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Effects of Climate Change on the Composition of Some Ruminant Feedstuffs - A Vital Tool for Feed Manufacturing Industries

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Abstract:

In a bid to provide recent values of nutrient composition and to check the effect of climate change on feed stuffs, proximate and energy analyses of 21 feedstuffs were studied. Mineral composition of egg shell meal and bone meal were also compared. Processed samples were sent to Animal-Care Laboratory. Results showed that among the leaves, fluted pumpkin recorded the highest crude protein (CP) (30.35%) and metabolisable energy (ME) (2294.92 kcal/kg) while the highest fibre value was recorded by oil palm frond (30.70%). For the seeds, soya beans recorded the highest CP (37.41%) while Moringa had the highest fibre (15.42%) and ME of 4523.25 kcal/kg. For the peels, cashew nut testa had the highest CP (16.60%), and ME (3572.25kcal/kg) while plantain peel recorded the highest values for fibre (7.27%). Northern gamba grass recorded 93.71%, 10.31%, 2.11%, 22.73%, 7.82%, 57.03% and 1246.28kcal/kg for DM, CP, fat, fibre, ash, NFE and ME respectively. The mineral composition of egg shell and bone meals showed that egg shell meal recorded the highest values for sodium (0.725%), calcium (43.170) and potassium of 0.078% while bone meal recorded the highest values for magnesium (0.595%) and phosphorus (17.910%). Based on the nutrient composition of these feedstuffs, they can be fed to both ruminants and monogastric. Some of the results obtained showed variation from those analyzed in the 80's and 90's. This difference may be due to the effect of climate change over time or due to variations in age, variety or even cultural practices and soil type.

Keywords:

Climate Change, Leaves, Peels, Proximate Composition, Ruminants, Seeds

1. Introduction

According to [1] the success of the livestock industry anywhere in the world depends greatly on feed quality and quantity. It is the mixture of the various feed stuffs that make up a feed. [2] reported that feed cost accounts for 65-70% of the total cost of production in the intensive system of animal production. Considering this, it is very important to be sure of the composition of the feed stuffs/feeds fed to the animals. This is important to ensure that the body requirement of the animals is met. This can be achieved through several analyses, including proximate and mineral analyses. It is from the results of these analyses that proximate and mineral compositions are obtained.

Animal protein is one of the most important components of human diet and its consumption varies from country to country [3]. Rapid human population increase coupled with low protein intake constitutes a major problem facing developing countries. An average Nigerian consumes only about 10g per day of the minimum daily intake of 35g per head per day protein intake recommended by Food and Agricultural Organization [4]. Getting the nutrition of the animals right by ensuring that the composition of the feed stuffs/feed are adequate will ensure more animal productivity and make available more animal protein to close the gap that exist between the present protein intake and the required/recommended protein intake.

1.1. Effects of Climate Change on the Composition of Feedstuffs

Global climate change conditions often alter plant chemical composition, which in turn can affect food and fodder quality [5,6]. These alterations in the chemical composition of plants grown under future climate will have significant impact on economic and ecological processes [7,8,9].

Climate changes are predominately associated with the rise in the concentrations of CO2 and a gradual rise in the earth's temperature, but also include increased frequency and intensity of extreme events (e.g. drought, heat wave and flooding) [7]. Effects of elevated CO2 in altering the chemical composition of plants have been extensively studied [10]. Drought stress and high temperature are important environmental factors, which restrict plant growth and alter tissue chemical composition [11,12]. When applied separately, temperature [12] and drought have been shown to alter the chemical composition of plants. For example, under drought conditions, alfalfa accumulated starch, but lowered soluble sugars during vegetative growth [12]. Severe drought and elevated temperature significantly reduced the accumulation of free amino acids and soluble proteins in Leymus chinensis [11].

The anticipated changes in chemical composition are likely to alter tissue quality and decomposition rate. For example, elevated CO2 caused a reduction in forage quality through a lower crude protein content in different plant species [13], and in combination with high temperature, reduced digestibility by enhancing fiber content in Medicago sativa [8]. Other CO2 induced tissue quality changes include an increased C/N ratio in soybean [14], and tannin accumulation in Lotus corniculatus [15].

1.2. Composition of Leaves Used as Livestock Feed

Leaves of some plants are used to feed animals especially the ruminants. *Gmelina arborea* leaf are considered good for cattle [16] and are also used as a feed to goat and sheep [16]. Gmelina *arborea* has a high digestibility [16] but showed that most of the rumen fermentation occurred very rapidly in the first 24 hours. Today, *Gmelina* plantations in Nigeria are estimated at 112,000.00 trees ha-1 [17]. The inclusion of *Gmelina arboea* at 25 % in the diet of West African Dwarf (WAD) goats gave the optimum performance [18].

Vernonia amygdalina is commonly called bitter leaf in English because of its bitter taste [19].The proximate composition of bitter leaf in percentages and mineral composition in part per ml as analysed by [20] are as follows; Moisture 76.67 %, Ash 7.67%, Oil 1.10%, Protein 22.07%, Manganese 0.444mg, Calcium 0.185mg, Iron 0.045mg and Phosphorus 6.136 mg. The inclusion of bitter leaf in the diet of *C. gariepinus* had no detrimental effects on growth performance and production economy of the fish [21]. From the findings of [21], bitter leaf is a potential alternative to synthetic antibiotic as growth promoter in the production of *Clarias gariepinus*

Pigeon pea (*Cajanus cajan* (L.) Huth) is one of the most common tropical and subtropical legumes cultivated for its edible seeds. The leaves and pods are valuable and palatable protein-rich fodder. Leaves are sometimes used to replace alfalfa in ruminants' diets where alfalfa cannot be grown. Seed processing by-products and sometimes the seeds themselves are used as livestock feed [22]. [23] reported that pigeon pea leaf had low tannin content as compared to the other browse tree or shrub species as a result pigeon pea leaf was palatable and did not cause any negative effect in feed intake of the sheep.

Tridax procumbens, commonly known as coatbuttons [24]or tridax daisy, is a specie of flowering plant in the daisy family. *Tridax procumbens,* tropical forage of *compositae* family is reported as having great potential for use as livestock feed ingredient [25]. It has crude protein values ranging from 15 – 22% depending on time of harvest [26] high in mineral (ash) depending on stage of maturity and high in essential amino acid content [27]. Rabbits in the tropics are said to prefer *Tridax procumbens* compared to other forage species [28]. [29] from the results of their studies observed that the replacement of Ficus with *Tridax* in diets of WAD goats shows increasing effect on the level of feed intake and nutrient digestibility.

Centrosema pubescens, common name centro or butterfly pea, is a legume in the family *Fabaceae*, subfamily *Faboideae* and tribe *Phaseolae*. This is a very cheap alternative to other sources of protein that are usually more expensive, like soybean [30]. Centro is one of the most palatable legumes and is considered to be a valuable feedstuff since it provides fresh green matter during the dry season when most grasses are not very palatable. Including centro in cattle diets increases the solubility of Phosphorus and sodium [31]. Sheep preferred centro to pueraria. Dry matter intake was higher when centro was mixed with *Asystasia gangetica* within a three strata association of herbs, cashew and mango [32]. Fresh centro leaves supplementing a commercial broiler diet had a slight positive effect on body weight gain [33]. Centro can be included successfully in rabbit diets to supplement a mash [34].

Bamboo (Family: *Poaceae*) is a grass with a woody culm (stem), which is used often inconstruction much like conventional wood [35]. [36] reported 53.57%, 10.69%, 18.45%, 1.45%, 10.14%, and 59.25% for Dry Matter, Crude Protein, Crude Fibre, Ether Extract, Ash and Nitrogen free Extract respectively. [37] reported 12% and 16.2% for Crude Protein and Dry Matter respectively.

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Oil palm fronds are a by-product of the cultivation of oil palm trees. [38] reported that the proximate composition of oil palm frond is 41.9%, 3.9%, 6.5%, 1.66%, 47.6% and 40.3% for Dry Matter, Ash, Crude Protein, Ether Extract, Crude Fibre and Nitrogen Free Extract respectively. [39] reported 11.6%, 1.6%, 17.7%, 8.0% and 51.1% for Crude Protein, Ether Extract, Crude Fibre, Ash and Nitrogen Free Extract respectively. Oil palm fronds are a suitable feed for ruminants they can replace tropical grasses or roughages such as rice straw [40].

[41] reported that sweet potato leaves have 15.60%, 26.55% and 12.83% for Dry Matter, Crude Protein and Crude Fibre respectively. [42] reported 83.8%, 12.0%, 18.4%, 3.0% and 12.2 for Dry Matter, Crude Protein, Crude Fibre, Ether Extract and Ash respectively. [43] reported 4.07%, 24.21%, 7.74%, 3.88%, 11.05%, 49.05%, 81.78% and 2668.36 kcal/kg for moisture, crude protein, crude fibre, ash, Nitrogen Free Extract, dry matter and metabolizable energy respectively.

Cassava leaves, depending on the varieties are rich in protein (14-40 or 20-35% DM), minerals, Vitamins B_1, B_2, C and carotenes [44]. [45] gave the proximate composition of cassava leaves to be 21%, 5.5%, 20.0%, 8.5% and 93% for crude protein, fat, fibre, ash and dry matter respectively.

[46] gave the proximate analysis for fluted pumpkin leaves to be 32.34%, 9.37, 82.30%, 9.03% and 8.15% for crude protein, fat, moisture content, fibre and ash respectively. [47] also gave the proximate analysis for fluted pumpkin leaves to be 21.14%, 6.46%, 10.94% and 8.31% for crude protein, fat, moisture contents and ash respectively.

1.3. Composition of Seeds Used as Livestock Feeds

According to [48], the proximate composition of maize grain is (%) 8.9, 4.0, 2.7 and 1.3, for C.P, fat, fibre, and ash respectively. [49] reported the proximate composition of maize to be, 9.87 C.P, 11.6 M.C, 2.17 fat, 2.10 fibre and 1.10 ash.

For the composition of guinea corn grain (sorghum), [39] reported 11.0, 2.6, 2.0 and 1.7, for C.P, ether extract, crude fibre, and ash respectively. [50] reported 93.31, 10.48, 2.97, 2.01, 6.94, and 61.24 for D.M, C.P, ether extract, crude fibre, ash and N.F.E respectively. According to [51] sorghum contains 10.4, 3.1, 2.0, and 1.6 for C.P, ether extract, crude fibre and ash respectively.

[51] reported that millet seeds contain 11.8, 4.8, 2.3 and 2.2 for C.P, ether extract, crude fibre and ash respectively. According to [27] the proximate composition of millet seeds is 11.5, 3.5, 5.5, 0.30 and 2881 for C.P, ether extract, fibre, ash and energy (kcal/kg) respectively. [52] reported that millet seed contains 91.0, 14.0, 4.3, 3.0 and 2,675, for D.M, C.P, ether extract, crude fibre and metabolizable energy (kcal/kg) respectively. [39] reported that the C.P, ether extract, crude fibre and ash of millet seed are 11.5, 3.6, 6.5 and 3.2 respectively.

[53] reported the proximate analysis of pigeon pea seeds to be 18.8%, 1.9% and 6.6%, for Protein, fat and fibre respectively. [54] reported the proximate analysis of pigeon pea seeds to be 24.02%, 2.02%, 6.63%, 3.14% ,1.24% and 62.23Kcal for crude protein, fat, moisture contents, fibre, ash and energy respectively.

[55] reported the proximate analysis for Moringa seeds to be 35.97%, 38.67%, 9.97%, 8.67% and 3.87%, for crude protein, fat, moisture contents, fibre and ash respectively. [56] gave the proximate analysis of moringa seeds to be 23.69%, 14.62%, 9.43%, 5.48%, 4.34%, and 438.62Kcal for crude protein, fat, moisture content, fibre,

ash and energy respectively. [57] also gave a proximate analysis of moringa seeds to be 39.57%, 32.50%, 10.50%, 5.00% and 5.00% for crude protein, fat, moisture content, fibre and ash respectively.

Approximately 85% of the total soybean meal usage is fed to pigs and poultry, the chicken meat industry is the major user, consuming about 50% of all soybean meal used by the livestock industries. The pig industry is the next biggest user, at about 35% [58]. [58] reported this composition for soyabean seed: DM 90.0%, CP 38.0%, CF 5.5%, fat 19.0%, lysine 2.11%, threonine 1.30%, methionine 0.52%, isoleucine 1.58%, tryptophan 0.43%, phosphorus 0.19% and calcium 0.23. [48] reported CP 40%, fat 1.8%, CF 5.0, lysine 2.6%, methionine 0.60%, calcium 0.25% and phosphorus of 0.60%.

1.4. Composition of Peels Used as Livestock Feeds

Yam peels have been reported to contain 2 to 6% of crude protein depending on the varieties, the crude fibre ranges between 9 to 15% [59]. However, their utilization is sometimes limited as a result of poor understanding of their nutritional, anti-nutritional and economic values as well as proper use in livestock diets [60]. They constitute environmental hazard where it is not properly utilized. [39] reported that yam peels contain 11.21, 1.17, 9.47 and 9.76 for CP, ether extract, fibre, and ash respectively.

Nigeria is one of the largest plantain producing countries in the world; available data has shown that Nigeria produced 2.103 million tons of plantain, harvested from 389,000ha in the year 2004 [61]. Plantain peels, a waste from plantain is observed to have some nutritional values as it contains about 12% crude protein, 16% crude fibre and 1300kcal/kg energy on dry matter basis [27]. Further study by [62] revealed that fresh plantain peels are good sources of energy for broilers. [63] reported that plantain peel diets can be tolerated by African catfish, hence, can replace the more expensive maize, thereby, reducing cost of production and curtail environmental filth and disposal problems associated with plantain peel in Nigeria.

Cashew nut testa is the red skin that is manually or mechanically removed in the final step of preparing cashew nuts for confectionery. These skins may contain pieces of broken kernels and can be used. The chemical composition of cashew kernel processing waste, not testa as reported by [64] was dry matter (93.8%), crude protein (17.85%), moisture content (6.20%), ash (2.50%), crude fibre (11.60%), NFE (26.85%), ether extract (35.00%) and Metabolisable energy of 4476.63 kcal/kg.

1.5. Composition of northern gamba grass

[65] gave that the proximate composition of Northern Gamba Grass as 4.19%, 9.20%, 24.68% and 9.00% for Crude Protein, Ether Extract, Crude Fibre and Ash respectively. [66] reported 8.95%, 91.05%, 9.48%, 47.80%, 0.71%, 16.91%, 25.10% and 1299.32 Kcal/kg for Moisture, Dry Matter, Crude Protein, Ether Extract and Energy respectively. [67] reported 1261kcal/kg for Metabolizable Energy of Andropogon gayanus. [68] reported the composition of Northern Gamba grass to be crude protein 8.51, crude fibre 11.55, NFE 57.30, ether extract 6.94, 2.55, moisture content 13.15, dry matter 86.85 and ME (Kcal/kg) 2911.16.

2. Materials and Methods

2.1. Sample Collection and Processing

Samples of the 21 feed stuffs and those of bone and egg shell were collected, processed, sundried and then milled. This was then packaged in air tight containers and sent to the laboratory in duplicate. Analysis for proximate composition and energy value was done at Animal Care feed analysis and quality control Laboratory, located at Iperu – Ogere road, off Lagos Ibadan express way, Ogere – Remo, Ogun State.

2.2. Analytical Procedures

The proximate analysis of the samples was carried out according to [69] for moisture, fat, ash and crude fibre. Protein was determined by the method described by [70].

Nitrogen free extract (NFE) =100 – (values of crude protein + fat +crude fibre +ash)

3. Results and Discussion

Table 1. *Proximate composition and energy values of some leaves fed to ruminants.*

Feed stuffs	DM (%)	CP (%)	Fat (%)	Fibre(%)	Ash (%)	NFE(%)	ME (Kcal/kg)
Pigeon pea	92.49	21.05	2.49	17.67	6.08	52.71	1670.09
Gmelina	92.84	19.63	3.47	9.85	8.37	58.68	1699.62
Bitter leaf	91.64	23.46	1.88	8.40	9.27	56.99	1707.12
Centro	94.32	22.04	2.11	22.37	8.26	45.22	1674.20
Tridax	93.68	17.40	4.37	23.91	19.75	34.57	1693.10
Fluted Pumpkin	92.49	30.35	5.92	17.44	8.92	37.37	2294.92
Cassava	92.78	24.2	6.41	11.99	6.79	50.61	2111.21
Bamboo	93.88	14.96	1.68	22.36	14.9	46.1	1379.8
Sweet potatoes	93.43	30.21	2.58	23.83	9.82	33.56	2009.9
Oil palm frond	92.66	17.71	1.48	30.7	9.57	40.54	1463.55

DM- dry matter, CP- crude protein, NFE- nitrogen free extract, ME- metaboliasable energy

Table 2. *Proximate composition and energy values of some seeds, peals and grass fed to ruminants.*

Feed stuffs	DM (%)	CP (%)	Fat (%)	Fibre (%)	Ash (%)	NFE (%)	ME (Kcal/kg)
Seeds							
Soya beans	93.68	37.41	13.93	9.36	6.42	32.88	3453.59
Guinea corn	92.17	9.62	3.33	1.34	1.19	84.52	3312.47
Maize	90.79	8.43	3.85	1.13	1.38	85.21	3287.37
Millet	92.87	11.06	3.63	0.95	1.58	82.78	3355.12
Moringa	95.43	35.76	38.64	15.42	4.49	5.69	4523.25
Pigeon pea	91.53	18.03	4.38	8.80	4.02	64.77	2996.06
Peels							
Plantain	89.16	9.78	5.65	7.27	10.99	66.31	1513.98
Yam	89.85	5.02	1.63	5.86	5.08	82.41	1013.26

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Sweet potatoes	92.28	3.08	1.43	4.53	4.54	86.42	925.58
Cashew nut testa	95.90	16.60	12.05	6.13	3.59	61.63	3572.25
Grass							
Northern gamba	93.71	10.31	2.11	22.73	7.82	57.03	1246.28

DM- dry matter, CP- crude protein, NFE- nitrogen free extract, ME- metaboliasable energy

Table 3. *Mineral composition of egg shell meal and bone meal.*

Mineral	Egg shell meal	bone meal
Magnesium	0.365	0.595
Sodium	0.725	0.705
Calcium	43.170	29.450
Potassium	0.078	0.062
Phosphorus	1.135	17.910
Copper	BDL	BDL
Cobalt	BDL	BDL

BDL: Below detection level

3.1.Composition of Leaves Used as Livestock Feeds

From the results obtained among the leaves analysed, centro (94.32%) and bitter leaf (91.64%) had the highest and lowest dry matter (DM) respectively. Fluted pumpkin leaves recorded the highest crude protein (CP) (30.35%) and metabolisable energy (ME) (2294.92 kcal/kg) while bamboo leaves recorded the lowest CP (14.96%) and ME (1379.80kcal/kg). Cassava leaves recorded the highest fat value of 6.41% while oil palm frond recorded the lowest value of 1.48%. The highest fibre value was recorded by oil palm frond (30.70%) while bitter leaf recorded the lowest fibre value of 8.40%. For ash, tridax leaves (19.75%) and pigeon pea (6.08%) recorded the highest and lowest values respectively. The highest and lowest nitrogen free extract (NFE) were recorded by gmelina (58.68%) and sweet potatoes leaves (33.56%). The protein and energy contents of fluted pumpkin are outstanding among the other leaves analysed. The differences in the compositions of these leaves compared to those reported by other authors as presented under the literature review could be due to a lot of factors ranging from the effect of climate change over time. As stated under the introduction by different authors, several changes in climatic factors affects the nutrient composition of feed stuffs. This differences might also be due to variations in age, analytical procedure, variety or even cultural practices and soil type.

3.2. Composition of Seeds Used as Livestock Feeds

For the seeds analysed, moringa had the highest DM (95.43%), fat (38.64%), fibre (15.42%) and ME of 4523.25 kcal/kg while maize seed recorded the lowest DM of 90.79%. The figures of 3.33% (guinea corn seed), 0.95% (millet seed) and 2996.06 kcal/kg (pigeon pea seed) were recorded as the lowest values for fat, fibre and ME respectively. Soya beans seed recorded the highest CP (37.41%) and ash of 6.42% while maize seeds recorded the lowest CP of 8.43% and guinea corn recorded the lowest value for ash (1.19%). Maize seed recorded the highest NFE of 85.21% while moringa seed recorded the lowest NFE of 5.69%. The higher values of CP and energy for the seeds of soya beans and moringa when compared to the other seeds studied is worthy of note. Variations exist in nutrient compositions for seeds when compared to those reported by other authors under the literature review.

3.3. Composition of Peels Used as Livestock Feeds

For the peels analysed, cashew nut testa had the highest values for DM (95.90%), CP (16.60%), fat (12.05%) and ME (3572.25kcal/kg). The figures of 89.16% (plantain peel), 3.08%, 1.43% and 925.58 kcal/kg (sweet potatoes peel) were recorded as the lowest values for DM, CP, fat and ME respectively. Plantain peel recorded the highest values for fibre (7.27%) and ash (10.99%) while the lowest values for fibre (4.53%) and ash (3.59%) were recorded by sweet potatoes peel and cashew nut testa respectively. For NFE, sweet potatoes peel recorded the highest value of 86.42% while cashew nut testa recorded the lowest value of 61.63%. Among the peels studied, the composition of cashew nut testa was outstanding as it recorded the highest values for DM, CP, fat and ME.

3.4. Composition of Northern Gamba Grass

Northern gamba grass recorded 93.71%, 10.31%, 2.11%, 22.73%, 7.82%, 57.03% and 1246.28kcal/kg for DM, CP, fat, fibre, ash, NFE and ME respectively. The composition of northern gamba grass shows that it is a good feed resource for ruminants.

3.5. Comparison between Pigeon Pea Leaves and Pigeon Pea Seeds

The comparison between pigeon pea leaves and the seeds of pigeon pea shows that the leaf is higher in DM (92.49%), CP (21.05%), fibre (17.67%) and ash (6.08%) while the seed is higher in fat (4.38%), NFE (64.77%) and ME (2996.06kcal/kg).

3.6. Comparison Between Leaves, Seeds, Peels and Grass

Among the leaves, seeds, peels and grass studied, cashew nut testa/peel had the highest DM (95.90%), soya beans seed had the highest CP (37.41%), moringa seed had the highest values for fat (38.64%) and ME (4523.25%). The highest fibre value was recorded by oil palm frond/leaf (30.70%), tridax leaf recorded the highest ash (19.75%) while sweet potatoes peel recorded the highest NFE of 86.42%.

3.7. Comparison Between the Mineral Composition of Egg Shell and Bone Meal

The mineral composition of egg shell and bone meals showed that egg shell meal recorded the highest values for sodium (0.725%), calcium (43.170) and potassium of 0.078% while bone meal recorded the highest values for magnesium (0.595%) and phosphorus (17.910%). Copper and cobalt were below detection level in both egg shell and bone meals.

4. Conclusions and Recommendation

There were variations in the composition of feed stuffs studied when compared to those reported by other authors. These variations as opined by some researchers may be due to the effect of climate change and other reasons. Based on the nutrient composition of these feedstuffs, they (their leaves and peels especially) can be fed to ruminant while their seeds can be fed to both ruminants and monogastric without adverse effects. Egg shell and bone meal can also be used to meet the mineral requirements of animals; egg shell to supply calcium and bone meal to supply both calcium and phosphorus.

We recommend that farmer/feed millers/manufacturers determine the composition of the individual feed stuffs before mixing their livestock feed. This is due to the fact that the composition of their feed stuffs may be different from that available in literature.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

Author Contributions

U.O.; J.A.B.; I.A.D.; A.S.O.; O.B.D; and G.P.; carried out the practical/ part offunding, U.O.; Supervision/ Formal analysis/ Writing – review and editing.

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