

PERFORMANCE OF WEST AFRICAN DWARF GOATS FED MICROBIAL TREATED MAIZE COB AND HUSK DIETS

OGUNJEMITE, Gbenga Enobong and IBHAZE, Gladys Abiemwense

Department of Animal Production and Health, Federal University of Technology, Akure, PMB 704, Ondo State, Nigeria.

Corresponding Author: Ibhaze, G. A. Department of Animal Production and Health, Federal University of Technology, Akure, PMB 704, Ondo State, Nigeria. **Email:** gaibhaze@futa.edu.ng
Phone: +234 8055865289

Received June 08, 2020; Revised September 02, 2020; Accepted September 03, 2020

ABSTRACT

*A study was conducted using twenty four (24) West African Dwarf (WAD) goats with an average weight of 6.57 ± 0.56 kg to evaluate the nutrient intake, weight gain and nitrogen balance of WAD goats fed microbial treated maize cob and husk diets. Chemical and mineral compositions of the diets were also determined. The goats were allotted to six dietary treatments, replicated four times in a completely randomized design. The chopped maize cobs and husks were sterilized for 60 minutes, inoculated with mixture of 15 ml each of *Neurospora crassa* and *Lactobacillus delbrueckii*, incubated for 5 days and air dried. The treated maize cob and husk were incorporated in the diets at the rate of 0 % (Diet A), 20 % (Diet B), 30 % (Diet C) [maize cob diets], 0 % (Diet D), 20 % (Diet E), 30 % (Diet F) [maize husk diets] respectively. The experimental period lasted for 56 days excluding 2 weeks of adaptation. Result showed that the proximate compositions were significantly influenced ($p < 0.05$) by the treatment. Calcium content increased with increasing level of treated cob and husk. Phosphorus ranged from 0.05 – 0.10 % while magnesium varied from 0.07 – 0.15 % and Potassium from 0.13 – 0.50 %. Goats fed Diet E (20 %) had the highest daily weight gain (39.29 g/day), highest nitrogen balance (1.73 g/day) and best feed/gain ratio of 5.57. Conclusively, microbial treatment of maize cob and husk will help in conversion of these wastes to better quality ruminant feed for better performance.*

Keywords: West African Dwarf (WAD) goat, *Neurospora crassa*, *Lactobacillus delbrueckii*, Maize cob, Maize husk

INTRODUCTION

The limited and inadequate supply of forages of low quality in dry season results in retarded growth of ruminants and placed an increasing demand for livestock products in the world. Future hope of feeding the nations and safe guarding their food security will depend on the better utilization of wastes and agro-industrial by-products as feed resources for animals (Makkar, 2002; Fajemisin *et al.*, 2014). An important class of non-conventional feedstuff in Nigeria is maize cob and husk which are

obtained during the processing of harvested maize. The most recent data from the International Grains Council put Nigeria's 2018/19 maize production estimate at 11 million tons, which equates to a 16.1 % share of sub-Saharan Africa's maize harvest (Sihlobo, 2019). Maize husk is the leafy outer covering of an ear of maize (corn) as it grows on the plant (Wikipedia, 2020). Maize cobs are a highly fibrous product with many agricultural and industrial applications (Heuzé *et al.*, 2016a). Maize cob and husk had dry matter of 78.07 and 80.63 %, crude fibre of 23.36 and 20.90 %, and

crude protein of 7.32 and 8.30 % respectively as determined in this study. Maize husk and cob in spite of their limitations could be recycled and used as a source of valuable lignocellulose biomass for animals if treated with fungi. Belewu and Okhawere (1998) reported on the delignification and nutritive values of rice husk and sorghum stover treated with *Trichoderma harzanium*. They observed increase in crude protein content and decrease in crude fiber content of the fungal treated substrates.

Neurospora crassa has a long history as an excellent model for genetic, cellular and biochemical research. Although this fungus is known as a saprotroph, it normally appears on burned vegetation or trees after forest fires. The filamentous fungal species is commonly found on carbohydrate-rich foodstuffs and residues of sugar-cane processing (Kuo *et al.*, 2014). It can be very easily genetically manipulated and a wealth of molecular tool. In addition, *N. crassa* is very fast growing and non-toxic. All of these features point to a high but so far untapped potential of this fungus for biotechnological applications (Havlik *et al.*, 2017).

Lactobacillus delbrueckii is a rod shaped gram positive, non-motile bacterium. It has the ability to ferment sugar substrates into lactic acid products under anaerobic conditions (Penetrante, 2010).

Thus, this study was conducted to evaluate the effect of using *N. crassa* and *L. delbrueckii* in improving nutritive value of maize cob and husk as feed resources for West African Dwarf (WAD) goat.

MATERIALS AND METHODS

Experiment Site: The experiment was carried out at the Sheep and Goat Unit of the Teaching and Research Farm of the Federal University of Technology, Akure, Ondo State, Nigeria. Akure is located on longitude 4.944055°E and 5.82864°E, and latitude 7.491780°N with annual rainfall ranging between 1300 and 1650 mm and annual daily temperature ranging between 27° and 38° C (Daniel, 2015).

Collection and Preparation of Experimental Diets:

Maize cobs and husks were collected at various farmlands in Akure, Ondo State, sun-dried for 3 days to reduce the moisture content. The cob was crushed at the FUTA feed mill to about 1 mm particle size, while the husk was chopped to smaller size. One kilogram each of maize cob and husk meal respectively was moistened with water at ratio 1:1 (w/v). The moistened maize cob and husk were sterilized for 60 minutes according to the procedure of Aro *et al.* (2008) to eliminate microbial contamination of the cob and husk thereafter were allowed to cool and were inoculated with mixture of 15 ml each of *N. crassa* and *L. delbrueckii*. The microbial treated maize cobs and husks were fermented anaerobically for five days. Thereafter, they were sun-dried for some days based on the intensity of the sun and were incorporated into the complete diets at the rate of 0 % (Diet A), 20.00 % (Diet B), 30.00 % (Diet C) [maize cob meal diets], and 0.00 % (Diet D), 20.00 % (Diet E), 30.00 % (Diet F) [maize husk diets]. Other ingredients added to the complete diets are presented in Table 1. Maize cob contains 5.22 % protein, anti-nutrients such as saponin (2.09 %), tannin (0.03 %) and phytate (0.72 %) (Ukanwoko and Nwachukwu, 2017), cellulose (27.71 %) and hemicellulose (38.78 %) but also contain a significant amount of lignin (9.4 %) (Shinners *et al.*, 2007), calcium (17.19 mg/100g), potassium (375.25 mg/100 g), sodium (129.19 mg/100 g) (Abubakar *et al.*, 2016) and antioxidant activity of 0.3 – 10.0 µmol/gdw (Nawaz *et al.*, 2018) while maize husk constitutes 33.15 % cellulose, Lignin (4.91 %) and hemicellulose of 44.67 % (Danmek *et al.*, 2014), total phenolic compounds of 1.62-14.77 g, 1.48-2.05 g flavonoids, 0.45-3.63 g carotenoid and antioxidant activity of 11.85 % (Nawaz *et al.*, 2018), potassium (31.14 mg/g), calcium (61.74 mg/g), manganese (0.10 mg/g) (Duru, 2020). The levels of incorporation of maize husk in this study were above the median lethal dose (LD₅₀) for crude husk extract which was calculated to be 1874.83 mg/kg (Okokon *et al.*, 2017), but did not show any toxicity as no mortality of animal was recorded.

Table 1: Gross composition of microbial treated maize cob and husk meal based diets

Ingredients	Maize cob diets			Maize Husk Diets		
	A (0 %)	B (20 %)	C (30 %)	D (0 %)	E (20 %)	F (30 %)
Cassava peel	50.00	30.00	20.00	50.00	30.00	20.00
Treated	0.00	20.00	30.00	0.00	20.00	30.00
Brewer's dry grain	11.00	11.00	11.00	11.00	11.00	11.00
PKC	24.00	24.00	24.00	24.00	24.00	24.00
Molasses	10.00	10.00	10.00	10.00	10.00	10.00
Salt	3.00	3.00	3.00	3.00	3.00	3.00
Premix	1.00	1.00	1.00	1.00	1.00	1.00
Bone meal	1.00	1.00	1.00	1.00	1.00	1.00
Total	100	100	100	100	100	100

No toxic effect has been reported for corn cob meal in their several uses in the cosmetic industry (Anderson *et al.*, 2011). Brewers' grain has crude protein content of about 24 – 26 % on dry matter basis (Westendorf and Wohlt, 2002), cassava peel contains protein content of 3.72 % (Heuzé *et al.*, 2016b), palm kernel cake 16 – 18 % crude protein (Alimon, 2006), dry matter of 94 %, lipid 8 – 17 %, ash 3 – 6 % and gross energy of 4998 kcal/kg (Sundu *et al.*, 2006).

Experimental Layout and Animal Management:

The study was conducted from February 1 to April 11, 2020. Twenty four WAD goats (buck) of about 6 to 7 months of average weight of 6.57 ± 0.56 kg were randomly assigned to six dietary treatments of four replicate per treatment in a Completely Randomized Design. Animals were housed in individual pens and offered fresh clean water. Prior to the commencement of the experiment, the WAD goats were vaccinated against PPR disease and treated against ecto-parasites. The goats were given daily ration at 3 % of their body weight. *Panicum maximum* was given as basal diet long side experimental diets. The feeding trial lasted for 56 days excluding the 2 weeks of adaptation. All animals were cared for and managed according to the ethical approval and guidelines of NENT (2016).

Data and Sample Collection: The animal's growth response to the experimental diets was monitored by taking their initial body weights, followed by weighing on weekly basis prior to feeding. Feed offered to animals was recorded and leftover was weighed on daily basis to compute feed intake by the animals.

Analytical Procedures: Data obtained were analyzed using one-way analysis of variance (ANOVA) using statistical analysis software (SAS, 2001) and means were separated using the Duncan Multiple Range Test of the same package. Significant means were accepted at $p < 0.05$.

RESULTS AND DISCUSSION

Chemical Composition of Microbial Treated Maize Cob and Husk Diets:

The dry matter (DM) values of the microbial treated maize husks diets (80.63 Diet D – 83.92 Diet F) were higher than those of the microbial treated maize cob diets (77.44 Diet C – 78.07 Diet A) (Table 2). This observation was similar to the findings of Akinfemi *et al.* (2009a) when they treated maize husk with four different white-rot fungi, and had values ranged between 86.44 to 87.70 %. However, the dry matter values of the treated maize cob diets decreased with increased inclusion level of the treatment, while the DM of the treated maize husk diet increased with increased inclusion level of the treatment. This may be due to the fibre content, texture and low moisture content of the microbial treated maize cob diets. However, the DM values obtained by Akinfemi *et al.* (2009a) and the values observed in this experiment were also lower when compared to the value 94.55 % reported by Olagunju *et al.* (2013) for fungus (*Lachnocladium* spp.) fermented corncobs.

The crude protein (CP) content of the microbial treated maize cob and husk diets were more than the critical 7 % CP recommended for ruminant animals by McDonald *et al.* (1995). The CP increased with increased inclusion level in both the cob and husk meals.

Table 2: Chemical and mineral composition of microbial treated maize cob and husk diets fed to West African Dwarf goats

Parameters	Maize cob diets			Maize husk diets		
	A (0 %)	B (20 %)	C (30 %)	D (0 %)	E (20 %)	F (30 %)
Dry matter	78.0 ± 0.75 ^{ab}	77.90 ± 0.81 ^{ab}	77.44 ± 0.53 ^{ab}	80.63 ± 0.42 ^b	83.82 ± 0.32 ^b	83.92 ± 0.27 ^b
Crude protein	7.32 ± 0.11 ^a	8.05 ± 0.08 ^b	8.24 ± 0.05 ^b	8.30 ± 0.04 ^b	8.35 ± 0.03 ^b	8.56 ± 0.03 ^b
Crude fibre	23.36 ± 0.08 ^c	20.95 ± 0.10 ^b	20.60 ± 0.17 ^b	20.90 ± 0.13 ^b	17.55 ± 0.10 ^a	17.25 ± 0.09 ^a
Ether extract	6.32 ± 0.78 ^c	7.05 ± 0.86 ^d	7.80 ± 0.57 ^d	3.47 ± 0.43 ^a	5.46 ± 0.34 ^b	7.56 ± 0.29 ^d
Ash	7.77 ± 0.59 ^b	9.01 ± 0.65 ^c	5.92 ± 0.43 ^a	9.08 ± 0.33 ^c	10.48 ± 0.26 ^d	10.58 ± 0.22 ^d
Nitrogen free extract	36.06 ± 0.52 ^b	32.43 ± 0.58 ^a	34.53 ± 0.38 ^b	45.06 ± 0.29 ^d	40.42 ± 0.23 ^c	36.11 ± 0.19 ^b
Neutral detergent fibre	65.00 ± 0.69 ^d	62.31 ± 0.75 ^c	62.12 ± 0.50 ^c	61.00 ± 0.38 ^{ab}	59.36 ± 0.31 ^a	59.30 ± 0.25 ^a
Acid detergent fibre	45.98 ± 0.98 ^c	43.60 ± 1.08 ^b	43.53 ± 0.72 ^b	43.10 ± 0.54 ^b	41.74 ± 0.43 ^a	41.71 ± 0.36 ^a
Acid detergent lignin	20.20 ± 0.35 ^{bc}	19.21 ± 0.50 ^{ab}	19.18 ± 0.54 ^{ab}	19.18 ± 0.40 ^{ab}	18.02 ± 0.50 ^{ab}	17.99 ± 0.75 ^a
Hemicellulose	19.02 ± 0.58 ^c	18.71 ± 0.65 ^b	18.59 ± 0.43 ^b	17.90 ± 0.33 ^a	17.62 ± 0.26 ^a	17.59 ± 0.21 ^a
Cellulose	25.78 ± 0.01 ^{bc}	24.39 ± 0.01 ^{ab}	24.35 ± 0.01 ^{ab}	23.92 ± 0.01 ^a	23.72 ± 0.01 ^a	23.72 ± 0.01 ^a
Calcium	0.45 ± 0.05 ^a	0.46 ± 0.04 ^a	0.46 ± 0.03 ^a	0.47 ± 0.02 ^a	0.55 ± 0.02 ^{bc}	0.67 ± 0.01 ^c
Phosphorus	0.10 ± .01 ^c	0.06 ± .01 ^b	0.05 ± .01 ^a	0.05 ± .01 ^a	0.05 ± .01 ^a	0.05 ± .01 ^a
Magnesium	0.13 ± 0.01 ^d	0.07 ± 0.01 ^a	0.15 ± 0.01 ^e	0.08 ± 0.02 ^b	0.11 ± 0.01 ^c	0.08 ± 0.01 ^b
Potassium	0.50 ± 0.05 ^e	0.13 ± 0.06 ^a	0.27 ± 0.04 ^d	0.14 ± 0.03 ^{ab}	0.15 ± 0.02 ^{bc}	0.15 ± 0.02 ^{bc}
Energy KJ/100g DM	12.81	12.70	13.28	12.54	13.16	13.19

a, b, c = means within the same row with different superscript are significantly ($p < 0.05$) different

However, the highest crude protein content was obtained in Diet F (fermented husk based diet) (8.56 %) although similar to (8.90 %) reported by Fajemisin *et al.* (2014) but higher than 4.97 % reported by Olagunju *et al.* (2013) for fungus (*Lachnocladium spp.*) fermented corncobs. This improved CP value in the fungal treated maize husk may be due to the release of polysaccharide bound protein and thus making the substrate nutritionally better (Belewu *et al.*, 2003). This was in agreement with the report of Broerse and Visser (1996) who stated that the extra cellular enzymes secreted by the fungus contain amorphous homo-hetero polysaccharides which is often in association with proteins. Microbial degradation has also been reported to increase crude protein content of crop residues. Soccol *et al.* (1994) reported a similar result in respect of the CP content (7.15 %) of raw cassava when fermented with *Rhizopus* in an experiment to enrich animal feed by using microbes on raw cassava.

The fibre fraction values observed decreased with increased inclusion levels and the fibre content of the microbial treated maize husk diets were significantly lower ($p < 0.05$) compared to that of the microbial treated maize

cob diets. Crude fibre (CF) values agreed with the observed values (24.14 % to 32.68 %) obtained by Akinfemi *et al.* (2009b) for fungi treated maize cob using *in vitro* gas production technique, also agreed with the report of Belewu (2001). This observation indicated that the action of the microbes (*N. crassa* and *L. delbrueckii*) introduced in the fermentation process have degraded the cellulose of the husk Diet Better than that of the cob diet, which will make available the nutrients locked up in the cell walls for goats use. The much decrease in fibre content in the husk based diets may be attributed to the utilization of hemicellulose by the microorganism (Chen *et al.*, 1995).

The decrease in the values of nitrogen free extract (NFE) of the microbial treated maize cobs may also be as a result of fibre delignification and utilization of the contents in the diets. This also agreed with the report of Belewu *et al.* (2003) that fermentation generally degrade or break cellulose bonds of crude fibre content in crop residue especially when fermented with fungi, because they possess ability to produce cellulase that can degrade ligno-cellulose fibre. The values of ash were higher in the diets that contained microbial treated maize husk.

This may be due to the silica content, debris of dead microorganism in the materials (McDonald *et al.*, 1995). The calcium was significantly influenced with increase in inclusion levels of the treated maize husk and cob. The calcium and phosphorus composition of the diets compared favourably with the recommended levels reported by McDowell (1992) for goats. The concentration of potassium in all the diets favourably furnished adequate requirement of 0.25 – 0.50 % for goats (NRC, 2007).

Nutrient and Mineral Intake of WAD Goats Fed Microbial Treated Maize Cob and Husk Diets: The dry matter intake (DMI) recorded in this study (Table 3) were significantly influenced ($p < 0.05$) by the inclusion levels of the microbial treated maize cob and husk in the diets. This observation may be attributed to the protein quality, palatability and acceptability of the experimental diets. This observation was in agreement with the report of Ahamfule *et al.* (2006) that higher level of crude protein stimulates dry matter intake. This observation was also in agreement with the report of Ventura *et al.* (1995) that nutrient intake increases as dry matter intake and as crude protein concentration quality increased. However, the average voluntary DMI values of the goats were above 3.5 % of the body weight recommended for small ruminant by McDonald *et al.* (1995).

The crude protein intake ranged from 9.24 to 16.83 g/day, these values obtained were lower than 76.26 – 83.2 g/day reported by Ahamfule *et al.* (2006) for WAD bucks fed pigeon pea- cassava peel based diet.

The ether extract (EE) intake was highest in goats fed Diet F (14.87 g/day). This may be connected to the higher concentration of fat/oil in the diet. Maia *et al.* (2012) reported increase in ether extract intake in sheep fed oils. Ether extract represents the fat portion of the diet and this can be used as a source of energy by the goats. This therefore suggests that more energy would be available to the animals for metabolic processes. Moreover, this higher ether intake did not show any deleterious effect on the animals.

Excess fat in ruminant feeds slows down the activities of rumen microorganisms when it is above 50 g/10 kg feed (McDonald *et al.*, 1995). However, the values obtained are slightly lower than the range (15.36 – 16.44 g/day) reported by Ibhaze (2018) in WAD goats fed milled bio-fibre waste rations.

Nitrogen free extract intake was highest in the goats fed Diet E (88.51 g/day) suggesting higher amounts of fermentable carbohydrates for energy supply suggesting the availability of soluble carbohydrate that enhanced the "gut fill" of the goats (Lu *et al.*, 1991). The values of the crude fibre intake in the microbial treated maize husk (29.63 – 45.77 %) were slightly higher than those of the microbial treated maize cob (29.49 – 37.03 %). This may be due to that the microorganism degraded the cob diet better. This suggests that maize husk may require longer days of fermentation for the husk to be better degraded. Chen *et al.* (1995) and Fawolu and Fajemisin (2013) reported that preferential degradation of cellulose and hemicelluloses may be due to substrate type, duration of degradation and physiological behaviours of the organism used. The mineral (calcium, magnesium, potassium and phosphorus) intake in this study were adequate according to NRC (2007) recommendation for small ruminants.

Weight Gain and Nitrogen Balance of WAD Goats Fed Microbial Treated Maize Cob and Husk Diets: In the maize husk diets, goats fed Diets E and F had significantly ($p < 0.05$) higher nitrogen intake than those fed other diets (Table 4). This observation was in agreement with the report of Olorunnisomo *et al.* (2008), that there was an increase in nitrogen utilization as the nitrogen intake improved in sheep fed maize offal and sorghum brewer's grain. This may be as a result of improved nitrogen availability in the rumen for microbes' activities and protein synthesis when fed to ruminant. However, the result of this study showed that goats fed Diet E had the highest nitrogen balance (1.73 g/day), although statistically similar to the value observed in goats fed Diet F (1.71 g/day).

Table 3: Nutrient and mineral intake of WAD goats fed microbial treated maize husk and cob diets (g/day)

Parameters	Maize cob diets			Maize husk diets		
	A (0 %)	B (20 %)	C (30 %)	D (0 %)	E (20 %)	F (30 %)
Dry matter	179.76 ± 4.0 ^e	138.04 ± 4.37 ^a	152.47 ± 2.91 ^b	168.85 ± 2.18 ^c	218.97 ± 1.80 ^f	196.64 ± 1.50 ^d
Crude fibre	37.03 ± 0.82 ^{ab}	29.49 ± 0.91 ^a	32.08 ± 0.60 ^b	29.63 ± 0.45 ^a	45.77 ± 0.36 ^c	37.38 ± 0.31 ^{ab}
Crude protein	13.16 ± 0.33 ^c	12.11 ± 0.36 ^{bc}	12.61 ± 0.24 ^{bc}	9.24 ± 0.18 ^a	16.80 ± 0.15 ^d	16.83 ± 0.12 ^d
Ether extract	11.36 ± 0.35 ^c	9.73 ± 0.39 ^b	11.94 ± 0.26 ^c	5.86 ± 0.19 ^a	11.96 ± 0.15 ^c	14.87 ± 0.13 ^d
Ash	13.99 ± 0.60 ^{bc}	12.44 ± 0.66 ^b	9.07 ± 0.44 ^a	15.33 ± 0.33 ^c	23.38 ± 0.26 ^e	20.80 ± 0.22 ^d
Nitrogen free extract	64.68 ± 1.87 ^c	44.77 ± 2.07 ^a	52.88 ± 1.38 ^b	76.08 ± 1.03 ^{ad}	88.51 ± 0.83 ^e	71.01 ± 0.69 ^{abd}
Neutral detergent fibre	114.68 ± 2.52 ^d	89.75 ± 2.80 ^b	97.71 ± 1.87 ^a	108.34 ± 1.40 ^c	143.12 ± 1.12 ^f	126.93 ± 0.93 ^{ae}
Acid detergent fibre	84.64 ± 2.10 ^d	68.49 ± 2.33 ^b	62.25 ± 1.55 ^a	80.86 ± 1.16 ^c	108.92 ± 0.93 ^f	95.63 ± 0.78 ^e
Acid detergent lignin	37.18 ± 0.70 ^c	26.49 ± 0.78 ^a	27.16 ± 0.57 ^a	30.04 ± 0.43 ^{ab}	39.46 ± 0.34 ^d	39.82 ± 0.29 ^d
Hemicellulose	30.05 ± 1.41 ^c	21.26 ± 0.74 ^a	35.47 ± 0.50 ^d	27.47 ± 0.37 ^{ab}	34.20 ± 0.29 ^d	31.30 ± 0.25 ^c
Cellulose	47.45 ± 1.40 ^c	42.01 ± 1.55 ^b	35.09 ± 1.03 ^a	50.82 ± 0.77 ^{bd}	69.46 ± 0.62 ^f	55.81 ± 0.52 ^e
Gross energy (KJ)	23.58 ± 0.06 ^c	17.54 ± 0.60 ^a	18.64 ± 0.40 ^a	21.18 ± 0.30 ^{bb}	28.82 ± 0.24 ^e	25.93 ± 0.20 ^d
Calcium	0.81 ± 0.07 ^c	0.63 ± 0.08 ^a	0.70 ± 0.05 ^b	0.79 ± 0.04 ^b	1.20 ± 0.03 ^d	1.32 ± 0.03 ^e
Magnesium	0.23 ± 0.02 ^a	0.10 ± 0.01 ^a	0.23 ± 0.02 ^a	0.14 ± 0.01 ^b	0.24 ± 0.02 ^a	0.16 ± 0.01 ^{ab}
Potassium	0.90 ± 0.02 ^e	0.18 ± 0.01 ^a	0.41 ± 0.01 ^d	0.24 ± 0.01 ^b	0.33 ± 0.01 ^{ac}	0.30 ± 0.01 ^c
Phosphorus	0.18 ± 0.01 ^d	0.08 ± 0.01 ^a	0.08 ± 0.01 ^a	0.08 ± 0.01 ^a	0.11 ± 0.01 ^c	0.10 ± 0.01 ^b

a, b, c, d = means within the same row with different superscript are significantly ($p < 0.05$) different

Table 4: Performance characteristics of WAD goats fed microbial treated maize husk and cob diet

Parameters	Maize cob diets			Maize husk diets		
	A (0 %)	B (20 %)	C (30 %)	D (0 %)	E (20 %)	F (30 %)
Nitrogen intake (g/day)	2.11 ± 0.07 ^{bc}	1.94 ± 0.07 ^b	2.02 ± 0.05 ^{bc}	1.48 ± 0.04 ^a	2.69 ± 0.03 ^d	2.69 ± 0.02 ^d
Faecal Nitrogen (g/day)	0.79 ± 0.04 ^a	1.13 ± 0.02 ^c	1.19 ± 0.02 ^c	0.84 ± 0.03 ^b	0.81 ± 0.03 ^b	0.80 ± 0.04 ^b
Urinary Nitrogen (g/day)	0.08 ± 0.04 ^{bc}	0.02 ± 0.02 ^a	0.14 ± 0.02 ^d	0.06 ± 0.03 ^b	0.15 ± 0.02 ^{de}	0.18 ± 0.05 ^f
Nitrogen balance (g/day)	1.24 ± 0.04 ^d	0.79 ± 0.03 ^c	0.69 ± 0.04 ^b	0.58 ± 0.03 ^a	1.73 ± 0.02 ^e	1.71 ± 0.02 ^e
Initial weight (kg)	6.37 ± 0.06	6.93 ± 0.08	6.57 ± 0.05	6.40 ± 0.03	6.40 ± 0.03	6.40 ± 0.03
Final weight (kg)	7.40 ± 0.04	7.93 ± 0.04	7.83 ± 0.03	7.73 ± 0.04	8.83 ± 0.02	7.73 ± 0.04
Dry matter intake	179.76 ± 3.93 ^d	138.04 ± 4.36 ^a	152.47 ± 2.9 ^b	168.85 ± 2.18 ^c	218.97 ± 1.75 ^f	196.64 ^a ± 1.46 ^e
Daily weight gain (g/day)	18.39 ± 1.48 ^b	17.86 ± 1.65 ^a	22.68 ± 1.09 ^c	23.75 ± 0.82 ^c	39.29 ± 0.66 ^d	23.75 ± 0.55 ^c
Feed gain ratio	9.77 ± 0.79 ^a	7.73 ± 0.88 ^c	6.72 ± 0.59 ^{bc}	7.11 ± 0.44 ^{bc}	5.57 ± 0.35 ^a	8.26 ± 0.29 ^{cd}

a, b, c = means within the same row with different superscript are significantly ($p < 0.05$) different

The positive nitrogen balance obtained in this study signified that the diets were adequate in their supply of nitrogen to the rumen. Goats fed Diet E (20 % microbial treated husk based diet) had the highest weight gain (39.29 g/day). This was comparable with the results of 29.00 – 38.44 g/day obtained by Ibhaze (2015) for WAD goats fed fermented maize cob based diets. Results obtained in this study may be as a result of the palatability, protein quality of the feed and microbial protein available for the goats which stimulated high intake and consequent utilization of diets. This was in agreement with the findings of Adebowale and Taiwo (1996) that weight gain is dependent of the dry matter, protein intake and digestibility of the nutrient. However, goats fed Diet E also had the best feed/gain ratio (5.57) than all other goats fed the experimental diets. Considering the performance characteristics, goats fed husk based diets had better weight gain than the goats fed the cob based diets.

Conclusion: This study has been able to compare the nutrient potentials of microbial treated maize cob and husk diets in complete diets of WAD goats. However, microbial treated maize husk possesses better potentials to be used as feed stuff for goats than maize cob. Goats on Diet E (husk based diet, at 20 % inclusion level) showed better performance in terms of weight gain which is the interest of every farmer. Hence, treating maize husks using microorganisms (*N. crassa* and *L. delbrueckii*) helped in conversion of this agricultural waste to higher quality ruminant feed.

ACKNOWLEDGEMENTS

The authors are grateful to the management and staff of Teaching and Research Farm, Federal University of Technology, Akure for the provision of equipment and materials for the study.

REFERENCES

ABUBAKAR, U. S., YUSUF, K. M., SAFIYANU, I., ABDULLAHI, S., SAIDU, S. R., ABDU, G. T. and INDEE, A. M. (2016). Proximate

and mineral composition of corn cob, banana and plantain peels. *International Journal of Food Science and Nutrition*, 1(6): 25 – 27.

- ADEBOWALE, E. A. and TAIWO, A. A. (1996). Utilization of crop residues and agro-industrial by-products as complete diets for West African Dwarf sheep and goats. *Nigerian Journal of Animal Production*, 23(2): 153 – 160.
- AHAMEFULE, F. O., IBEAWUCHI, J. A. and IBE, S. N. (2006). Nutrient intake and utilization of pigeon pea-cassava peel based diets by West African Dwarf (WAD) bucks. *Pakistan Journal of Nutrition*, 5(5): 419 – 424.
- AKINFEMI, A., ADU, O. A. and DOHERTY, F. (2009b). Assessment of the nutritive value of fungi treated maize cob using *in vitro* gas production technique. *Livestock Research for Rural Development*, 21: 188. <http://www.lrrd.org/lrrd21/11/akin21188.htm>
- AKINFEMI, A., BABAYEMI, O. J. and JONATHAN, S. G. (2009a). Bioconversion of maize husk into value added ruminant feed by using white-rot fungus. *Revista Científica UDO Agrícola*, 9(4): 972 – 978.
- ALIMON, A. R. (2006). The nutritive value of palm kernel cake for animal feeds. *Palm Oil Developments*, 40(1): 12 – 14.
- ANDERSEN, F. A., BERGFELD, W. F., BELSITO, D. V., KLAASSEN, C. D., MARKS, J. G., SHANK, R. C., SLAGA, T. J. and SNYDER, P. W. (2011). Final report of the safety assessment of cosmetic ingredients derived from *Zea mays* (com). *International Journal of Toxicology*, 30(Suppl. 3): 17S – 39S.
- ARO, S. O., ALETOR, V. A., TEWE, O. O., FAJEMISIN, A. N., USIFO, B. and FAWOLO, A. B. (2008). Preliminary investigation on the nutrients, anti-nutrients and minerals composition of microbially fermented cassava starch residue. Pages 245 – 251. *In: Proceedings of 33rd Annual Conference of Nigeria Society of Animal Production*, held at Olabisi Onabanjo University,

- Ayetoro, Ogun State, Nigeria, March 16 – 20, 2008.
- BELEWU, M. A. (2001). Conversion of sorghum stover into feed by *Trichoderma harzanium* and the feeding of resulting materials to red Sokoto goats. *Bioscience Research Communication*, 13(1): 25 – 30.
- BELEWU, M. A. and OKHAWERE, O. C. (1998). Evaluation of feeding fungi treated rice husk to ram. *In: Proceeding of the 25th Annual Conference and Silver Jubilee of the Nigerian Society of Animal Production*, held between 21st and 24th March, 1998 at Gateway Hotel, Abeokuta.
- BELEWU, M. A., AFOLABI, O. Y., MUSA, A. K. and ADEROLU, A. Z. (2003). Chemical composition and biodegradability of corn cobs and *Gmelina arborea* saw dust colonized by edible mushroom. Pages 261 – 263. *In: Proceedings of the 28th Annual Conference of the Nigerian Society for Animal Production*. Held at Institute of Agricultural Research and Training, Obafemi Awolowo University, Ile Ife, Ibadan, Nigeria.
- BROERSE, J. E. W. and VISSER, B. (1996). Assessing the potential. Pages 131 – 180. *In: BUNDERS, J., HAVERKORT, B. and HIEMSTRA, W. (Eds.). Biotechnology: Building on Farmers' Knowledge*. Macmillan Education Limited, London, United Kingdom.
- CHEN, J., FALES, S. L., VARGA, G. A. and ROYSE, D. J. (1995). Biodegradation of cell wall components of maize stover colonized by white-rot fungi and resulting impact on *in-vitro* digestibility. *Journal of the Science of Food and Agriculture*, 68(1): 91 – 98.
- DANIEL, O. A. (2015). Urban extreme weather: a challenge for a healthy Living environment in Akure, Ondo State, Nigeria. *Climate*, 3(4): 775 – 791.
- DANMEK, K., INTAWICHA, P., THANA, S., SORACHAKULA, C., MEIJER, M. and SAMSON, R. A. (2014). Characterization of cellulase producing from *Aspergillus melleus* by solid state fermentation using maize crop residues. *African Journal of Microbiology Research*, 8(24): 2397 – 2404.
- UKANWOKO, A. I. and NWACHUKWU, J. (2017). Nutrient and anti-nutritional composition of crop residues and kitchen wastes fed to small ruminants in Choba, Port Harcourt. *Greener Journal of Agricultural Sciences*, 7(2): 054 – 059.
- DURU, C. E. (2020). Mineral and phytochemical evaluation of *Zea mays* husk. *Scientific African*, 7: e00224. <https://doi.org/10.1016/j.sciaf.2019.e00224>
- FAJEMISIN, A. N., OLUYEDE, A., IBHAZE, G. A., AGBEDE, J. O., ALOKAN, J. A. and FAJEMISIN, A. J. (2014). Nutrients intake and milk composition of lactating West African Dwarf goats fed varying levels of microbial degraded corncob diets. Pages 141 – 144. *In: LIANG, J. B., DEVENDRA, C., ORSKOV, E. R. and TAKAHASHI, J. (Eds.). Proceedings of 2nd Asia Dairy Goat Conference*. Organized by Faculty of Animal Science, Bogor, Agricultural/Australasian-Asian Dairy Goats Network held at IPB International Convention Centre Bogor, Indonesia, April 25 – 27th, 2014.
- FAWOLU, T. S. and FAJEMISIN, A. N. (2013). Performance of West African Dwarf ram fed amylotic micro-organism degraded corncobs based diets. Pages 484 – 486. *In: Proceedings of 38th Annual Conference of School of Agriculture and Agricultural Technology, held at the Federal University of Technology, Akure, Nigeria*. 21st May 2008.
- HAVLIK, D., BRANDT, U., BOHLE, K. and FLEIßNER, A. (2017). Establishment of *Neurospora crassa* as a host for heterologous protein production using a human antibody fragment as a model product. *Microbial Cell Factories*, 16: 128. <https://doi.org/10.1186/s12934-017-0734-5>
- HEUZÉ, V., TRAN, G., ARCHIMÈDE, H., RÉGNIER, C., BASTIANELLI, D. and LEBAS, F. (2016b). *Cassava Peels, Cassava Pomace and Other Cassava By-*

- Products*. Feedipedia, a Programme by INRA, CIRAD, AFZ and FAO. <http://www.feedipedia.org/node/526> Accessed August 30, 2020.
- HEUZÉ, V., TRAN, G. and LEBAS, F. (2016a). *Maize Cobs*. Feedipedia, a Programme by INRA, CIRAD AFZ and FAO. <https://www.feedipedia.org/node/718> Accessed August 22, 2020.
- KUO, H.C., HUI, S., CHOI, J., ASIEGBU, F. O., VALKONEN, J. P. and LEE, Y. H. (2014). Secret lifestyles of *Neurospora crassa*. *Scientific Reports*, 4: 5135. <https://doi.org/10.1038/srep05135>
- IBHAZE, G. A. (2018). Assessment of nutrient intake and nitrogen utilization by West African Dwarf goats fed milled bio-fibre waste rations. *Archiva Zootechnica*, 21(1): 33 – 40.
- IBHAZE, G. A. (2015). Feeding quality of fermented maize-cob based diets as feed for West African Dwarf goats. *Applied Tropical Agriculture*, 20(1): 52 – 56.
- LU, C. D., AKINSOYINU, A. O. and QI, K. (1991). Predicting dry matter intake of lactating goats. Pages 258 – 289. *In: Proceeding of the 7th National Conference on Goat Production*, Monterrey, Mexico.
- MAKKAR, H. P. S. (2002). Application of the in vitro gas method in the evaluation of feed resources, and enhancement of nutritional value of tannin-rich tree leaves and agro-industrial by product. Pages 23 – 40. *In: Development and Field Evaluation of Animal Feed Supplemental Packages. Proceeding of Final Review Meeting of IAEA Technical Cooperation Regional AFRA*.
- MCDONALD, P., EDWARD, R. A., GREHAIGH, J. F. D. and MORGAN, C. A. (1995). *Animal Nutrition*. 5th Edition, Pearson Education Limited, Edinburg Gate, Garlow Essex CM20 2JE, United Kingdom.
- MCDOWELL, L. R. (1992). *Minerals in Animals and Human Nutrition*. 1st Edition, Academic Press, New York, USA.
- MAIA, M. D. O., SUSIN, I., FERREIRA, E. M., NOLLI, C. P., GENTIL, R. S., PIRES, A. V. and MOURÃO, G. B. (2012). Intake, nutrient apparent digestibility and ruminal constituents of sheep fed diets with canola, sunflower or castor oils. *Revista Brasileira de Zootecnia*, 41(11): 2350 – 2356.
- NAWAZ, H., MUZAFFAR, S., ASLAM, M. and AHMAD, S. (2018). Phytochemical composition: antioxidant potential and biological activities of corn. Pages 49 – 68. *In: AMANULLAH, K. and FAHAD, S. (Eds.). Corn Production and Human Health in Changing Climate*. Intech Open, London. <http://dx.doi.org/10.5772/intechopen.79648> Accessed August 31, 2020.
- NENT (2016). *Guidelines for Research Ethics in Science and Technology*. The Norwegian National Committee for Research Ethics in Science and Technology. https://www.etikkom.no/globalassets/documents/english-publications/60126_fek_guidelines_nent_digital.pdf Accessed August 3, 2020.
- NRC (2007). *Nutrient Requirement of Small Ruminants*. National Academies Press, Washington DC, USA.
- OKOKON, J. E., ANTIA, B. S., MOHANAKRISHNAN, D. and SAHAL, D. (2017). Antimalarial and antiplasmodial activity of husk extract and fractions of *Zea mays*. *Pharmaceutical Biology*, 55(1): 1394 – 1400.
- OLAGUNJU, A., ONYIKE, E., MUHAMMAD, A., ALIYU, S. and ABDULLAHI, A. S. (2013). Effects of fungal (*Lachnocladium* spp.) pretreatment on nutrient and antinutrient composition of corn cobs. *African Journal of Biochemistry Research*, 7(11): 210 – 214.
- OLORUNNISOMO, O. A., ADEWUMI, M. K. and BABAYEMI, O. J. (2008). Effects of nitrogen level on the utilization of maize offal and sorghum brewer's grain in sheep diets. *Livestock Research for Rural Development*, 18(1): 10. <http://www.lrrd.org/lrrd18/1/olor18010.htm>

- PENETRANTE, M. (2010). *Lactobacillus delbrueckii*. MicrobeWiki, The Student-Edited Microbiology Resource. https://microbewiki.kenyon.edu/index.php?title=Lactobacillus_delbrueckii&oldid=56559 Accessed August 22, 2020.
- SAS (2001). *SAS User's Guide*. Statistical Analysis Institute Incorporated, Cary, North Carolina.
- SHINNERS, K. J., ADSIT, G. S., BINVERSIE, B. N., DIGMAN, M. F., MUCK, R. E. and WEIMER, P. J. (2007). Single-pass, split-stream harvest of corn grain and stover. *Transactions of the ASABE*, 50(2): 355 – 363.
- SIHLOBO, W. (2019). *Nigeria Becomes Sub-Saharan Africa's Leading Maize Producer*. Agric News, Africa. www.agriorbit.com/nigeria-becomes-sub-saharan Accessed August 30, 2020.
- SOCCOL, C. R., MARIN, B., RAIMBAULT, M. and LEBEAULT, J. M. (1994). Breeding and growth of *Rhizopus* in raw cassava by solid state fermentation. *Applied Microbiology and Biotechnology*, 41(3): 330 – 336.
- SUNDU, B., KUMAR, A. and DINGLE, J. (2006). Palm kernel meal in broiler diets: effect on chicken performance and health. *World's Poultry Science Journal*, 62(2): 316 – 325.
- VENTURA, M., MOORE, J. E., RUELKE, O. C. and FRANKE, D. E. (1975). Effect of maturity and protein supplementation on voluntary intake and nutrient digestibility of *Pangola digitgrass* hays. *Journal of Animal Science*, 40(4): 769 – 774.
- WESTENDORF, M. L. and WOHLT, J. E. (2002). Brewing by-products: their use as animal feeds. *Veterinary Clinics North America: Food Animal Practice*, 18(2): 233 – 252.
- WIKIPEDIA (2020). *Husk*. <https://en.wikipedia.org/w/index.php?title=Husk&oldid=965616861> Accessed August 22, 2020.



This article and articles in *Animal Research International* are Freely Distributed Online and Licensed under a [Creative Commons Attribution 4.0 International License \(CC-BY 4.0\)](https://creativecommons.org/licenses/by/4.0/) <https://creativecommons.org/licenses/by/4.0/>