Nutritional Analysis of Sweet Sorghum Stalk as Main Excipient of Compounded Dairy and Beef Cattle Feed

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Received: December 18, 2021, Manuscript No. NPCR-21-15084; **Editor Assigned:** December 24, 2021, **PreQC No.** NPCR-21-15084; **Reviewed:** December 27, 2021, QC No. NPCR-21-15084; Revised: December 29, 2021, Manuscript No. NPCR-21-15084 (R); **Published:** January 06, 2022; DOI: 10.37532/npcr.10.1.1-4

Abstract

Sweet sorghums have been bred primarily for syrup production, the byproduct of which could provide a source of livestock feed. Sweet Sorghum stalk, cowpea fodder and husk, rice bran and coconut cake were analyzed for nutritional, anti-nutritional and mineral content. Livestock feed was formulated and analyzed for their nutritional and energy value. The sugar content analysis carried out in this work showed higher total sugar and brix (%) in the species NRSS00012 at 23% and 11.46% for 501 which is the lowest. The sugar type identified in the extract from the most of stalk samples are Glucose, D-fructose, sucrose, NRSSS005 however showed the presence of only galactose. The result of the nutritional analysis showed protein in the range 4.08 to 1.22% NRSS0012 to 503, carbohydrate is in the range of 9.35 in 501 to 5.36 in 503 sample. The fiber content of 33.28% in NRSS0005 was the highest and lowest of 23.03% in NRSSS0003. Ash and lipid are in the range 1.77 to 1.10 and 2.20 to 1.35 in sample 503 and NRSS005 and Dan sadau and NTJ-2 respectively. NTJ-2 had the highest moisture content of 63.69% and lowest value of 53.04% in NRSS005 sample. Anti-nutrient analysis showed the highest value of 5.01% alkaloid in NRSS0003 sample and the lowest value of 1.51% in the 503 sample. The mineral analysis showed the trend of K>Ca>Na>Zn>Cu>Fe in the sweet sorghum stalk. The feed compounded showed protein content of 4.37% for dairy feed and 4.23% for beef feed. Fiber content was 32.13% in dairy feed and 32.40% beef feed. The total digestible nitrogen was 92.33% for dairy feed while beef feed was 97.93%. Nitrogen free energy for dairy feed and beef feed was 46.73% and 54.01% respectively. The mineral composition showed Ca as 25.02 mg/Kg and 22.87 mg/kg, Mg is 8.60 mg/kg and 8.50 mg/kg, K is 27.14 and 45.40, Na 25.02 and 22.52, Zn 0.66 and 0.61, Fe 12.81 and 14.98, Mn 3.71 and 2.19, Cu, 0.96 and 0.52, P 18.15 and 17.90 and S 31.26 and 25.67 mg/Kg for dairy and beef feed respectively. The present result showed that sweet sorghum stalk from the different cultivars analyzed are good sources of raw materials for the production animal feeds, while the results from the feed compounded will be a good source of nutritional feed for dairy and beef cattle.

Keywords: Sweet sorghum • Nutritional composition • Animal feed

Introduction

The livestock industry is a thriving subsector of the 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 a good source 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 levels 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 plant in Africa, Asia and Latin America. More the 7000-sorghum variety has been identified as reported by Oden [5]; while most are produced for human consumption, the remaining are cropped for industrial applications.

Sweet Sorghum is cultivated explicitly for the purpose of making sugar as reported by Akbulul and Ozcan 2008, [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 products 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].

This work seeks to analyse seven different cultivars of sweet sorghum (*Sorghum bicolor*) *via* sugar content, nutritional and anti-nutritional factor. The best will be used to compound dairy and beef cattle feed in addition to other agricultural waste such as; cowpea fodder, cowpea husk rice bran and coconut cake.

Materials and Methods

Samples of sweet sorghum were collected from the Raw Material Research and Development Council. (NTJ-2, NRSS012, NRSS0003, DAN SADAU, 503, NRSS0005 501). They were stored in a polythene bag until samples were ready for analysis. Cowpea fodder and husk were collected from a farm located with 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 reagents used for the analysis were of analytical grade and were used without further purification.

Brix

The Brix value of the samples was analyzed using Abbe Refractometer. The sugar type was analyzed using the method described by Sameera [9]. Proximate analysis including determinations of moisture content, ash content, crude lipid, crude protein and carbohydrate was carried out using the AOAC (1990) method [10].

Quantitative determination of ant nutrient factor

This analysis was carried out to test for the presence and quantity of phenol, alkaloids, tannins, flavonoids, saponins, Oxalate as described by Akiode in the year 2018 [11].

Mineral analysis

Two grams (2 g) of each of the samples were weighed into a beaker and 20 ml of nitric acid was added to the sample. This was heated on the hotplate at 60°C 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 polypropylene bottle. The samples were

analysed for metals on Thermo Scientific iCE 3000AA02134104 Atomic Absorption Spectrometer using appropriate working standards as reported Emmanuel in 2016 [12].

Formulation of animal feed

The feeds were composed of both dairy and beef cattle. The feed formulation was carried out using a slight modification of the methods described in the literature [13-15]. Sweet sorghum stalk was the main excipient for feed. 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 such as cowpea husk, cowpea fodder, rice bran, coconut cake were also dried and pulverized. The components were then mixed thoroughly together in the ratio described in the literature.

Analysis of animal feed

Analyses of feed and materials were carried out as reported in the literature [14,15].

Results and Discussion

Nutritional and anti-nutrient factor grain and stalk

The physicochemical of the sorghum cultivars are shown in Tables 1-4. In Table 1, the result of the sugar analysis showed the sugar composition of NTJ-2, NRSS0005, 501, and DAN SADAU as glucose, D-fructose and sucrose, 503 contains only sucrose and D-fructose, while NRSS0003 and NRSS0012 contains only galactose and sucrose respectively. the result further indicated that the stalks (S) had higher total sugar and brix (%) sugar value than the grain samples (G). Comparing the individual species, the stalk sample 503 and NRSSS003 with 13.10 g/100 g showed higher levels of total sugar content and the least is Dan Sadau with 9 g/100 g. Among the grain sample NRSSS012 has the highest sugar content of 6.75 g/100 g and NTJ-2 with 1.56 g/100 g. The highest brix sugar content is found in NRSSS012 sample and the lowest is 501 among the stalks. Literature report between 17.8%-40.3% of total sugar content on dry weight basis and 7.0%-15.9% on wet matter, while the grain indicates between 1.02%-2.23%. A sugar content (brix%) of stalk juice was reported by Atokple in 2014 as 6.2%-21%. The present analysis shows a total sugar content in the range reported literature and the brix (%) sugar appears within result reported by Atokple in 2014.

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 between 53.04% to 63.69%, with NRSSS0005 having the lowest and NTJ-the highest respectively. The crude fiber content range from 23.03% to 33.28%. the crude fiber content of NRSS0005 was highest 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.

Thus, this study indicates that the stalks could serve as a potential ingredient in formulation of feedstock for animal feed. As shown in the high level of fiber content, considerable quantity of crude protein, carbohydrate, ash content, crude lipid. The mineral analysis results also showed that the samples contain 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 S.O. Akiode on the nutritional composition of some agricultural waste as potential animal feed stock [16]. The grain samples also showed result similar to the report given by Sarmarth in 2018 [17]. The low levels of anti-nutrients factors are in Table 3. Further showed 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 have collaborated these assumptions [18-21]. Similarly, the results of Tables 5 and 6 shows the proximate composition and energy values of forage and concentrate additive. 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 kcal, 244.78 kcal 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 value being 363.54 kcal and 324.42 kcal respectively.

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

Similarly; the results of proximate analysis of other forage as compared to cowpea fodder, and cowpea husk is displayed in Table 5. From the display results the ash content, fiber, crude protein and total digestible nutrient values of cowpea forages was higher than that of sweet sorghum,

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

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 [22].

Also, the proximate analysis of additives i.e. 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.

The result of elemental analysis Table 7, for the forage and concentrates, showed a relatively high value of calcium of 55.06 and 43.39 in cowpea fodder and cowpea husk respectively while that of sweet sorghum was 9.84 mg/kg. potassium was also moderate at 17.66 mg/kg, 17.14 mg/kg and 15.23 mg/kg in cowpea fodder, cowpea husk and sweet sorghum. Respectively. surprisedly, sweet sorghum showed high iron content of 15.23 mg/kg. other elements present were relatively low.

Feed Nutritional Composition

The results of proximate and mineral composition carried out on the compounded feeds are shown in Table 8 The analysis showed that the addition of other sources of feedstock materials increased the nutritional composition of the feed. The dairy feed showed improved protein content

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

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

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

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

Table 8: Composition of feed formula Proximate.

Parameter	Dairy feed	Beef feed
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

Table 9: Mineral composition of feed.

Element mg/Kg	Dairy feed	Beef feed
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

from 1.73% in sweat sorghum to 4.37% in dairy feeds and 4.23% in beef feed, the ash content also improved from 2.78% to 12.73% in Dairy feed and 7.63% in Beef Feed.

This is further collaborated by the elemental composition result shown in Table 9. In the result the concentrations of calcium, potassium, sodium, iron, phosphorus and Sulphur increased to 25.02 mg/kg, 27.14 mg/kg, 25.02 mg/kg, 12.81 mg/kg, 18.15 mg/kg and 312.66 mg/kg in dairy feed while 22.87 mg/kg, 45.50 mg/kg, 22.52 mg/kg, 14.98 mg/kg, 17.90 mg/kg and 256.66 mg/kg respectively. These results are in agreement with literature reports [23-26]. The feed was also fortified with vitamins A, B, C to boost the vitamin content of the feed and take care of deficiencies in animals.

Conclusion

The study showed that there was a considerable increase in ash content, crude protein in compounded feed as a result of the added components from other agricultural waste materials as compared to the low values in the sweet sorghum forage.

It also showed that due to an increase in ash content, the feeds also had improved concentration levels of macro and micro mineral elements (Ca, Mg, K, Na, P and S).

Acknowledgement

The authors wish to acknowledge the management and staff of Sheda Science and Technology Complex for providing an enabling environment for the analysis to be carried out. The efforts of David Bwai Macham, Adebisi Fagbohun, Sunday Nwachi and Olajide Falayi is greatly appreciated. Also, the management of RMRDC is greatly appreciated for their contributions in funding the project.

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Cite this article: Emmanuel SA, Ibrahim HD, Mika SR, et al. Nutritional Analysis of Sweet Sorghum Stalk as Main Excipient of Compounded Dairy and Beef Cattle Feed. Nat Prod Chem Res. 2022, 10 (1), 1-4.