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DRY MATTER AND PROTEIN DEGRADABILITIES OF SOME FEED INGREDIENTS SOLD IN ABEOKUTA, OGUN STATE, NIGERIA

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ABSTRACT

A study was carried out to determine the chemical composition and evaluate the dry matter and crude protein degradabilities of some commercial feed ingredients sold in Abeokuta, Nigeria, viz corn offal, brewers dried grain, soybean meal, wheat offal, groundnut meal and maize meal. The feed samples as obtained from different sources were incubated in triplicates for 6, 12, 24, 36, 48, 72 and 96 hours in 3 rumen-fistulated goats. The incubation was used to estimate the *in sacco* dry matter (DM) and N degradation characteristics. The dry matter contents of the feedstuffs ranged from 799.3 – 956.0 g/kg. All the feedstuffs recorded low crude protein contents and high washing loss at 0 hour. They recorded more than 70% dry matter degradability at 48 hours, which implied that they were all highly degradable in the rumen. Feeding these feedstuffs in large quantities terminants may lead to diarrhea and bloat due to the accumulation of methane and ammonia gases in the rumen. However, their incorporation into high fibre diets may be advantageous in supplying rumen degradable nutrients to complement the undegradable dietary nutrients from fibrous feeds.

Keywords: Degradable nutrients, dry matter, feed ingredients, goats and undegradable nutrients.

INTRODUCTION

Ruminant animals are traditionally reared on feeds like straw, stover and pasture hay. These feed resources are fibrous and deficient in some essential nutrients and this informed the supplementation of concentrate rations to ruminant animals (Van Soest, 1994). It has, however, been observed that the returns from sole feeding of such concentrate supplements to ruminant animals does not always justify their cost contrary to what obtains in non – ruminant species (NRC, 1985).

A good understanding of ruminant digestive system and their nutrient requirements is necessary for efficient utilization of concentrates by ruminant animals in their complex gastrointestinal tracts (GIT). This will help in matching the available feed resources with production needs of different classes of animals and thereby reducing the cost of feeding.

According to Van Soest (1994), two critical sites have been identified in ruminant GIT for nutrient digestion. The first site is the rumen, where fermentation of feeds takes place. The nutrients released here are known as rumen degradable nutrients (RDN). They are used mainly for microbial multiplication while the excess is excreted in the urine and through eructation as gases (Van Soest, 1994). The second site is the abomasum or the true stomach where enzymatic digestion takes place. Nutrients released here are known as undegradable dietary nutrients (UDN). They are used by the body for tissue synthesis and other metabolic functions (Dewhurst *et al*., 2000). Ruminant feeds should therefore, consist of both the RDN and UDN for efficient metabolism and utilization. Feeds that are rich in only RDN will not produce enough nutrients for tissue synthesis, since most of its nutrients are released in the rumen (Cabrita *et al*., 2006). This results in gas accumulation in the rumen and wastage of such gases through eructation. If feed ingredients contain mainly UDN, most of the nutrients will escape microbial fermentation in the rumen and become only available in the hind gut. Consequently, the population of rumen microbes will be depleted leading to inefficient degradation of feeds, reduction in rumen pH and in extreme cases, death of the animal (ARC, 1980).

The screening of ruminant feed resources especially concentrates to identify the level of RDN and UDN in each feedstuff as undertaken in this study is imperative to improved ruminant production through better understanding of supplementation regime for such feedstuffs.

MATERIALS AND METHODS

The study was carried out at the International Livestock Research Institute (ILRI) farm located at the International Institute of Tropical Agriculture (IITA), Ibadan. Three West African Dwarf Goats fitted with permanent cannula were used. They were allowed to graze *Panicum maximum* and *Stylosanthes guianensis* pasture supplemented with corn offal. Clean water and salt lick were given to the animals *ad libitum.* Samples of six feed *ingredients* namely: maize offal (MO), brewers dried grain (BDG), soybean meal (SBM), wheat offal (WO), groundnut meal (GNM) and maize meal (MM) were obtained from feed depots and distributors in Abeokuta metropolis. They were oven dried at 65^{o}C for 48 hours to remove residual moisture and then ground with hammer mill with a 2.5cm sieve.

Five grams of three replicate samples of each feed ingredient were weighed into nylon bags of size 9 x 18cm and mesh size 41µm (Polymon, Switzerland). Each bag was attached to plastic tubes with the aid of rubber band and well labelled for easy identification. The bags were incubated for 6, 12, 24, 36, 48, 72 and 96 hours inside the rumen of the fistulated goats. The zero time disappearance was estimated by soaking two bags of each feed ingredient in warm water at 37^{o}C for 30 minutes. All the bags were withdrawn at the end of their respective incubation periods, thoroughly washed under tap water until the rinse water was clear. They were arranged on metal trays and transferred into the oven to dry at 65^{o}C for 48 hours. Dried weight of each sample was later taken and used to estimate the dry matter (DM) losses. The 3 samples for each incubation hour were bulked, reground and used for nitrogen analysis (AOAC, 1995). The CP was calculated as N x 6.25. Potential degradabilities (P) of DM and CP were calculated using NEWAY model of McDonald *et al*., (1988);

$P = a + b(1 - e^{-ct})$ where;
a = Water soluble fraction
b = Insoluble but fermentable fraction in time't'
e = Exponential sign.
c = Degradation constant of the fermentable fraction.
t = Degradation time 6, 12, 24, 36, 48, 72 and 96 hours
P = Potential degradability

The data obtained for DM and CP of each feed ingredient were subjected to one-way analysis of variance SAS (2002) with 3 replicates. The model used was:

$Y_{ij} = \mu + s_i + \varepsilon_{ij}$

Where: Y_{ij} = observation, μ = population mean, s_i = sample effect (i = 1 to 6) and ε_{ij} = residual error.

Means of the different ingredients were compared by applying the probability of difference (PDIFF) option of the least squares means statement in the GLM procedure.

RESULTS

Table 1 shows the chemical composition of the sampled feed ingredients before incubation. The DM content was highest in GNM being 956.0g/kg. This value was not significantly different (P>0.05) from values recorded for MO and SBM. The CP content ranged between 96.9 – 404.4g/kg DM. Expectedly, the CP contents of SBM (404.4g/kg DM) and GNM (403.1g/kg DM) (being legumes) were significantly higher (P<0.05) than those of the other ingredients.

Table 1: Chemical composition (g/kg DM) of the feed ingredients before incubation

Feed ingredients	DM	CP	Ash	NDF	ADF	Hemicellulose
Maize Offal	853^b	96.9^e	31.8^b	448^c	203^b	246^b
Brewers Dried Grain	953^a	256^b	26.4^c	621^a	176^c	444^a
Soyabean meal	799^b	404^a	29.4^c	312^d	183^c	130^c
Wheat Offal	903^a	124^c	20.8^d	413^c	267^a	146^c
Groundnut meal	956^a	403^a	28.4^c	182^e	103^d	78.9^d
Maize meal	922^a	103^d	54.3^a	533^b	103^d	432^a
SEM	3.10	4.70	1.30	4.90	4.0	4.60

Means with different superscripts along columns are significantly (P<0.05) different.
DM = dry matter, CP = crude protein,
NDF = neutral detergent fibre, ADF = acid detergent fibre

The cereal grains like corn offal, maize meal and wheat offal recorded lower CP values of 96.9, 102.5 and 124.4g/kg DM, respectively. BDG on the other hand recorded higher CP value (256.3g/kg DM) than the other cereals. The ash or inorganic component of the feed ingredients was generally low. It ranged from 20.8 – 54.3g/kg DM with MM and WO recording the highest and lowest values, respectively.

The fibre components as reflected by the neutral detergent fibre (NDF) and acid detergent fibre (ADF) contents were generally low for all the feed ingredients especially SBM and GNM with values of 312.2 and 181.8g/kg DM for NDF, as well as 182.5 and 102.9g/kg DM for ADF, respectively. The highest NDF value of 620.5g/kg DM was recorded for BDG while the highest ADF content of 267.0g/kg DM was recorded for WO. These values were significantly different (P<0.05) from others. The hemicellulose content taken as the difference between the NDF and ADF was highest (444.3g/kg DM) in BDG and lowest (78.9g/kg DM) in GNM.

Figure 1 shows the sequential DM disappearance to 96hours or potential degradability of the feed ingredients. The result showed that more than 70% DM were degraded in most feed ingredients at 48hrs with the exception of BDG and WO. The highest DM degradation of 90.39% was recorded for SBM at 96hrs while the lowest of 53.61% was recorded for BDG. The effective degradability values (Table 2) of DM for all the three ruminal passage rates (2, 5 and 8) were lowest for the BDG that had the lowest degradation constant, i.e. was degraded slowly. The undegraded fraction ranged from 5.90%.

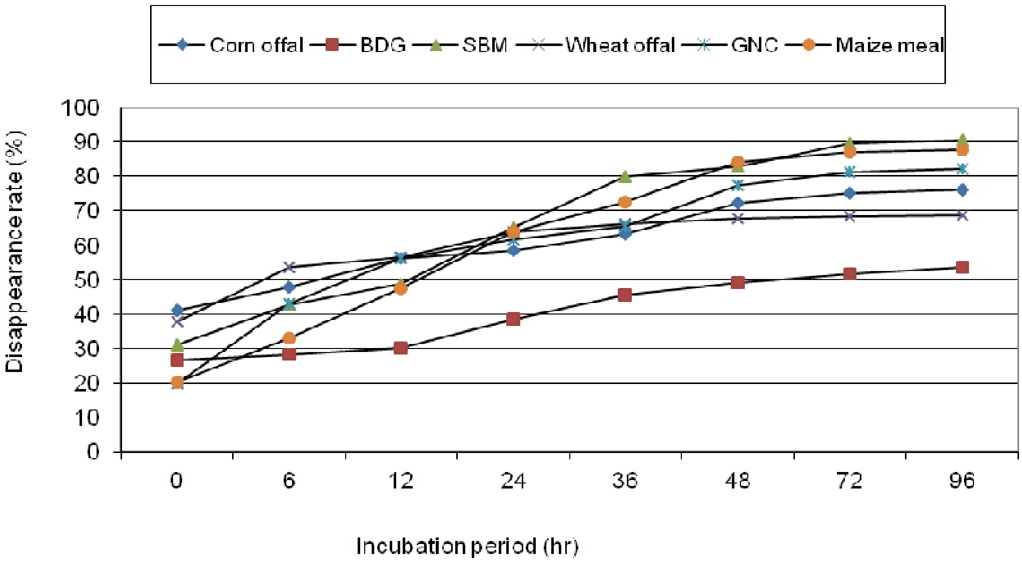

Figure 1: Dry matter disappearance rate of the feed ingredients in the rumen of WAD goats.

The soluble (a) and insoluble but potentially degradable fractions (b) of DM degradation differed significantly (P<0.05) among the feed ingredients (Table 2). The soluble fraction of the DM ranged from 19.12% in MM to 42.04% in CO. MO and WO recorded the highest values which were significantly higher (P<0.05) than values recorded for the other ingredients. The lowest degradable fraction of the DM (29.27%) was recorded in WO, and the highest value of 71.37% was recorded for MM. The rate of degradation (c) of the DM varied from 0.0153 h^{-1} in BDG to 0.0916 h^{-1} in WO and these values are relatively high.

Table 2: Nonlinear estimates and effective degradability values of dry matter of the feed ingredients.

Ingredients	a (%)	b (%)	C/hr	Undegraded (%)	2%	5%	8%
MO	42.0^{a}	37.1^{c}	0.0288c	20.9^{ab}	64.0^{a}	55.6^{a}	51.9^{a}
BDG	24.4^{bc}	40.2^{c}	0.0153c	35.4^{a}	41.8^{b}	33.8^{b}	30.8^{b}
SBM	29.9^{b}	64.2^{ab}	0.0352^{bc}	5.90c	70.9^{a}	56.5^{a}	49.6^{a}
WO	38.7^{a}	29.3^{d}	0.0916^{a}	32.0^{a}	62.8^{a}	57.7^{a}	54.4^{a}
GNC	23.7^{bc}	56.8^{b}	0.054^{b}	19.5^{ab}	65.1^{a}	53.1^{a}	46.5^{ab}
MM	19.1^{c}	71.4^{a}	0.0414^{b}	9.50^{c}	67.2^{a}	51.4^{a}	43.5^{ab}
SEM	1.17	1.59	0.0063	1.34	1.25	1.16	1.13

Means with different superscripts along columns are significantly (P<0.05) different.
MO = maize offal, BDG = Brewers' dried grain, SBM = soya bean meal,
WO = wheat offal, GNM= ground nut meal, MM = maize meal.

MM recorded the highest CP degradation with a value of 82% while the lowest value was recorded for BDG (62%) as shown in Figure 2. At 48 hrs, more than 60% of the CP in all the ingredients had been degraded, which shows that the CP was highly degradable. The sampled ingredients also recorded high zero – time washing loss of between 11 – 41%, which fell within the range of values for soluble nutrients an indication that most of the nutrients in the tested ingredients were soluble. MO had the lowest effective degradability at all the three ruminal passage rates (Table 3). The undegraded fraction of the CP ranged from 17.7% in MM to 38.0% in BDG.

The soluble fraction of the CP content for all the feed ingredients showed low values and ranged from 6.9% in MO to 41.2% in GNC (Table 3). The degradable fraction was however, high ranged between 64.5% in MO to 35.5% in SBM. The rate of degradation of the CP varied from 0.0264 h^{-1} in GNC to 0.0736 h^{-1} in BDG.

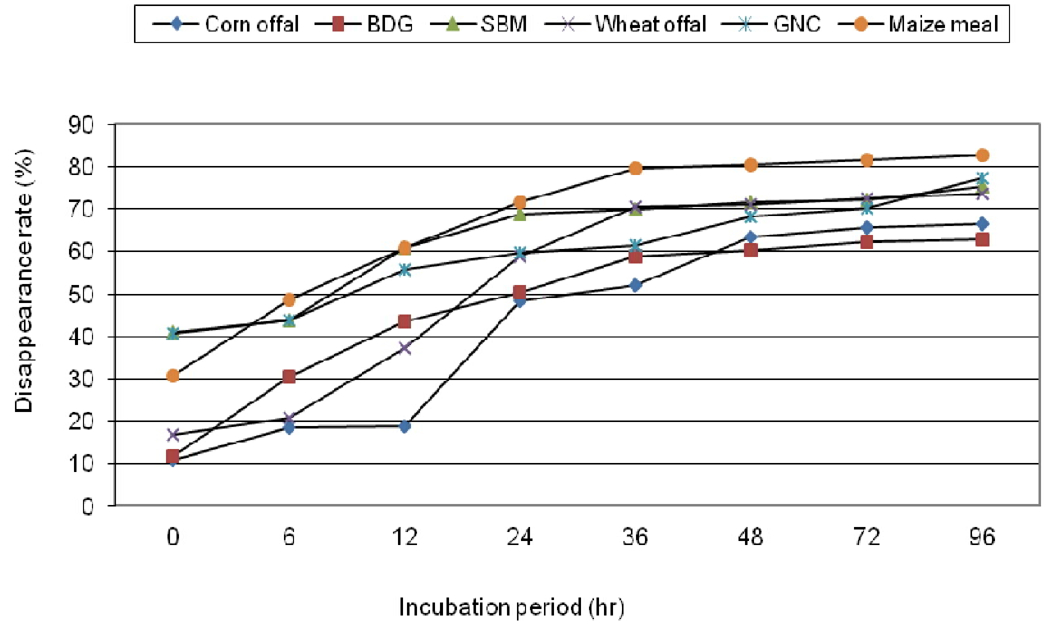

Figure 2: Crude protein disappearance rate of the feed ingredients in the rumen of WAD goats.

Table 3: Nonlinear estimates and effective degradability values of crude protein of the feed ingredients

Species	a (%)	b (%)	c/hr	Undegraded (%)	2%	5%	8%
MO	6.99[c]	64.5[a]	0.0341[bc]	28.5	47.7[b]	33.2[c]	26.3[c]
BDG	12.3[bc]	49.7[b]	0.0736[a]	38.0	51.4[ab]	41.9[c]	36.1[b]
SBM	38.7[a]	35.5[c]	0.0631[a]	25.8	65.6[a]	58.5[ab]	54.4[a]
WO	12.1[bc]	64.0[a]	0.0462[b]	23.9	56.7[a]	42.8[c]	35.5[b]
GNC	41.2[a]	36.9[c]	0.0264[c]	21.9	62.2[a]	54.0[b]	50.4[a]
MM	30.7[ab]	51.6[ab]	0.0709[a]	17.7	71.0[a]	61.0[a]	55.0[a]
SEM	1.51	1.38	0.0055	1.03	1.16	1.29	1.35

Means with different superscripts along columns are significantly (P<0.05) different.
MO = maize offal, BDG = Brewers' dried grain, SBM = soya bean meal,
WO = wheat offal, GNM= groundnut meal, MM = maize meal.

DISCUSSION

The chemical composition revealed an abundance of major nutrients in all the sampled feed ingredients which justifies their use in concentrate rations for both monogastrics and ruminant livestock species. The range of their DM content showed that all the ingredients were well dried to below the 20% recommended DM content for all agricultural products meant for long term storage (ARC, 1984).

The CP contents were generally high for all the feed ingredients and the results obtained were comparable to those from other tropical regions. The lowest CP content recorded for MO in this study was higher than the 8% minimum CP content at which the DM intake of ruminant animals becomes limited (Van Soest, 1994). This implied that these feed ingredients qualified as rich CP sources in diets of ruminant animals in tropical countries.

The ash content which represents the inorganic mineral level in the sampled feeds revealed that only MM and MO could serve as ready sources of inorganic minerals while others are considered to be low. Earlier studies (Maynard *et al*., 1979) showed that the mineral composition of most feed ingredients decreased with length of storage. The low ash contents of feed ingredients used in this study might be an indication that they have been kept in the store for a substantial period of time.

The low fibre content as shown by the low contents of NDF and ADF showed that the feed ingredients were generally low in fibre except for BDG. The presence of higher proportion of NDF to ADF is a reflection that the fibre content of the feed ingredients is soluble. Ruminant animals are known to possess the ability to degrade complex carbohydrates with the aid of microbes in their rumen.

When soluble carbohydrates, as in these concentrate ingredients, are fed in high amounts, they are rapidly degraded in the rumen and eructed, especially if there is no concomitant amount of nitrogen (Givens and Rulquin, 2004). This scenario could result in diarrhoea and bloat. Thus, such feedstuffs when fed to ruminant animals should be accompanied with fibrous feeds like dried and conserved forages.

The fact that all the feed ingredients have high washing loss at 0 hour shows that they contain soluble nutrients that will be rapidly utilized in the rumen. With the exception of BDG, all the ingredients recorded more than 60% DM degradability at 48 hours and this also, implied that they were extensively degraded in the rumen. Since the nutrients in the feed form the DM, the ingredients could be said to contain essentially rumen degradable nutrients. Most of these nutrients will be released in the rumen if fed to ruminant animals (Cabrita *et al*., 2006) and rumen microbes will utilize little proportion of it while the remaining will be lost through urinary nitrogen or in form of gases through eructation. The little proportion of the nutrients referred to as undegradable dietary nutrients that are passed to the abomasum will not be adequate to support any meaningful productivity and consequently, the animal becomes emaciated causing losses to the farmer (ARC, 1980).

The highest proportion of the crude protein in all the tested feed ingredients disappeared before 48 hours incubation. Even though, the rates of degradation of the nutrients were variable and some did not obey the NEWAY model, it confirmed a general observation that concentrate feeds contained highly soluble nitrogen. To maximize the efficiency of microbial protein synthesis with soluble non-protein nitrogen, it is considered essential to guarantee a source of easily fermentable energy in the diet that allows the use, by rumen microbes, of the rapidly released ammonia nitrogen (Cabrita *et al*., 2006). This nitrogen known as rumen degradable nitrogen will be converted by rumen microbes to ammonia nitrogen which is a waste to the nitrogen economy of the animals. The remaining proportion called undegradable dietary nitrogen will be inadequate to support high rates of growth or milk production (Dewhurst *et al*., 2000). Even though MO and WO differed largely in terms of rate of DM disappearance from the rumen, they had similar effective DM degradability values. The same trend was observed in the CP disappearance of BDG and WO on one hand and SBM and GNC on the other. Effective degradability of CP for SBM and GNC (66 and 62%) at an outflow rate of 2% suggest that both were able to deliver substantial amounts of ruminally undegraded CP to the duodenum.

Concentrate supplements and oil rich cakes have previously been found to contain high proportion of rumen degradable nutrients which is of little value to ruminants if the energy and nitrogen are not properly synchronized (Dewhurst *et al*., 2003). Since the proportion of DM and nitrogen eructed is wasted and could not be conserved by ruminant animals, these concentrate feed ingredients except SBM will not justify their cost if fed to ruminant animals in high amounts as most of their nutrients will be wasted in the rumen. In fact, they could even result in methane and ammonia gas accumulation in the rumen resulting in bloat which could be dangerous to the animal (Van Soest, 1994).

For efficient utilization of concentrate ingredients for ruminant animals, similar screening trials should be carried out to look for those that have equal proportion of RDN and UDN. According to (Dewhurst *et al*., 2000), some oil rich seeds contain anti-nutritional factors which prevent their nutrients from being degraded in the rumen. The extent to which this will prevent nutrient utilization in the hind gut should be investigated before such seeds are used for ruminant feeding.

CONCLUSION

In conclusion, the study re-affirmed the fact that concentrate ingredients contained mainly soluble nutrients which if not properly matched with ruminant nutrient requirements may not justify their cost of purchase. Further studies on the utilization of chemicals such as tannins, formic acid, formaldehyde, ethanol to prevent concentrate nutrients from being degraded by rumen microbes should therefore be intensified. This will assist in developing high concentrate feeds suitable for intensively managed ruminant animals and other feeding systems, especially during dry seasons when forage resources are scarce.

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