Apparent Digestibility and Nitrogen Utilization by Red Sokoto Goats fed Brewer's Dried Grains and Malted Sorghum Sprouts in Complete Diets

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Abstract

Forage shortage, especially, during the dry periods has caused a major setback in the development of ruminants; hence, the need to source for by-products like brewer's dried grains (BDG) and malted sorghum sprouts (MSP), which are produced in large quantities during brewing. The apparent digestibility and nitrogen utilization were evaluated using Red Sokoto (RS) goats fed BDG and MSP as complete diets. The trial was conducted in a completely randomised design. Four diets (T1, T2, T3 and T4) were formulated to contain proportions of BDG and MSP in the ratios of 40:10, 30:20, 20:30 and 10:40 respectively with Andropogon tectorum (AT) hay meal fixed at 31% to form complete diets. Twelve RS bucks weighing between 12 and 15 kg live weights (LW) were selected and transferred into separate metabolism crates. Three (3) bucks constituted a treatment with one (1) buck per replicate. Samples of the test ingredients, diets and feaces were analysed for proximate compositions and energy while the urine samples were collected and analysed for nitrogen (N). The results showed that BDG, MSP and AT hay meal contained; 91.90, 89.72 and 91.34% dry matter (DM); 18.22, 23.20 and 13.27% crude protein (CP); 13.95, 9.62 and 26.90% crude fibre (CF); 3.92, 5.52 and 3.15% ether extract (EE); 45.46, 48.19 and 40.18% nitrogen free extract (NFE); 6.35, 3.19 and 7.84% ash and 1.72; 1.79 and 1.65 MJ/kg energy. Dietary treatments T1, T2, T3, T4 contained 15.60, 16.10, 16.59 and 17.09% CP and 1.66, 1.68, 1.68 and 1.70 MJ/kg energy, respectively. Except for CF, all the nutrients evaluated for apparent digestibility differed (P<0.05). T1, T2, T3 and T4 recorded 75.23, 62.41; 82.55, 69.38; 85.50, 68.03 and 87.76, 68.54% for CP, Energy respectively. The mean LW, dry matter intake (DMI), N-intake, Absorbed-N and N-balance were statistically unaffected (P>0.05) while DMI as % of live weight, N-feaces, N-urine and Apparent-N-digestibility varied (P<0.05). DMI as % of LW were 3.22, 2.61, 2.56 and 2.68, N-feaces (g/d) values were; 3.15, 1.89, 1.65 and 1.57 while N-urine (g/d) were; 2.34, 2.14, 1.97 and 1.63 respectively for T1, T2, T3 and T4. It was concluded that the diets promoted the performance of RS bucks in respect to the parameters studied.

Keywords: digestibility, nitrogen, goats, andropogon, sorghum

Digestibilité apparente et utilisation de l'azote par les chèvres Red Sokoto alimentées avec des drêches de brasserie séchées et des germes de sorgho malté dans des régimes complets

Résumé

La pénurie de fourrage, surtout pendant les périodes sèches, a causé un recul majeur dans le développement des ruminants ; d'où la nécessité de trouver des sous-produits comme les drêches de brasserie séchées (DBS) et les germes de sorgho malté (GSM), produits en grandes quantités lors du brassage. La digestibilité apparente et l'utilisation de l'azote ont été évaluées en utilisant des chèvres Red Sokoto (RS) alimentées avec des DBS et des GSM comme régimes complets. L'essai a été réalisé selon un plan complètement aléatoire. Quatre régimes (T1, T2, T3 et T4) ont été formulés pour contenir des proportions de DBS et de GSM dans les ratios de 40:10, 30:20, 20:30 et 10:40 respectivement, avec de la farine de foin d'Andropogon tectorum (AT) fixée à 31% pour former des régimes complets. Douze mâles RS pesant entre 12 et 15 kg de poids vif (PV) ont été sélectionnés et transférés dans des caisses de métabolisme séparées. Trois (3) mâles constituaient un traitement avec un (1) mâle par réplique. Des échantillons des ingrédients testés, des régimes et des fèces ont été analysés pour les compositions *proximales et l'énergie, tandis que les échantillons d'urine ont été collectés et analysés pour l'azote (N). Les résultats ont montré que les DBS, GSM et la farine de foin AT contenaient respectivement ; 91,90, 89,72 et 91,34% de matière sèche (MS); 18,22, 23,20 et 13,27% de protéines brutes (PB); 13,95, 9,62 et 26,90% de fibres brutes (FB); 3,92, 5,52 et 3,15% d'extrait éthéré (EE); 45,46, 48,19 et 40,18% d'extrait sans azote (ESA); 6,35, 3,19 et 7,84% de cendres et 1,72; 1,79 et 1,65 MJ/kg d'énergie. Les traitements alimentaires T1, T2, T3, T4 contenaient respectivement 15,60, 16,10, 16,59 et 17,09% de PB et 1,66, 1,68, 1,68 et 1,70 MJ/kg d'énergie. Sauf pour la FB, tous les nutriments évalués pour la digestibilité apparente différaient (P<0,05). T1, T2, T3 et T4 ont enregistré respectivement 75,23, 62,41; 82,55, 69,38; 85,50, 68,03 et 87,76, 68,54% pour la PB, l'énergie. Le PV moyen, l'ingestion de matière sèche (IMS), l'ingestion de N, le N absorbé et le bilan de N n'ont pas été statistiquement affectés (P>0,05) tandis que l'IMS en % du poids vif, le N des fèces, le N de l'urine et la digestibilité apparente du N variaient (P<0,05). L'IMS en % du poids vif était de 3,22, 2,61, 2,56 et 2,68, les valeurs de N des fèces (g/j) étaient ; 3,15, 1,89, 1,65 et 1,57 tandis que le N de l'urine (g/j) était respectivement de 2,34, 2,14, 1,97 et 1,63 pour T1, T2, T3 et T4. Il a été conclu que les régimes ont amélioré les performances des mâles RS par rapport aux paramètres étudiés.*

Mots-clés : digestibilité, azote, chèvres, andropogon, sorgho

Apparent digestibility and nitrogen utilization by Red Sokoto goats

Introduction

The rainforest constitutes a dense source of forage resources for the improvement of ruminant animal production in the zone. However, the number, species and breeds of ruminants in the zone are limited due to the quality and seasonality of the forage resources, pest and disease infestations as well as the rapid urbanization which has reduced the availability of land for forage production. There is scarcity of fodders, especially, during the critical dry periods when their nutritive values are poor. The search for and interest in the use of unconventional and less expensive feed ingredients to mitigate the feed scarcity (Odeyinka *et al*., 2003) has prompted many researchers to investigate the level of acceptability of these alternative feed ingredients for feedlot practices. Among these feed resources are the brewer's dried grains (BDG) and malted sorghum sprouts (MSP) that are by-products resulting from the industrial processing of grain seeds into food and beverages.

Brewer's grain is the material that is remaining after the fermentation of grains during the beer making process (Jovanka *et al*., 2010) which could be used in the wet or dried forms (BWG or BDG respectively). The BDG is an excellent source of quality by-pass protein and digestible fibre, with a good amino acid profile and high mineral and B-Vitamin contents (Ironkwe and Bambgose, 2012). According to National Research Council (1989) BDG is generally sought for their higher content of undegraded intake protein while Adebowale and Ademosun (1981) reported that the idea of feeding BDG arose from the desire to investigate cheap and alternative feed for livestock.

The MSP on the other hand is a by-product of the sorghum malting process (Oduguwa *et al*., 2006). It is turned out in large quantities by breweries, food and allied industries (Ikediobi, 1989), making it a prospective feed resource for the livestock industry. The level of acceptability, digestibility and nitrogen utilization by RS goats were evaluated in this study using varying proportions of these two industrially processed by-products in order to see how the problem of poor nutrition occasioned by shortage of fodder for goat production could be ameliorated.

Materials and methods

Location of experiment

The experiment was conducted in the Sheep and Goat Unit of Michael Okpara University of Agriculture, Teaching and Research Farm, Umudike. Umudike is in Ikwuano L.G.A of Abia State, Nigeria.

Experimental animals and their management

Twelve intact Red Sokoto (RS) bucks aged 10-12 months and weighing between 12-15 kg were used in this experiment. The goats were supplied from the Sahel agro-ecological zone by a major ruminant livestock dealer in Obinze, along Owerri-Port Harcourt Express Way, Imo State, Nigeria. On arrival, they were put in a thoroughly sanitized house for a 21-day quarantine. Initially, the animals were fed the original feeds they were used to in their natural environment. These comprised of groundnut vines and wheat offal. Gradually, components of the experimental diets were introduced. Water was also provided ad-libitum. Prophylactic treatment of the bucks included the injection of long-acting oxytetracycline intramuscularly at the rate of 0.10 ml/kg body weight repeated 48 hours later. Levamisole injection was administered subcutaneously (s/c) at the rate of 1 mL per buck to control endo-parasites while ivermectin injection given s/c was used to manage common ecto-parasites. PPR vaccine was given s/c at the rate of 1 mL per buck on the 15th day of the 21-day quarantine.

Experimental diets

Four diets as shown in Table 1 were formulated and mixed from the following ingredients: *Andropogon tectorum* (AT) hay meal, BDG, MSP, Palm Kernel Cake (PKC), molasses, bone meal and common salt. 250g of vitamin-mineral premix was added per 100kg of each diet in order to take care of the micro-nutrient needs of the goats. The grass hay used in this study was processed from AT harvested from uncultivated lands around Ahuwa-Oboro in Ikwuano Local Government Area, Abia State, Nigeria. The grass was cut between September – October, chopped into 3 cm length and sun dried for 5-7 days. The method of cutting and chopping ensured maximum reduction of the grass stem. The dried grass was later ground in a local mill to form AT hay meal. This was thoroughly mixed together and stored in an air proof condition until required for feed mixing. Other ingredients were procured from livestock feed dealers in Umuahia and Aba, Abia State.

Processing of Malted Sorghum Sprouts (MSP)

According to Fafiolu *et al*. (2006), malt is extracted from germinated sorghum seeds and the residue consists of sorghum shoots and roots. The left over shoots and roots are called malted sorghum sprouts (MSP). Aletor *et al.* (1998) opined that the malting process involves soaking of cereal grains (in this case, sorghum) for 24-48 hours under controlled conditions of moisture, aeration and temperature. The grains are transferred to an aseptically cleaned malting floor; then allowed to germinate for 3-5 days. The resulting green malt is dried in a rotary dryer at a temperature of 70°C. The dried friable malt is mechanically agitated to free the roots and the shoots which are subsequently separated through screening.

Table 1: Composition of the experimental diets (%)

Ingredient	T1	T2	T3	T4
Andropogon tectorum hay meal	31	31	31	31
Brewers Dried Grain	40	30	20	10
Malted Sorghum Sprout	10	20	30	40
Palm Kernel Cake	10	10	10	10
Molasses	5	5	5	5
Bone Meal	3	3	3	3
Common Salt	1	1	1	1
Total	**100**	**100**	**100**	**100**

Digestibility studies

The twelve bucks were transferred into individual metabolism crates constructed as described by Ibeawuchi and Tula (1991) to provide maximum comfort for the animals. The design of the crates enabled separate collection of feaces and urine. Feed and water were offered ad-libitum and provided in enclosures attached to the crates such that the animals consumed the diets as in a normal pen condition. They received a known quantity of feed daily at two feeding periods (08.00 am and 02.00 pm). The feeds offered were adjusted according to weekly body weight changes and rate of feed intake of the bucks over a 28-day period. This method of feeding ensured at least 10% left-over of the previous day feed in the feeders. A 21-day preliminary feeding was followed by a 7-day total collection (feaces and urine). Feed refusals were collected and weighed to determine daily feed intake by difference before the next feeding. Total feacal and urine collection for the 7 days were weighed and measured in the morning before the next feeding and watering. Urine was collected in a plastic container placed under the crates to which 10 mL of concentrated Sulphuric acid (H_2SO_4) was added. This was done to reduce nitrogen loss by ammonia volatilization. Feaces and urine collected were bulked together according to the treatments and replicates for the 7 days' collection, stored in a refrigerator for analyses. Individual weekly weighing of the animals was done in the morning. Live weight changes were determined as the difference between the initial and final weight of the bucks.

Chemical analyses

Feed from the four diets and feaces sampled from the bulked per replicate per treatment were analysed according to official methods (AOAC, 2006) for dry matter (DM %), crude protein (CP %), crude fibre (CF %), ether extract (EE %) and Ash %. Urine nitrogen was also determined by AOAC (2006) methods. Nitrogen Free Extract (NFE) in feed and feaces was calculated using the formula: NFE% = DM – (%CP + %CF + % EE + %Ash) while feed and feacal energy were evaluated according to MAFF (1977).

Statistical analysis

The data were subjected to analysis of variance (ANOVA) in CRD using SPSS base for windows while the treatment means showing statistical differences at a probability of 5% were compared using the Duncan's multiple range procedures of the same package.

Results and discussion

Table 2 shows the nutrient profiles of the major ingredients used in diets formulation as well as the experimental diets while Table 3 presents the coefficients of apparent nutrient digestibility by RS goats fed the four diets. The coefficients of digestibility for all nutrients evaluated were affected ($P<0.05$) by dietary treatments except crude fibre (CF). Dry matter (DM) digestibility was significantly lower ($P<0.05$) in T1 but similar ($P>0.05$) in the other 3 groups. Crude protein (CP) digestibility differed ($P<0.05$) across the four (4) groups while ether extract (EE) and energy digestibility followed the same pattern as DM whereas nitrogen free extract (NFE) coefficients were similar ($P>0.05$) in T1, T3 and T4 but differed ($P<0.05$) between T1 and T2.

Table 2: Nutrient compositions of diets and major ingredients used in diet formulation

Parameters (%DM)	Diets				BDG	MSP	AT
	T1	T2	T3	T4			
Dry matter	92.23	91.67	91.48	91.38	91.90	89.72	91.34
Crude protein	15.60	16.10	16.59	17.09	18.22	23.20	13.27
Crude fibre	17.57	16.74	15.91	15.08	13.95	9.62	26.90
Ether extract	2.87	2.89	3.12	3.19	3.92	5.52	3.15
Nitrogen free extract	48.32	49.35	49.42	50.29	45.46	48.19	40.18
Ash	7.87	6.59	6.44	5.73	6.35	3.19	7.84
Energy (MJ/kgDM)	1.66	1.68	1.68	1.70	1.72	1.79	1.65

BDG: Brewer's dried grains, MSP: Malted sorghum sprouts, AT: *Andropogon tectorum* hay meal

Table 3: Apparent nutrient digestibility coefficients by RS goats fed BDG and MSP in complete diets

Parameter %	Diets				SEM
	T1	T2	T3	T4	
Dry matter	56.76^{b}	63.63^{a}	62.58^{a}	62.77^{a}	1.09
Crude protein	75.23^{d}	82.55^{c}	85.50^{b}	87.76^{a}	1.45
Crude fibre	60.56	65.40	62.83	61.39	0.88
Ether extract	81.91^{b}	85.45^{a}	87.06^{a}	87.47^{a}	0.72
Nitrogen free extract	55.11^{b}	62.97^{a}	59.91^{ab}	59.68^{ab}	1.14
Energy	62.41^{b}	69.38^{a}	68.03^{a}	68.54^{a}	1.02

^{a,b,c,d} means on the same row with different superscripts are significant (P<0.05)
SEM: Standard error of mean

Nitrogen balance and utilization by the RSGs subjected to the 4 dietary treatments are presented in Table 4. Dry matter intake (DMI) as % of live weight (LW), crude protein (CP) output (g/d), nitrogen in feaces (g/d), nitrogen in urine (g/d) and apparent nitrogen digestibility were affected (P<0.05) by dietary treatments. The other parameters evaluated were statistically unaffected (P>0.05) by the diets offered. DMI as % of LW was similar (P>0.05) in T2, T3 and T4 and also between T1 and T4 but differed (P<0.05) between T1 and T2 or T3. CP output was statistically higher (P<0.05) in T1 but similar (P>0.05) in the other three treatments. Nitrogen in feaces followed the same trend as CP output whereas nitrogen in urine were similar (P>0.05) in T1, T2 and T3 but differed (P<0.05) between T1 and T4. Apparent nitrogen digestibility varied (P<0.05) across the four treatment means.

Table 4: Nitrogen balance and utilization by RS goats fed BDG and MSP in complete diets

Parameters	Diets				SEM
	T1	T2	T3	T4	
Mean live weight (kg)	14.67	14.75	15.33	16.00	0.30
Mean live weight (kgw$^{0.75}$)	7.49	7.53	7.75	8.00	0.12
DMI (g/d)	473.82	385.30	391.86	428.78	17.50
DMI (g/d/kgw$^{0.75}$)	101.25	86.94	88.07	94.18	2.85
DMI (as % LW)	3.22^{a}	2.61^{b}	2.56^{b}	2.68^{ab}	0.11
CP intake (g/d)	80.14	67.67	71.06	80.19	2.91
CP output (g/d)	19.70^{a}	11.84^{b}	10.30^{b}	9.80^{b}	1.29
N-intake (g/d)	12.82	10.83	11.37	12.83	0.47
N-faeces (g/d)	3.15^{a}	1.89^{b}	1.65^{b}	1.57^{b}	0.21
N-urine (g/d)	2.34^{a}	2.14^{ab}	1.97^{ab}	1.63^{b}	0.12
N-absorbed (g/d)	9.67	8.94	9.72	11.26	0.40
N-Balance (g/d)	7.33	6.80	7.75	9.63	0.48
N-intake (g/d/kgw$^{0.75}$)	6.75	5.97	6.19	6.78	0.19
N-absorbed (g/d/kgw$^{0.75}$)	5.46	5.17	5.51	6.14	0.17
N-balance (g/d/kgw$^{0.75}$)	4.41	4.21	4.64	5.46	0.22
AND(%)	75.23^{d}	82.58^{c}	85.51^{b}	87.74^{a}	1.45

^{a,b,c,d} means on the same row with different superscripts are significant (P<0.05)
SEM: Standard error of mean, DMI: Dry matter intake, CP: Crude protein, N: Nitrogen,
AND: Apparent Nitrogen Digestibility

The nutrient constituents of the BDG varied from the values obtained elsewhere (Aduku, 1993; Keshab and Randy, 1998). The dry matter (DM), crude fibre (CF), ether extract (EE) and ash contents were similar to the values obtained by Ironkwe and Bamgbose (2012) while the crude protein (CP) and nitrogen free extract (NFE) levels were different from the figures given by the same authors. Jovanka *et al*. (2010) explained that the nutrient content of brewer's grain will vary from plant to plant and depending upon the type of substrate (barley, wheat, corn, etc.), extent of fermentation and the type of fermentative process. Since brewer's grain used in the study was in the dried form, the method and extent of drying could have also contributed to the variations in the nutrient composition.

The MSP used in the study has higher DM content than the value in the product reported earlier (Fafiolu *et al*., 2006; Oduguwa *et al*., 2006) but compared favorably with the value of 92.84% reported by Adekanbi *et al*. (2020). The CP content is similar to the CP value presented by the same authors and those of Aning *et al*. (1998) and Akinola (2002). A higher CF content was recorded in the present study as against 46.7g/kg and 48.1g/kg CF representing 4.67% and 4.81% respectively, obtained by Fafiolu *et al*. (2006) and Oduguwa *et al*. (2006). However, Oduguwa *et al*. (2001) obtained 83.0g/kg (8.30%) CF close to the value of 9.62% obtained currently. The CF in MSP could be influenced by the amount of the lignin in the shoots and roots formed during the germination process and the rate at which the germination proceeds before drying. EE and ash values also differed from the content of these nutrients reported by earlier workers. Disparities in the nutrient composition of MSP and those of earlier workers could be accounted for by the species differences of the sorghum used for the malting.

The DM of AT hay was within the value of 900g/kg DM described as good (Frame, 1992). This was achieved through particle size reduction of the leaves, thin spread of the chopped forage under the sun and regular turning. Moreover, the processing of the hay was carried out on sunny days. The CP value was slightly higher than the values reported for the same forage (Mecha and Adegbola, 1980; Obua, *et al*., 2012; Aderinola *et al*., 2013,) and). However, the CP was close to the value of 150g/kg DM representing 15.0% suggested as good (Frame, 1992). The CF content fell within the middle range of 24.62% and 29.30% reported by Obua *et al*. (2012) and Mecha and Adegbola (1980). The EE and ash values were slightly higher in the present AT compared to the values reported earlier while NFE value was far below 60.0% given by Aderinola (2011) but close to 43.57% presented by Obua *et al*. (2012). The differences in the nutrient composition of AT hay used in the study as compared to the earlier results could be attributed to the methods of processing used, periods of growth (wet or dry season) or harvesting of the forage plant (Ajayi, 2012). In addition, the nutrient profile of the soil where the forage was harvested, the geographical location as well as rate of H_2O and nutrient uptake by the forage plant could be responsible for the variations in the compositions.

The DM contents of the diets increased as the level of BDG increased across the diets. This was expected since the BDG used in the diets had higher DM than MSP. Similarly, there was a corresponding increase in CP contents of the diets from T1-T4 as a result of proportional increase in the level of MSP. MSP had a higher CP content than BDG. The same trend was observed for the other nutrients in the diets except crude fibre and ash; though the differences were not too pronounced. The diets had sufficient protein and energy to support the growth, maintenance and general performance of a growing small ruminant.

The significantly lower DM digestibility in T1 in spite of increased DMI of the diet was as a result of corresponding increase in output of DM by the affected animals. The reduced DM digestibility as against increased DM intake is in line with the findings of McDonald *et al*. (1995) that DM digestibility is negatively correlated with DM intake. The non-significant relationship in DM digestibility in the other three treatments could be attributed to better retention of DM consumed by the bucks as the level of MSP increased.

CP digestibility which appreciated as the level of MSP in the diets increased was demonstrated by the statistical variance across the four treatment means. This was expected as the MSP used in this study was richer in CP than BDG. Similar trend was observed in WAD sheep fed up to 15% MSP (Oduguwa *et al*., 2006). The authors had implicated increased microbial protein synthesis to MSP supplementation in sheep. Also, D'Mello, (2000) reported that moderate levels of tannin (30 – 40g/kg) resulted in nutritional advantages in respect to increased by-pass protein availability and bloat suppression in cattle. MSP has been reported in literature to contain tannin (Aning *et al*., 1998; Saka *et al*., 2017)

Similarity in CF digestibility could be attributed to the 31% fixed level of inclusion of AT hay meal across the four dietary treatments which supported fibre fermentation by cellulolytic organisms.

Patterns of digestibility of EE, NFE and energy were similar to the digestibility of DM. It could be deduced that the factors that affected DM digestibility affected these nutrients since they are also components of the DM.

Generally, the digestibility coefficients were enhanced by the treatments; an indication that the inclusion levels of BDG and MSP in the diets supplied adequate nitrogen to sustain the activities of rumen microbes which improved the nutrients digestibility of the goats (Fajemisin *et al*., 2008). Saka *et al*., (2020) observed improved nutrients digestibility in goats fed alkaline treated MSP.

DMI expressed as % of LW in T1 exceeded the maximum 3% DM intake for meat goats in the tropics (Devendra and Mcleroy, 1982) as against the dry matter intake in the other treatment groups. The reduced DMI as the level of MSP increased could be as a result of the tannin content in the product (Oduguwa *et al*., 2006). Tannin has been reported to have bitter taste (Isikwenu and Bratte, 1999). The observed enhanced growth of the bucks that consumed below 3% DM as LW would have resulted from increased nitrogen intake and reduced nitrogen output as well as enhanced DM digestibility recorded. This shows that DMI by animals for growth partly depends on the level, intake and utilization of other nutrients in the diet.

Increased nitrogen intake by RSG on T1 promoted significantly higher ($P<0.05$) nitrogen output indicating poor biological value of the protein in the diet. This was further shown by the higher urinary nitrogen outputs by the affected animals. Decandia *et al*. (2011) observed positive relationship between total nitrogen excretion/DMI, urinary nitrogen excretion/DMI and dietary CP in sheep and goats at all physiological states.

The positive non-significant nitrogen balance demonstrated by the bucks clearly depict that the requirements of the animals for body maintenance and growth were met by the diets. Apparent nitrogen digestibility values were similar to CP digestibility.

Conclusion

The various proportions of BDG and MSP in combinations with *Andropogon tectorum* hay meal in the diets were observed to promote the nutrient digestibility and nitrogen utilization by RS goats across the treatments. This is an indication that exploring these agro by-products as supplements to declining forage availability and quality in order to improve the productivity of ruminants could ameliorate problems of nutrition in goats.

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