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Research Article

Effects of Microbial Degradation on Nutritional and Antinutritional Composition of *Pennisetum glaucum* Cobs

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Abstract

Proximate, mineral and antinutritional composition of millet cobs were assessed. Antinutritional analyses in mg/g showed the presence of phytate, saponin and tannin. Proximate composition of samples ranged from 0.86 to 4.62%; 57.04 to 65.95%; 1.39 to 10.42%; 5.10 to 11.53%; 0.35 to 0.98% and 19.42 to 25.75% for ash, carbohydrate, moisture, crude protein, crude fat and crude fibre contents respectively. Zinc showed the lowest mineral concentration out of the minerals assayed with a value of 0.15 ± 0.01 while potassium exhibited the highest mineral concentration with 47.27 ± 0.33.Saponin (mg/g) was observed to be the highest anti-nutrient (102.90 ± 0.55), while tannin (mg/g) was the lowest (1.31 ± 0.01). Hence, millet cobs that are indiscriminately disposed could serve as an alternative source for the fortification of animal feeds.

Keywords: Millet Cobs; Proximate; Antinutrients; Minerals

Introduction

High magnitude of agro-industrial waste are annually produced all over the nations of the earth, in which are possible feed stocks for livestock, their high fiber components is the main limitation [1]. As a result of arrays of different crop residues are produced pose both disposal and environmental problems [2]. These wastes could be used as dietary matter such as biofuels, chemicals, improved animal feeds and human nutrients [1,2]. Thepotentialofagro-industrial and crop residues in supporting the goals of livestock production cannot be over-emphasized.

According to FAO statistics [3], the world production of millets was 26.7 million metric tons from 33.6 million hectare. Asia produced 22.9 million metric tons of millet, while Africa produced 20.6 million metric tons of millet in 2009 [4]. Millet accounts for 5% of the world cereal production when compared to wheat, rice, maize and barley in terms of production and plantation [5]. Eight common millets species (Sorghum, Pearl millet, Finger millet, Foxtail millet, Kodo millet, Proso millet, Barnyard millet and Little millet) are usually grown under rain nourished conditions. However, millet has rich inter/intra-species diversity and wider climatic adaptability cultivation of diverse millet species/varieties which is gradually narrowing in the recent past [4]**.** The millet plant comprises of the stalks, husks, shanks, silks, leaf blades, leaf sheaths, inner glume, outer glume and cobs. The cobs contain the grains of the millet plant. The cobs of millet are usually disposed after harvest.

Millet cobs create a disposal problem and cause more problems with increase in industrial production without the conversion of these wastes to useful forms. Demerits of using crop wastes includes; low digestibility, low protein concentration and colossal crude fiber content [6]. Fermentation, a cheap process helps to reduce the effects of these limitations and increase the protein content [7].

The aim of this study is to investigate the nutritive and anti-nutritive values present in millet cobs. Hence, analyses were carried out to provide substitute material for the production or fortification of animal feeds.

Materials and Methods

Sample collection and preparation

Millet cobs were collected 28th of December, 2017 during the harvesting (Dry season) from a farm in Gusau, Zamfara State and transferred to the Postgraduate laboratory of the Federal University of Technology, Akure on the 5th of January, 2018 for assessment. The millet cobs were dried for three weeks and grinded into powdered form using an electric blender. The sample was divided into two. Sample 'A' served as the control sample which was not degraded and Sample 'B' served as the degraded sample which was degraded by the millet cobs inherent microorganisms.

Submerged substrate degradation

In the submerged substrate degradation, 10.0 g of the 'B' substrate was soaked in 100.0 ml of sterile distilled water. The submerged degradation was done for 20 days [8].

Evaluation of proximate composition of the samples

Proximate composition viz; moisture, crude fibre, ash, crude protein and carbohydrates were evaluated by the standard technique of Association of Official Analytical Chemists [9].

Evaluation of mineral Composition

The mineral content were analysed by dry-ashing the solution in 10% (vol/vol) HCl, filtered and made up to the mark in a 100ml volumetric flask using distilled de-ionised water. Sodium and potassium were determined by flame photometry, while calcium and zinc were determined by atomic absorption spectrophotometer (AAS) [9].

Determination of anti-nutrients

Antinutrients components that were determined include tannin, Saponin and Phytate using the standard methods of Makkar and Goodchild [10]; Brunner [11]; and Wheeler and Ferrel [12] respectively.

Statistical analysis

Mean and standard errors of the mean of triplicate readings obtained in the study were subjected to statistical analysis using SPSS version 16 Microsoft windows and analysis of variance (ANOVA).

Results

The effects of f biodegradation on proximate composition of millet cobs were shown in Table 1. There was progressive increase in moisture and ash content as degradation progresses compared to the control sample. The crude protein was increased from Day 4 to Day 8 in biodegradation period compared to the control sample and then reduced from Day 12 to Day 20. Crude fat was reduced from Day 4 to Day 20 at the biodegradation period compared to the control and showed the highest value. This was also applicable for crude fiber apart from Day 12 when there was a slight increase. Reduction in carbohydrate content from Day 8 to Day 20 of the biodegradation period as compared to control exhibited highest carbohydrate content. The minerals composition such as sodium, potassium, zinc and calcium is shown in figure 1. The highest calcium was recorded on Day 20, while the lowest on Day 12 of the biodegradation period. The highest values of zinc, sodium and potassium were observed on Day 20 and the lowest value was recorded on Day 8.

Samples	% Moisture content	% Ash content	% Nitrogen content (crude protein)	% Crude fat content	% Crude fibre content	% Carbohydrate content
Control	1.39 ± 0.00^a	0.89 ± 0.00^a	5.12 ± 0.01^a	0.98 ± 0.01^f	25.75 ± 0.01^f	65.95 ± 0.02^e
Day4	2.22 ± 0.00^b	1.24 ± 0.01^b	6.56 ± 0.01^b	0.94 ± 0.00^e	22.04 ± 0.02^e	66.95 ± 0.02^f
Day8	5.46 ± 0.01^c	3.67 ± 0.01^d	11.53 ± 0.01^f	0.77 ± 0.01^d	20.06 ± 0.01^c	58.57 ± 0.02^b
Day12	8.01 ± 0.01^d	2.85 ± 0.01^c	8.77 ± 0.01^e	0.58 ± 0.01^c	20.89 ± 0.01^d	58.99 ± 0.01^d
Day16	9.49 ± 0.01^e	3.79 ± 0.02^e	8.39 ± 0.01^d	0.43 ± 0.01^b	19.74 ± 0.02^b	58.72 ± 0.01^c
Day 20	10.42 ± 0.01^f	4.62 ± 0.02^f	8.15 ± 0.01^c	0.35 ± 0.01^a	19.42 ± 0.01^a	57.08 ± 0.01^a

Table 1: Proximate composition of millet cobs.

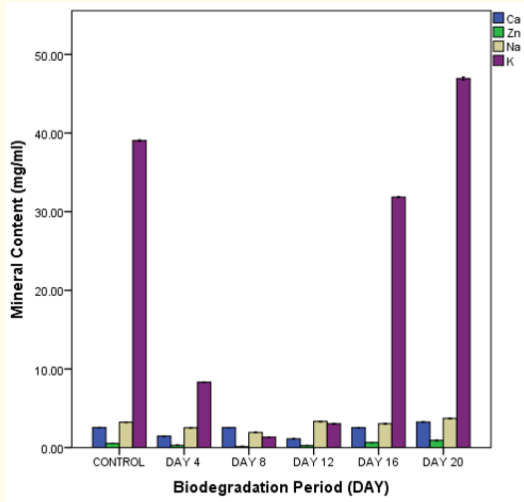

Figure 1: Mineral content of millet cobs.

Anti-nutrients analysis on the biodegraded and control samples presented in Table 2. Reduction of saponin on Day 4 was found in biodegradation period, while it was increased gradually from Day 8 to Day 20 thereafter. Phytate was gradually reduced from Day 4 to Day 16 but increased in Day 20.

Anti-nutrients	Control	Day 4	Day 8	Day 12	Day 16	Day 20
TANNIN (mg/g)	1.31 ± 0.01[a]	3.73 ± 0.08[b]	3.83 ± 0.01[c]	5.12 ± 0.01[d]	5.61 ± 0.01[e]	6.65 ± 0.03[f]
SAPONIN (mg/g)	29.82 ± 0.18[c]	5.09 ± 0.18[a]	8.73 ± 0.18[b]	52.09 ± 0.27[d]	76.05 ± 0.07[e]	102.90 ± 0.55[f]
PHYTATE (mg/g)	15.66 ± 0.82[c]	9.48 ± 0.41[b]	6.59 ± 0.00[a]	5.36 ± 0.41[a]	5.29 ± 0.00[a]	5.77 ± 0.00[a]

Table 2: Anti-nutrient composition of millet cobs.

Discussion

The increase in moisture content as the biodegradation period can be attributed to intake water known as imbibition process and this encouraged the growth of microorganisms particularly bacteria thereby using the nutrients in the millet cobs, resulting in nutrient depletion [6].

High moisture content recorded in this study due to inlet of water in the biodegradation process that enabling the microorganisms to growand enhanced them to use nutrients from the millet cobs [6,13]. It can be as Lipase production by microorganisms caused an effect on fat content and hydrolyzed the fat in the millet cobs [14], thus, the higher the lipase activity, the lower the fat content. High ash content observed in the biodegraded product might be as a result of rational quantity of minerals poduction during metabolism by microorganisms [15] in biodegradation period that was evident as increased some minerals in this process.

The highest fibre content was observed in control that can be characterized with the presence of cellulose, hemicellulose, lignin and pectin [16-19]. The progressive reduction in fibre was found due to the biodegradation process while, carbohydrate including cellulose, pectin, lignocelluloses and starch were broken down by biodegrading microorganisms [6]. These microorganisms used them as their carbon source converted it to metabolites in reducing the fiber content of the sample [20]. Reduction in fibre content could also be attributed to production of various lignocelluloses enzymes such as cellulase, pectinase, amylase, protease and lipase by the biodegrading microorganisms [21].

Secretion of proteinases such as protease into biodegradation medium which will facilitate the breakdown and subsequent metabolism of proteins for amino acid might be the reason for increasing protein (nitrogen) content of the samples. Structural proteins as a pivotal composition of microbial cells of organisms involved in the biodegradation process [22]. Reduction of carbohydrate in biodegradation process was observed. As a result, utilization of sugar and its conversion particularly in the production of alcohol and organic acids generated energy for cell metabolism during biodegradation, and enhanced microbial growth [6]. Increase in carbohydrate as observed in Day 4, in this case, it could be as a result of most of the microorganisms such as *Saccharomyces cerevisae*, *Candida*spp, *Aspergillus*spp, Lactic Acid Bacteria involved in the fermentation and will produce metabolites as carbohydrates [6]. Arogunjo and Arotupin [8] isolated *Macrococcuscarouselicus* strain H8B16*, Bacillus subtilis* strain b17a*, Bacillus licheniformis* strain ZULMMI012*, Bacillus cereus* strain FORC60*, Flavobacteriunferrugineum, Lactobacillus brevis*strain 14.8.28*, Lactococcus lactis* subsp. lactis strain Mast_19*, Candida albicans* strain h70b, *Saccharomyces cerevisiae* strain K289-3A, *Rhodotorulamucilaginosa* strain G20, *S. cerevisiae* strain BY4742, *Kluyveromycesmarxianus* strain GX-15, *Aspergillus fumigatus, A. flavus, A. candidus, Rhizopusstolonifer, Fusariumpoae* and *Scopulariopsisbrevicaulis* from millet cob samples. Hydrolysis of starch into glucose, lactose, fructose and other sugars by microorganisms was led to increase carbohydrate content as reported [23].

The presence of the antinutrients (tannin, saponin and phytate) in millet cobs was agreed with the observation of documentations of Hostettmann and Marston [24], Katie., *et al*. [25], Vikas., *et al*. [26] and different findings showed that these anti-nutrients were found in plant in varying concentration. The amount of phytate in the control sample exhibited highest and it can be extracted from undegraded millet cob which has arrays of industrial importance and able to reduce blood clots, cholesterol and triglycerides, and prevents heart diseases [26,27]. Phytate also served as anticancer, antioxidant and antidiabetic agent which were supported [28-31]. The presence of *Lactococcuslactis*and *Lactobacillus brevis*, both lactic acid bacteria maybe responsible for the reduction in the phytate content as the biodegradation progressed in accordance with the documentation of Reddy [33]. The reduction of phytate content helps in the absorption of nutrients particularly this may be, mixture of millet cob with varying proportion in feed constituent as food for animal as reported [34,35] that the presence of phytate in the human diet marked negative effect on mineral uptake. Vikas., *et al*. [26] also reported that the phytate reduced the digestibility of protein and produced more protein, while phytatewas reduced. Reduced phytate increased bioavailability of blood glucose. Lee., *et al*. [36] supported that phytate intake reduced the blood glucose response. It was also acknowledged that phytate-Ca^{2+} complex, inhibits amylase activity [37].

The progressive increase in tannin content might be the presence of fungi isolated from the millet cob and produced tannase (tannin acyl hydrolse, E.C.3.1.1.20) particularly by fungi could be responsible for the progressive increase in tannin content [38]. Belur and Mugeraya [39] acknowledged *Penicillium* spp as a producer of tannase. Aguilar., *et al*. [40] and Renovato., *et al*. [41] in their different findings of *Aspergillus* spp to be the best producer of tannase. *Aspergillus* spp were isolated during biodegradation period might be responsible for increased tannin production. Liquid substrate fermentation may also contribute to increased tannin content which biochemical reaction may not be facilitated for the production of bye-product such as tannic acid [42,43]. Submerged fermentation was in turn a good method for tannin production particularly in millet cobs. Prolonged biodegradation period led to more tannin production. Biodegraded millet cobs could serve a source of tannin which can be used for industrial production such as wine, juice, coffee, beer and chocolate liquor production which were supported [44-46].

L-arabinose, D-xylose, Dglucose, D-glucuronic acid, D-galactose, Lrhamnose and D-fructose were among the sugars constituents of saponins [47] and the degradation of these sugars could lead to the reduction in saponin content on Day 4, hence, four day of degradation is sufficient to reduce the saponin content of millet cobs to the barest minimum. Saponins were glycosylated compounds which composed of two main parts: a water soluble glucidic chain and a liposoluble structure [47,48]. The increase in saponin content from Day 8 to 20 might be due to distortion in the structure of saponin caused by the microorganisms made it porous that allowed the percolation of water into the saponin of the millet cobs particularly into water soluble glucidic chain. Hence, high amount of saponin content for industrial purposes such as adjuvants in vaccines [49] dietary supplements and food ingredients [50] can be extracted from biodegraded millet cobs.

The presence of sodium, potassium, calcium and zinc were observed to agree with the separate findings of Itagi [51] and Dayakar [4]. Itagi [51] reported that kodo millet was rich in minerals such as calcium, iron, potassium, magnesium and zinc. Dayakar [4] studied will be that millet whole grains are good sources of magnesium, iron, zinc, and copper and also will be stated that sorghum, a type of millet is considered a good source of potassium and practically devoid of sodium. This might be responsible for the high amount of potassium as against the low amount of sodium. Flunctuation in mineral composition of the millet cob samples could be due to degradation microbial microorganisms which led to the release and assimilation of minerals respectively [52].

Conclusion

Biodegradation of millet cobs at between Days 4 and 8 helps to improve its nutritional value, as it has been demonstrated to improve the protein content, fiber level, ash and mineral elements like calcium, sodium, potassium and zinc. It has also observed to reduce the level of some anti-nutrients like saponin, phytate and tannin. Hence, its usage as an animal feed has been improved. Millet cobs as a substitute for feed fortification will help to minimize pollution which is of environmental concerns. Studies should be carried out for further improvement on the nutritional and anti-nutritional composition of millet cobs.

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