NUTRITIVE EVALUATION OF SELECTED AGRO-INDUSTRIAL BY-PRODUCTS FOR SMALL RUMINANT PRODUCTION

K. J. Onaleye, A. J. Amuda, R. Elkanah & E. L. Buba
[1] *Department of Animal Production and Health, Federal University, Wukari, Taraba State*
Corresponding author: onaleyekj2000@gmail.com

ABSTRACT
The study was conducted to evaluate the chemical composition and dry matter degradability of four (4) Agro-industrial by-products (Cassava peel, Yam peel, Brewer's waste and Maize offal) from Jalingo, Taraba State using the nylon bag technique. Crude protein content was highest (23.77%) in Brewer's dry grain (BDG) and lowest (4.67%) in Cassava Peel. All the feedstuffs were at least 50% degradable at 48hours incubation period and as such are good feed resources for ruminant stock. Cassava peels had the highest (87.0%) dry matter degradability, followed by Yam peels (86.42%), Maize offal (75.44%) and Brewers dry grain (56.17%). The effective degradability(ED) of 74.3% at 50 hour rumen incubation of Maize offal coupled with its moderate crude protein content (CP) of 13.16% suggests that it is the most nutritive of the tested feedstuffs followed by BDG (55.7% ED ; 23.77% CP), Yam peel (82.4% ED; 7.64% CP) and Cassava peel (81.2% ED; 4.67% CP). The high (>10%) fat content of Maize offal may however place BDG at a better comparative advantage over Maize offal, more so that BDG may provide more bypass protein than the maize offal.

KEYWORDS: By-products, Rumen degradability, Effective degradability, Nylon bag technique, Ruminant

INTRODUCTION
The goal of meeting the growing need for animal protein in the diet of the ever increasing human population in the Sub-Saharan Africa is fraught with poor livestock nutrition. Achieving optimal levels of feeding is one of the most important factors determining profitability in livestock enterprises. This is most problematic during the dry season when forages decline in quantity and quality with consequent fluctuations in the growth rate of the animals (Mbahi *et al.*, 2006). Maize offal, BDG, yam and cassava peels abound in Jalingo, being products from well grown food crops. An adequate appreciation of the value of crop residues and agro-industrial by-products and their use in feeding animals can help reduce pollution, minimize waste-treatment costs, and reduce the cost of feeding in livestock production as well as generate some additional income to crop producers and agro-industrialists (Crickenberger and Carawan, 1996).

FAO (1986) recommended a degradability range of 40 – 50% for a feedstuff to be considered acceptable for feeding ruminant stock. In addition to degradability, the crude protein content of the feedstuff is important as it affects the activities of the microbes in the rumen. Norton (1994) stated that any feed with less than 1.35% nitrogen (8.4% CP) is nitrogen deficient and cannot provide the minimum ammonia levels required to support the activities of the rumen microbes. The bulkiness of most agro-industrial by-products necessitates the need to determine which of them is the most nutritive so as to justify the investment into its procurement and storage for feeding ruminant animals (Onaleye *et al.* 2012).

MATERIAL AND METHODS

PREPARATION OF EXPERIMENTAL SAMPLES

Cassava peel, Yam peel, Maize offal and Brewer's dry grain (BDG) were collected from Jalingo in Taraba State and used for the study. The dry samples were ground through a 2mm sieve and stored in sealed bottles after drying them for 48 hours in the oven at 65^{o}C.

EXPERIMENTAL ANIMALS

Three (3) fistulated male goats of an average weight of 18kg were used for the study. The animals were housed individually on concrete-floored pens and supplied with Groundnut haulms and Maize offal morning and evening. Salt lick and water were given *ad- libitum.*

INCUBATION OF FEED SAMPLES

Three (3) grams of triplicates samples of each feed ingredient per incubation period was weighed into nylon bags of size 7cm x 12.5cm and mesh (pore) size of about 45µm. The bags were made of filter cloth, weighed and numbered for easy identification. Each bag was attached to PVC string with the aid of rubber band. The bags were incubated for 6, 12, 24, 48, and 72 hours in the rumen of the cannulated goats.

After each incubation time, the bags were withdrawn from the animal; washed under running tap with a gentle squeeze between the fingers until the rinse water became clean and clear. They were then drained and oven-dried at 65^{o}C for 48 hours, cooled and weighed to determine the loss in weight due to degradation by rumen microbes. The loss in weight was used to calculate the percent actual dry matter disappearance (ADMD) of the samples. The washing loss (zero time dry matter disappearance) was estimated by soaking three (3) bags of each feed sample in warm (about 37 ^{0}C) water for 30 minutes and following the same procedure as described for incubated samples above.

CHEMICAL ANALYSIS OF SAMPLES

The experimental feedstuffs were chemically analyzed according to standard procedure of AOAC (2000) for DM, Ash, CP, CF and EE. Samples were also analyzed for Neutral Detergent Fiber (NDF), Acid Detergent Fiber (ADF) and Acid Detergent Lignin (ADL) using the Van Soest *et al.* (1991) method.

FIT CURVE ANALYSIS

The results of the incubation were analyzed using Fit curve macro (Chen, 1995) for Microsoft Excel (NEWAY Excel). Degradation constants were estimated from the non-linear equation: $PD = a + b (1-e^{-ct})$, proposed by Ørskov and McDonald (1979). Where PD = potential degradability of dry matter and crude protein at time t, a = soluble fraction (intercept); b = insoluble but rumen degradable fraction and; c = the rate of degradation of b at time t (6, 12, 24, 48, and 72 hours).

The effective degradability (ED = a + {bc/(c+k)}) of DM was calculated at rumen outflow rates (k) of 0.02, 0.05 and 0.08 /hr according to Ørskov and McDonald (1979): where a, b, and c are as described above and 'k' is the fractional out flow rate from the rumen. Percent actual dry matter degradability values were analyzed in a completely randomized design using the one-way analysis of variance procedures of SAS (1999) and significant means were separated Fisher's LSD

RESUL T AND DISCUSSION

Proximate composition and cell wall content

The Proximate composition and cell wall content of the agro-industrial by-products tested are presented in Table 1. The CP values ranged from 4.67% in Cassava peels to 23.77% in Brewer's dry grain. Maize offal had the highest (12.13%) ether extract (E.E) and the least Ash (5.52%) content. The high (12.13%) E.E in maize offal may result to low feed intake in ruminants as well as low calcium content as seen in the ash content of maize offal compared to other feedstuffs. This is consistent with the findings of Crickenberger and Carawan (1996) who noted that if fat exceeded 10% of the diet dry matter, feed intake and performance may be restricted though the problem can be overcome by adding more calcium to the diet, which invariably increases production cost. Brewer's dry grain had the highest (45.25%) neutral detergent fiber (NDF) followed by Maize bran (32.98%), Cassava peels (22.48%) and Yam peels (15.95%)

The CP content of the Cassava peel obtained in the experiment (4.67%) is close to the 5.33±2.52% reported by Morgan and Choct (2016). The values of the DM and CP of the Brewer's dry grain used in this experiment are also similar to those reported by Arigbede *et al.* (2002). The DM, CP and Ash content observed for Maize offal in this experiment are higher than those reported by Arigbede *et al*. (2002) but with similar NDF value. The differences may be due to harvesting time, location, variety and soil fertility (Heuzé *et al*., 2017). However, their high solubility and high NFE content qualify them as readily available carbohydrates for supplementing maize residues-based livestock feed (Lardy and Andersen, 1999).

Table 1: Proximate composition and cell wall content of the feedstuffs

Sample	DM	CP	ASH	EE	CF	NFE	NDF	ADF	ADL	HC	C
Cassava peel	95.61	4.67	7.62	1.04	6.05	75.78	22.48	10.92	5.89	11.56	5.03
Yam peel	95.31	7.64	7.63	3.50	5.91	70.63	15.95	7.73	4.04	8.22	3.69
BDG	95.20	23.77	6.29	3.28	6.10	55.76	45.25	13.04	0.91	32.21	12.13
Maize offal	95.10	13.16	5.52	12.13	8.64	55.65	32.98	7.90	1.24	25.08	6.66

DM = Dry matter, CP = crude protein, EE = ether extract, CF = crude fibre, NFE = Nitrogen free extract, NDF = Neutral detergent fibre, ADL = Acid detergent fibre, ADL = Acid detergent lignin, BDG = Brewer's dried grain. HC= Hemicelluloses, C= Cellulose, HC = NDF – ADF, C = ADF – ADL

Rumen degradability of feedstuffs

The actual dry matter disappearance (ADMD) by incubation time and the overall means by sample are shown in Table 2. The overall % ADMD ranged from 44.43% in BDG to 76.30% in Yam peels which was significantly ($P < 0.05$) higher than that of BDG. With these degradability values, all the tested feedstuffs may be considered acceptable for ruminant feeding in accordance with the 40 – 50% degradability range recommended by FAO (1986).

Table 2: Actual Dry Matter Disappearance (%ADMD) of incubated feed samples

		Incubation time								
Sample	%DM	0hr	6hr	12hr	24hr	48hr	72hr	Mean	LSD	P value
Cassava Peels	95.61	50.99	65.79	77.13	83.82	87.00	87.67	75.40	18.47	0.0058
Yam peels	95.31	47.66	70.53	79.42	85.78	86.42	88.00	76.30		
BDG	95.20	22.21	28.56	39.03	47.60	56.17	72.99	44.43		
Maize offal	95.13	51.68	57.72	64.37	69.13	75.44	85.00	67.22		

LSD = Least significant Difference

Effective Degradability of feedstuffs

Table 3 shows the Effective Degradability (ED) of feedstuffs at degradability constants a, b, c and rumen fractional outflow rate K = 0.02, K = 0.05 and K= 0.08. The ED values shown are the predicted *in vivo* degradability at mean retention time (MRT) of 50hrs, 20hrs and 12.5hrs respectively (i.e. K = 0.02, 0.05, 0.08). Yam peel and BDG had the highest (77.1%) and lowest (41.0%) ED respectively at k= 0.05 (i.e. 20 hr incubation time). By the 40-50% recommendation of FAO (1986), all the feedstuffs tested are qualified as ruminant feedstuffs on the basis of DM degradability. Yam and Cassava peels with high (> 80%) degradability (at k = 0.05) but low (<8.4%) CP could serve as readily available carbohydrates when ammoniated straw-based diet is fed to ruminants. The high (23.77%) CP content of BDG and its medium (55.7%) ED may imply that a large portion of its nutrients will escape rumen degradation as by-pass nutrients into the intestine goats for digestion and utilization for tissue development (Reddy, 2001).

Table 3: Effective Degradability (ED) (%) of feedstuff at degradability constants a, b, c and fractional outflow rates K = 0.02, 0.05 and 0.08 where ED = a + {bc/(c+k)}

SAMPLE	a	b	c	RSD	Effective Degradability at K =		
					0.02	0.05	0.08
Cassava peels	45.5	41.7	0.114	0.71	81.2	74.8	70.4
Yam peels	51.3	36.0	0.127	0.76	82.4	77.1	73.4
Brewer's waste	26.4	88.3	0.010	4.37	55.7	41.0	36.1
Maize offal	56.1	49.7	0.012	2.37	74.3	65.4	62.4

a = readily soluble fraction, b = insoluble but degradable fraction, c = degradability rate, RSD = regression standard deviation, K = fractional outflow rate

CONCLUSION AND RECOMMENDATION:

All the tested feedstuffs are good feed resources except that cassava peels and yam peels should not be fed solely as they are poor in crude protein. Based on the CP content, rumen degradability and E.E content, BDG is the best feedstuff among the tested samples, followed by Maize offal, Yam peel and Cassava peel. A mixture of BDG and yam or cassava peel meal is recommended for ruminant dry season feeding.

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