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NUTRITIONAL ANALYSIS OF SWEET SORGHUM STALK AS MAIN EXCIPIENT OF COMPOUNDED DAIRY CATTLE FEED

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ABSTRACT

Seven cultivars of sweet sorghum have been analyzed for sugar content, nutritional and antinutritional factor and mineral content as possible excipient for dairy cattle feed. These were done using brix method, proximate analysis (AOAC), and atomic absorption spectrophotometry respectively. The proximate results showed that the samples sugar content ranged from 23% to 11.46 %, protein content ranged from 4.08 % to 2.02 %, carbohydrate content ranged from 9.30 % in 501 to 1.13, fibre content ranged from 33.28% to 23.03%. Ash and lipid ranged from 1.77% to 1.10% and 2.20% to 1.35% respectively and, moisture content of 63.69% to 53.04 was determined. Anti-nutrient result revealed alkaloid content range from 5.01% to 1.51%. The following trend of K > Ca > Na > Zn > Cu > Fe minerals content were observed in the sample. The sample with the lowest protein content was used to formulate the two feeds in the study (C1 & C2) which showed the following nutritional content protein: 4.37% (C1), 4.23% (C2); Fibre:32.13% (C1), 32.40% (C2); digestible nitrogen: 92.33% (C1), 7.93% (C2) and acceptable mineral composition. The results obtained from the study show that sweet sorghum stalks are good sources of raw materials for the production animal feeds.

Key word: sweet sorghum, nutritional composition, animal feed

INTRODUCTION

The livestock industry is a thriving subsector of Nigerian agricultural sector. It has contributed immensely to the economy and well-being of its citizenry. There is a great potential in the use of agricultural by-products as sources of fodder/feed for livestock [1].

These by products are good sources of animal feed and play important role in the feed-food security nexus. In addition, they do not compete with human food and contribute to decreasing cereals and soya beans level in livestock diet in an intensive livestock production system [2]. The nutritional value of feed is associated with its chemical composition and the utilization level of nutrients [3]. Fractionation of carbohydrates and protein allows the formulation of appropriate diets, enabling maximum efficiency of energy and nitrogen use, both by microorganisms and by the animal [4].

Sweet sorghum belongs to the same species as grain sorghum (sorghum bicolor). It has the ability to accumulate sucrose in its stem parenchyma. Sorghum is a tropical plant belonging to the family poaceae. It is one of the most important plants in Africa, Asia and Latin America. More than 7000 sorghum varieties have been identified as reported by Oden [5]. While most are produced for human consumption, the remainder is cropped for industrial applications.

Sweet Sorghum is cultivated explicitly for the purpose of making sugar as reported by Akbulul and Ozcan [6]. Its rich sugar stalks provide grain and stalk that can provide several industrial applications [7]. As by-product from some of its industrial applications the stalk bagasse can be deployed as feedstock in the production of animal feeds.

The acquisition of good quality grain is fundamental to producing acceptable food product as well as industrial raw materials. It is in tandem with this that the study on some cultivars of sweet sorghum was carried out as a new source for industrial raw material for the feeds and other industrial applications [8].

Literature review showed that various cultivars of sweet sorghum have been used as possible excipient in the formulation of animal feed. Anandan and Blummel reported that sweet sorghum bagasse can be utilized as major component in animal feed as indicated by the result observed in their studies, which showed increased productivity of livestock, and improvement in the economic value of sweet sorghum value chain [9].

Jeff Jackson described sorghum silage as a product with high protein content and neutral detergent fiber digestibility in relation to corn silage [10]. In addition, Houx *et al* analysed some cultivars of sweet sorghum for protein content in treat and untreated form. The treated samples indicated improved protein content than the untreated. The ammonical treatment was carried out with the intent on increasing the digestible protein content of the sweet sorghum bagasse [11].

In light of the current herder and farmer challenges facing our society, the need for additional sources of animal feed for cattle breeders is inevitable. Therefore, this work seeks to provide a source of raw material for production of cattle feed via the use of sweet sorghum (sorghum bicolor) as main feed excipient. Seven different cultivars of sweet sorghum (sorghum bicolor) will be analyzed via sugar content, nutritional and anti-nutritional factors. The sample that provides unsurpassed result will be used to formulate dairy cattle feed in addition with other agricultural waste such as; cowpea fodder, cowpea husk rice bran and coconut cake.

MATERIALS AND METHODS

Samples of sweet sorghum (NTJ-2, NRSS012, NRSS0003, DAN SADAU, 503, NRSS0005501), were collected from the Raw Material Research and Development Council. They were stored in a polythene bag until samples were ready for analysis. Cowpea fodder and husk were collected from a farm located within the Sheda Science and Technology Complex, Sheda, Abuja. Rice bran was sourced from a local milling centre while the coconut cake was sourced from the local producer of coconut oil. All reagent used for the analysis were of analytical grade and were used without further purification.

BRIX

The brix values of the samples were analyzed using Abbe Refractometer (Model 10450, American Optical Corporation Scientific Instrument Division Buffalo, NY, 14215, USA). The sugar type was analyzed using the method described by Sameera *et al* [12]. Proximate analysis including determinations of moisture content, ash content, crude lipid, crude protein and carbohydrate were carried out using the AOAC method [13].

Quantitative Determination of Antinutrient factor

This analysis was carried out to test for the presence and quantity of phenol, alkaloids, tannins, flavonoids, saponins and oxalate as described in literature [14].

Mineral Analysis

Two grams (2 g) of each of the samples was weighed into a beaker and 20 ml of nitric acid was added to the sample. This was heated on the hotplate at 60ºC until white fume evolved. It was then removed from heat and allowed to cool. The solution was diluted with distilled deionized water and made up to 50 ml in a volumetric flask. A blank was prepared in the same manner and poured into a polyproplene bottle. The samples were analysed for metals on

Thermo Scientific (*iCE* 3000AA02134104) Atomic Absorption Spectrometer using appropriate working standards as reported Emmanuel *et al* [15].

Formulation of animal feed

The feeds were composed using two different compositions (C1 and C2). The feed formulation was carried out using a slight modification of the methods described in literature [8, 14-17]. The residue of the sweet sorghum stalk was air dried after extraction of the sugar content from the stalk. This was then pulverized and placed in a clean bag. Other agricultural by-products (cowpea husk, cowpea fodder, rice bran, coconut cake) were also dried and pulverized. The components were then mixed thoroughly together in appropriate ratio. Sweet sorghum stalk as main excipient of the feed constituted 50% of the stock, while other raw materials were varied [16, 17].

Analysis of animal feed

Analyses of feed and materials were carried out as reported in the literature [17-19].

RESULTS AND DISCUSSION

Nutritional and anti-nutrient factor grain and stalk

The results of the physicochemical of the sorghum cultivars are shown in Tables 1-4. In Table 1, the result of the sugar analysis showed the brix sugar composition in the range 14-23% in NJT-2 and NRSSS002, sugar type NTJ-2, and NRSS0005, 501, and DAN SADAU as glucose, D-fructose and sucrose. 503 contained only sucrose and D-fructose, while NRSS0003 and NRSS0012 contained only galactose and sucrose respectively. The highest total sugar content was found in NRSSS012 sample and the lowest was 501. Literature reported between 17.8-40.3% of total sugar content on dry weight basis and 7.0-15.9% on wet matter [6]. A sugar content (brix %) of stalk juice was reported by Atokple *et al* as 6.2-21% [8]. The present analysis shows a total sugar and the brix (%) sugar content in the range reported in the literature [8].

Table 1: Sugar Analysis of stalk and grain of the different cultivars

SAMPLE	BRIX (%) sucrose	TOTAL SUGAR (g/100g)	SUGAR TYPE
NTJ-2	14.0	10.92	Sucrose, glucose D-fructose
NRSS0012	23.0	10.94	Sucrose
NRSS0003	22.0	14.44	Galactose
DAN SADAU	22.0	9.61	Glucose, D-fructose, sucrose
503	22.0	13.1	Sucrose, D-fructose, sucrose
NRSS0005	22.0	13.1	Glucose, D-fructose, sucrose
501	19.0	11.46	Glucose, D-fructose, sucrose

The results of proximate analysis are shown in Table 2. The result showed the water content to be very high. It ranged from 53.04 to 63.69%, with NRSSS0005 having the lowest and NTJ, the highest. The crude fiber content ranged from 23.03 to 33.28%. The highest was observed in NRSS0005 while NRSS0003 content was lowest. The carbohydrate content was highest in 501 sample with the value of 9.30% while NTJ-2 sample had lowest carbohydrate content of 1.13%. The crude protein, lipid and ash content were generally very low.

Table 2: Result of Proximate analysis of sweet sorghum stalk

Sample	Ash (%)	Water (%)	Crude lipid (%)	Crude Fiber (%)	Crude protein (%)	Carbohydrate (%)
NTJ-2	1.35	63.69	1.17	30.22	2.45	1.13
NRSSS00012	1.63	62.66	1.26	24.94	4.08	5.44
NRSS0003	1.73	63.65	1.19	23.03	2.45	7.95
DAN SADAU	2.20	62.15	1.72	24.29	2.04	7.60
503	1.88	57.24	1.77	30.89	2.86	5.36
NRSS005	1.81	53.04	1.10	33.28	2.04	8.73
501	1.51	58.67	1.03	27.03	2.45	9.30

Table 3: Anti-nutrient factors of sweet sorghum stalk

Sample	Alkaloids (%)	Saponins (%)	Oxalate (%)	Tanins (%)	Phytate (%)
NTJ-2	3.19	0.80	0.13	0.02	0.004
NRSSS00012	2.20	0.40	0.11	0.08	0.004
NRSS0003	5.01	2.00	0.20	0.07	0.004
DAN SADAU	1.99	0.00	0.19	0.07	0.004
503	1.51	0.40	0.15	0.08	0.008
NRSS005	2.00	0.00	0.13	0.04	0.005
501	1.87	0.00	0.10	0.02	0.004

The results of mineral composition of the sweet sorghum stalk are shown in Table 4. Potassium was in the range of 91.44 to 209.09 mg/kg with the highest found in Dan sadau sample while the lowest was found in NTJ-2 sample. Calcium was low with concentration range of 1.65 to 6.81 mg/kg. Sodium is also low with its concentration found within the range of 1.00 to 1.99 mg/kg. Other important trace metals (zinc, iron, manganese), were also very low as their levels were within the range of 0.06-0.21 mg/kg, 0.02-0.20 mg/kg, 0.56-1.58 mg/kg respectively. The heavy metals (Cr, Co, Ni and Cu) contents were also very low in the range of <0.90mg/kg.

Table 4: Result of elemental analysis sweet sorghum sample

Sample	K mg/kg	Ca mg/kg	Cu mg/kg	Zn mg/kg	Cr mg/kg	Co mg/kg	Mn mg/kg	Fe mg/kg	Na mg/kg	Ni mg/kg
NRSSS003s	182.60	6.81	0.02	0.08	0.01	0.08	0.83	N.D	1.61	0.09
NTJ-2	91.44	3.95	0.08	0.12	0.01	0.80	0.58	0.01	1.62	0.20
NRSSS0005	160.82	4.87	0.04	0.10	0.07	0.06	1.58	N.D	1.10	N.D
501	169.65	1.65	0.13	0.06	0.28	N.D	0.59	N.D	1.00	0.16
NRSSS012	122.32	5.14	0.06	0.13	N.D	N.D	0.56	0.20	1.84	0.01
DAN SADAU	209.09	1.65	0.13	0.15	N.D	0.60	0.70	0.02	1.99	0.31
503	129.35	4.66	0.15	0.21	0.04	0.6	0.80	N.D	1.40	N.D

The results of proximate analysis of sorghum stalk as well as other forages which were used for compounding the feed were compared on Table 5. From the results the ash content, fiber, crude protein and total digestible nutrient values of cowpea forages were higher than that of sweet sorghum, while the ether extract, nitrogen free energy and energy value of sweet sorghum were higher than those of cowpea forages. The low ash content of sweet sorghum may probably be due to the higher stem proportion of these cultivars [4].

Table 5: Proximate composition of forages (dry matter basis)

Parameter	Sweet sorghum (SS)	Cowpea fodder (CF)	Cowpea husk (CH)
Moisture %	5.6	14.46	7.61
Ether extract %	1.62	1.1	1.1
Ash %	2.78	6.74	5.38
Fibre %	30.22	34.95	34.80
Nitrogen free energy %	63.65	48.20	50.98
Crude protein %	1.73	9.01	7.74
Total digestible nutrient	99.25	99.86	99.03
Energy (Kcal)	276.10	238.74	244.78

The results of proximate analysis of additives (rice bran and coconut cake) are displayed in Table 6. From the result the ash content of rice bran was also higher than that of sweet sorghum as well as the energy value while for the coconut cake the total digestible nutrient, energy, and nitrogen free energy were also higher than sweet sorghum values.

Table 6: Proximate composition of Additives

Parameter	Rice Bran (RB)	Coconut cake (CC)
Moisture %	9.85	6.44
Ether Extract %	1.5	0.5
Ash %	16.18	0.74
Fibre %	18.09	9.0
Crude protein %	5.23	5.24
Nitrogen free energy %	59.00	84.52
Total digestible Nutrient%	85.70	99.89
Energy (Kcal)	324.42	363.54

The results of elemental analysis are presented in Table 7. The forage and concentrates showed relatively high value of calcium at 55.06 and 43.39 mg/kg in cowpea fodder and cowpea husk respectively while that of sweet sorghum was 9.84 mg/kg. Potassium content was also moderate at 17.66, 17.14 and 15.23 mg/kg in cowpea fodder, cowpea husk and sweet sorghum respectively. Sweet sorghum showed high iron content of 15.23 mg/kg than others. Other elements present were relatively low.

Table 7: Mineral composition of materials dry matter basis

SAMPLE	Ca mg/kg	Mg mg/kg	Zn mg/kg	Mn mg/kg	K mg/kg	Na mg/kg	Fe mg/kg	Cu mg/kg
SS	9.84	9.65	0.60	1.72	15.23	1.10	14.58	0.29
CH	43.39	8.13	0.56	2.27	17.14	1.45	1.34	0.69
CF	55.06	8.55	0.92	5.40	17.66	2.88	2.97	0.58
RB	4.24	6.63	1.11	7.87	12.83	5.15	3.38	0.69
CC	1.75	6.93	0.38	0.28	12.27	3.12	0.82	0.48

FEED NUTRITIONAL COMPOSITION

The results of proximate analysis and mineral composition carried out on the compounded feeds are shown in Table 8. The analysis showed that addition of other sources of feedstock materials increased the nutritional composition of the feed. The C1 feed showed improved protein content from 1.73% in sweet sorghum to 4.37 % and 4.23% in C2, the ash content also improved from2.78% to 12.73% and 7.63% in both compositions respectively.

Table 8: Proximate composition of feed formula

Parameter	C1	C2
Moisture %	5.70	7.20
Ether Extract %	4.05	1.73
Ash %	12.73	7.63
Fibre %	32.12	32.40
Crude protein %	4.37	4.23
Nitrogen free energy %	46.73	54.01
Total digestible Nutrient%	92.33	97.93
Energy kcal	240.85	248.53

The mineral composition of the feeds is shown in Table 9. In the results, the concentrations of calcium, potassium, sodium, iron, phosphorus and sulphur increased to 25.02, 27.14, 25.02, 12.81, 18.15 and 312.66mg/kg in dairy feed while 22.87, 45.50, 22.52, 14.98, 17.90 and 256.66 mg/kg respectively. These results are in agreement with literature reports on animal feed [24-28].

Table 9: Mineral composition of feed

Element mg/kg	C1	C2
Ca	25.02	22.87
Mg	8.60	8.50
K	27.14	45.5
Na	25.02	22.52
Zn	0.66	0.61
Fe	12.81	14.98
Mn	3.71	2.19
Cu	0.96	0.52
P	18.15	17.90
S	312.66	256.66

It can be deduced from this study that the stalks of sweet sorghum bicolor could serve as ingredient in formulation of feedstock for animal feed due to the high level of fiber content, considerable quantity of crude protein, carbohydrate, ash content and crude lipid. Although, some of the samples showed low carbohydrate content, this is similar to the report given by Jeff Jackson [10] which showed that some sorghum silage contains less starch. Therefore, additional source of starch supplement is required for animal feed. The mineral analysis results also showed that the samples contained minerals such as Ca which is important for improved bone and muscle build, as well as Zn and Mn which are important for antioxidant activity and hence could protect the body from diseases caused by oxidative stress. This is similar to the report by Akiode *et al* on the nutritional composition of some agricultural waste as potential animal feeds stock [14]. The grain samples also showed result similar to the report given by Sarmarth *et al*. [20].

The low levels of anti-nutrients factors in Table 3 showed that there may be little or no danger in using the sample materials as source of raw materials for composing feed for animals. Similar reports from other studies collaborated these assumptions [4, 8, 19, 24-27]. The results of Tables 5 and 6 show the proximate composition and energy values of forage and concentrate additives. From the results, sweet sorghum had the highest total digestible nutrient (TDN) of 63.65% as compared to 50.98% of cowpea husk and 48.20% cowpea fodder while the energy values were 276.10, 244.78 and 238.74 kcal respectively. For the concentrate additives the coconut cake had the highest TDN of 99.89 % while the rice bran had 85.70 % with their energy values being 363.54 and 324.42 kcal respectively. The study showed that there was considerable increase in ash content, crude protein in compounded feed as a result of the added components from other agricultural waste material as compared to the low values in the sweet sorghum forage. It also showed that due to increase in ash content, the feeds also had improved concentration levels of macro and micro mineral elements (Ca, Mg, K, Na, P and S).

CONCLUSION

The results of the samples analysed in this study indicate that the stalks of sweet sorghum could serve as ingredient in formulation of feedstock for animal feed. This is shown in the levels of fibre, crude protein, carbohydrate, crude fibre, ash content, crude lipid and low levels of antinutrients factors. Also, it reveals that compounding it with additives such as cowpea waste, rice bran and coconut cake increases its nutritional value considerably.

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REFERENCES

1. Tona, G.O., Ogunbosoye, D.O. & Ayano, M.O. (2015). Nutritive value assessment of four crop residues by proximate composition and invitro rumen fermentation technique. *IJAAAR* II (1&2), 123-129
2. Sherasia, P.L, Garg, M.R. & Bhanderi, B.M (2017). Pulses and their by-products as animal feed, FAO, Animal Nutrition group, National dairy development board, Anand India
3. Ratnavathi, C.Y., Patil, J.V. & Chavian U.D. (2016). Sorghum Biochemistry and Industrial Perspective; Edition 1, Academic press Elsevier UK
4. Arthur Behling Neto, Rafael Henrique Pereira dos Reis , Luciano da Silva Cabral, Joadil Gonçalves de Abreu , Daniel de Paula Sousa, Fabiano Gama de Sousa, (2017). Nutritional value of sorghum silage of different purposes; *Ciência e Agrotecnologia* 41(3), 88-299, May/Jun. 2017
5. Chrisanto Oden; ittopics.org.cdn.amprojecy.org
6. Akbulut, M. & Ozcan, M. (2008). Some physical, chemical and Rheological properties of sweet sorghum (Sorghum bicolor (L) Moench) Pekmez (molasses). *International Journal of Food Properties*, 11, 79-91
7. Definition and classification of commodities. Sugar crops and sweeteners derived products 1994. www.fao.org accessed 27/02/2019
8. Atokple I.D.K, Gavers Oppong, & Solomon Chikpah (2014). Evaluation of grain and sugar yields of improved sweet sorghum varieties in the Guinea savannah zone of Ghana. *Pinnacle Agricultural Research &Management*, 2(2), 374-382
9. Anandan, S., Zoltan, H., Khan, A.A., Ravi, D., & Blummel, Michael (2021). Feeding value of sweet sorghum bagasse and leaf residues after juice extraction for bio-ethanol production fed to sheep as complete ration in diverse physical form. *Animal Feed Science and Technology*, 175 (3-4), 131-136
10. Jeff Jackson (2019). Is sorghum the best-kept secret to feed cattle right now? Progressive Cattle. Accessed @ progressivecattle.com on 14/1/2022
11. Houx, H. James, Craig Morrie, A., Fritschi, B. Felix (2013). Evaluation of sweet sorghum bagasse as an alternative livestock feed, *Crop Science* 53(4), 1784-1791

12. Sameera, P., Sapna, E., Komal, G., Rency, R., Rudra, P., Elizabeth, R. & Monisha, K. (2019). Quantitative and Qualitative analysis of glucose and fructose from flower nectaries; Interwoven: *An interdisciplinary journal of Navachana University,* 2(1) 41-46
13. AOAC (1990), Official Method of Analysis. 15th Edition Association of Official Analytical Chemist, Washinton DC
14. Akiode S.O., Fadeyi, A.E., Falayi, O.E., Emmanuel, S. A. & Onyenekwe P.C. (2018). Nutrients, Phytochemical Composition and Antioxidant analysis of SelectedAgricultural Wastes as Potential Livestock Feed Ingredients. *Nigerian Journal of Basic and Applied Science, 26(2), 35-44*
15. Emmanuel, S. A, Olajide, O., Abubakar, S., Akiode, S.O. & Etuk-Udo, G. (2016). Chemical Evaluation, Free Radical Scavenging Activities and Antimicrobial Evaluation of the Methanolic Extracts of Corn Silk (*Zea mays*). *Journal of Advances in Medical and Pharmaceutical Sciences,* 9(4),1-8
16. TNAU AGRICTECH portal animal husbandry, Livestock:Cattle:Feed management; ww.vuatkerala.org
17. Charlotte Kirk Baer, Norman Grossblatt, Stephanie Padgham, Melinda Simons(2012); Nutrient Requirements of Dairy Cattle. (2001) National Academy Press Washington DC
18. Proximate analysis- AnA312- Applied Animal nutrition feedstuffs and ratio formulation. http://courses.ecampus.oregonstate.edu
19. Fadeyi, A.E., Akiode, S.O., Emmanuel, S.A.,& Falayi, O.E. (2018). Compositional analysis and characterization of Lignocellulosic biomass from selected agricultural wastes; Conference Proceedings 41st Annual International conference, workshop and exhibition of Chemical Society of Nigeria.
20. Samarth, A.G., More, D.R. & Imran Hashme (2018). Studies on the physicochemical properties and nutritional profile of sweet sorghum; *International Journal of Chemical Studies* 6(2), 2826-2828
21. Yao Chen, Nicole M Stark, Zhiyong Cai, Charles R Frihart,Linda F Lorenz,& Rebecca E Ibach (2014). Chemical Modification of Kraft Lignin:Effect of chemical and thermal properties, *Bioresources, 9(3) 5488-5500*

22. Eman Ali & Lamaludin M Z (2015). Possibility of producing ethanol from Moringa Oleifera pod husk. *Journal of Advanced Research Design* 5(10), 1-9
23. Ephraim, Yona Baguma, Mohammaad Naushad Emmambaux, Joba Regina & Nuttal Taylor (2010). Physicochemical and functional properties of cassava starch in Uganda varieties and progenies. *Journal of plant breeding and crop science*, 2(1), 001-011
24. Fan zhu (2014). Structure, Physicochemical, Modification, and uses of sorghum starch. *Comprehensive review in food science and food safety* 13 (14), 597-610
25. Uses and Nutritional Features of Sorghum: agropedia.iitk.ac.in/con
26. Vaidyanathan Subramanian, Eswara, K., Prasada Rao, Melak H. Mengesha & Ramamurthi Jambunathan (1987). Total sugar content in sorghum stalk and grains of selected cultivars from world germsplasm collection. *Journal of science and food & agriculture*, 39(4), 289-295
27. Amrita Patel (2012); Nutritive value of commonly available fodders in India Animal Nutrition group; National dairy development board, Anand-3388001
28. Principles of animal nutrition: digestible nutrients ecourseonline.iasri.res.in