity at harvest, and relationships between productivity and components of feed quality. Grass and Forage Science, 73: 78-93.

34. Jangra SS, Madan VK (2018) Proximate, mineral and chemical composition of different parts of chicory (Cichorium intybus

L.). Journal Pharmacogn. Phytochem, 7: 3311-5.

35. López-Angulo J, Pescador DS, Sánchez AM, Luzuriaga AL, Cavieres LA et al. (2020) Impacts of climate, soil and biotic interactions on the interplay of the different facets of alpine plant diversity. Science of the Total Environment, 698: 133960.

36. Abewoy D, Megersa HG, Lamma DT, Banjaw DT (2023) Participatory Variety Selection of Orange Fleshed Sweetpotato (Ipomoea Batatas L.) Varieties at Wondo Genet and Koka Areas. Proceedings of Crops Improvement and Management Research Results.

37. Alfalfa (2023) In Wikipedia. https://en.wikipedia.org/wiki/Alfalfa Accessed 22 Feb. 2023.

38. Helaly AA, Abdullah HM (2017) Phytochemical analysis and yield characterization of eight Cichorium intybus L. landraces. J. Hortic. Sci. Ornam. Plants, 9: 39-51.

39. Joint FAO/WHO expert committee on food additives, meeting, & World Health Organization (2006) Safety Evaluation of Certain Contaminants in Food, Food & Agriculture Organisation, 82.

40. Nan L, Nie Z, Zollinger R, Guo Q (2019) Evaluation of morphological and production characteristics and nutritive value of 47 lucerne cultivars/lines in temperate Australia. Plant Production Science, 22: 490-500.

41. Niyireba TN, Ebong C, Agili S, Low J, Lukuyu B, Kirui J et al. (2013) Evaluation of dual-purpose sweet potato (Ipomea batatas (L.) Lam] cultivars for root and fodder production in Eastern Province, Rwanda. Agricultural Journal, 8: 242-7.

42. Rastogi S (2011) A review of aconite (Vatsanabha) usage in Ayurvedic formulations: Traditional views and their references. S-patula DD, 1: 233-44.

43. Rukundo P, Shimelis H, Laing M, Mashilo J (2020) Genotype-by-environment interaction for dual-purpose traits in sweet potato. Journal of Crop Improvement, 34: 800-23.

44. Shah MS, Supriya D, Mayuri G, Oswal DR.J (2020) A systematic review of one of the nutraceutical potential plants Medicago sativa (alfalfa). World Journal of Pharmaceutical Research, 7: 683-700.

45. Shumbusha D, Shimelis H, Laing M, Rukundo P (2019) Gene action and heritability of yield components of dual-purpose sweet potato clones. Euphytica, 215: 1-16.