



## Nutrient Digestibility and Rumen Metabolites of Yankasa Rams Fed Untreated Corn-cob-Sun-Dried Poultry Litter Mixture Ration with Different Energy Supplements

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### ABSTRACT

A feeding trial was conducted to determine the nutrient digestibility and rumen metabolites of yankasa rams fed grounded untreated corn-cob-sun-dried poultry litter mixture ration with different energy supplements for yankasa rams. A total of sixteen (16) Yankasa rams of about 10-12 months of age and having an average weight of 24 kg were used in an 84-day trial. The rams were randomly assigned into four (4) treatments with four (4) replicates per treatment in a completely randomized design (CRD). Four experimental diets were formulated and designated as: T1 (Corn cob + 150g SDPL + 150g MB), T2 (Corn cob + 150g SDPL + 150g RB), T3 (Corn cob + 150g SDPL + 150g MO), and T4 (Corn cob + 150g SDPL + 150g WO) and used to feed the Yankasa rams. The result of the performance of the rams showed that nutrient digestibility; CPD, EED, NDFD, ADFD, CELD and HEMD digestibility were significantly ( $P < 0.05$ ) affected across dietary treatments, except DMD and NFED digestibility were not significantly ( $P > 0.05$ ) across the treatments. Rams on T3 had higher ( $P < 0.05$ ) values (80.59) in CPD, while rams on T1 had higher ( $P < 0.05$ ) values (81.36) in NDFD and rams on T3 had higher ( $P < 0.05$ ) values (84.35) in ADFD. Observed results revealed that rumen metabolites (before and 2-hours after feeding) parameters were significantly ( $p < 0.05$ ) influenced by supplemental nitrogen sources across dietary treatments, except TVFA (before feeding) was not significantly ( $P > 0.05$ ) affected in all the treatments. There was slight increase in all the rumen metabolite parameters 2-hours after feeding. Rams on diet T3 recorded the highest ( $P < 0.05$ ) values (7.52 and 6.62) in rumen pH (before and 2-hours after feeding, respectively) and 7.73 value in rumen  $\text{NH}_3\text{-N}$  before feeding. Rams fed diet T2 and T1 had the highest ( $P < 0.05$ ) values (12.63 and 12.10, respectively) in rumen  $\text{NH}_3\text{-N}$  2-hours after feeding. Similarly, rams fed diets T2 had higher ( $P < 0.05$ ) value (117.26) which was statistically similar ( $P > 0.05$ ) to rams (113.17) on diet T4. Utilization of AIBPs generated from farms and feed mill not only will solve our environmental problem but also convert low quality residues into valuable local feed for ruminants. It can be concluded that feeding of corn cob with supplemental nitrogen to rams offers a potential result in the productive performance of Yankasa rams based on their nutrient digestibility and rumen metabolites qualities.

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### INTRODUCTION

Agro-industrial by-products (AIBPs) are solid or semi-solid residues originating from agricultural activity (Cabrera Núñez *et al.*, 2021). These AIBPs are mostly derived from the collection of a product or from some part of the

manufacturing agricultural processing industries such as cereal grain milling, oilseed extraction, brewery, malt production, fruit and vegetable processing (Atuhaire *et al.*, 2014). Major AIBPs are obtained from the processing of oilseeds and milling cereal grains for human consumption,



respectively (Wu, 2018). Among the by-products from these operations, brewer's grains or spent grains are highly valued as feed especially for dairy cattle and fattening animals (FAO, 2018). Crop residues are by-product after crop harvest and the quantity and quality of its harvest are directly linked to all the factors that normally affect the crop yield, but these residues are used as animal feed sources (Bhandari, 2019). Generally, by-products management is difficult, since they are characterized by seasonal, localized and perishable production. The industries that process agricultural products must find a final destination for the by-products that meet two minimum requirements: that it is not polluting the environment and that the processing and transportation costs are covered by the sale price of the same and do not generate costs, additional to production (Cabrera Núñez *et al.*, 2021). The inclusion of AIBP based diet had resulted in improved animal performance in terms of production and weight gain (Binuomote *et al.*, 2018). Utilization of agricultural by product as silage during the critical period of feed shortage will go a long way in reducing feed shortage e.g. corn cob and poultry dropping, although not aesthetically pleasing, has been recognized as a safe, nutritionally valid and environmentally friendly animal feed, especially when combined with other feed sources as supplements (Binuomote *et al.*, 2018). The characteristics of good silage are usually determined by colour, smell and texture. These AIBPs are generally feed with high energy, protein, some minerals, and vitamins, which are important rations for ruminants and non-ruminants to supplement other low quality feeds particularly roughages. Among the different by-products there is a high variability in the available chemical composition, some can be very regular in their composition because the industrial processes that generate them are highly controlled. While others may present a significant variation, so it is necessary to know the nutritional contributions when formulating the rations (Cabrera Núñez *et al.*, 2021). To assure better reproduction and production performance of sheep and thereby increase the supply of mutton in the country, feed resources for sheep must be improved in quality and increased in the supply of feeds (Shapiro *et al.*, 2015; CSA, 2019a, b). In the

literature, some AIBPs have been recently tested as replacers of human-edible feedstuffs (such as cereals) in the diet of farm animals (Natalello *et al.*, 2019; Biondi *et al.*, 2020). However, it could be reasonable to test a by-product to replace another by-product traditionally used in animal nutrition, especially when its production is more environmentally friendly (Adriana Campione *et al.*, 2020). So feeding cereal crop residue without treatment and supplementation could impede animal intake, and subsequently animal performance. That is why, an alternative approach has been proposed to improve degradability of fibres or any possible agricultural by-products for ruminant feeding which is by using lignocellulolytic fungi (Nur Nazratul *et al.*, 2019). Thus, the objectives of this study were to evaluate the in vitro nutrient digestibility and rumen metabolites of Yankasa rams fed grounded untreated corncob-sun-dried poultry litter mixture ration with different energy supplements.

## MATERIALS AND METHODS

### *Experimental Site*

The study was conducted at the Animal Farm of Aminu Saleh College of Education Azare Bauchi State from January – April, 2022. Azare is the second largest town in Bauchi State. It is situated between latitudes 11° 42' and 11° 40' and longitude 10° 11' east, at an elevation of 436 meters above sea level. It is 250km north of the state capital, Bauchi. It has an estimated land area of 11200 square kilometers (Katagum at a glance, 2003) located within the Sudan savanna agro-ecological zone of Nigeria. The annual rainfall is unimodal which averages about 700mm with a maximum temperature of 35°C. The mean monthly temperatures ranges from 20.10-22.50°C in December and January to 30.0-32.5°C in April and May. The temperature of the rainy season remains steady between 25°C-27°C for the month of June to October. The soils in the area are formed normally from Aeolian and/or alluvial deposits, and belongs to the entisols or inceptisol orders and the soil temperature regime is isohypothermic. The geology of the area is made up of sedimentary rocks comprising the kerri-kerri (sandstone) and Chad formation (Mustapha and Fagam, 2006).



### **Collection of Test Ingredient**

#### **Corn cob**

The test material (corn cob) was obtained from feed mill in Bauchi metropolis where the corn cob had already been grounded and bagged. To allow for more microbial digestion and passage out of the rumen, rumination and particle size reduction was considered essential functions to increase surface area of these feed particles (Dineen *et al.*, 2018). The feed was stored in appropriate, designated areas in an economical manner (Mid-West Plan Service MWPS, 2017). Feed in sacks used were stored off the floor and away from the walls on pallets or racks, and each sack was labeled, as recommended by the Association of American Feed Control Officials, with the contents and manufacture date (AAFCO, 2019).

#### **Sun-Dried Poultry Litter (SDPL)**

Broiler litter (deep litter) was collected from poultry farms within Bauchi metropolis. The poultry litter was collected from a finished broiler pens farm after the birds had attained eight (8) weeks; where it had been stored in an enclosed container before subsequent drying and pelleting (Pandey *et al.*, 2019). The litter was a mixture of chicken feces, residual feeds, feathers and material used as bedding such as wood shavings, sawdust and rice bran (Seyed *et al.*, 2017). The litter was spread (sun-dried) on cellophane sheets for air-drying for three days, referred to as sun-dried poultry litter SDPL (Ngele, 2008). Management practices for poultry litter to reduce nutrient losses from production facilities were carried out as in Kleinman *et al.* (2012) and were then packed into synthetic bags and transported to the animal farm and stored there for use.

#### **Experimental Diets**

Four experimental diets were compounded using the corn cob and the diets contained 150g MB + 150g SDPL, 150g RB + 150g SDPL, 150g MO + 150g SDPL and 150g WO + 150g SDPL supplements and corn cob was offered as basal diet, and these diets were tagged treatment T1, T2, T3 and T4 respectively.

#### **Experimental Animals, Housing and Management**

A total of sixteen (16) rams of average age of 10-12 months and average weight of 24 kg were bought from open market in a local market Bauchi and used for the study. Two weeks to the arrival of the animals, the experimental house was washed thoroughly using detergent and disinfectant (Izal) and allowed to dry. The feeding troughs and drinkers were also washed, sun-dried and kept in each compartment. After the arrival of the animals to the experimental site, all animals were thoroughly examined and closely monitored on the general health state (body temperature, food intake, behaviour, internal and external parasites and signs of their presence), and then especially on the respiratory system as described (Ibhaze, 2015). The animals were quarantined for three weeks during which they were identified using numbered plastic ear tags for easy identification. On arrival to the farm, the animals were treated against endo and ectoparasites using ivermectin and vaccinated against *Peste des petits ruminants* (PPR) disease using the PPR vaccine. The animals were weighed and randomly allotted into four (4) treatments groups and each treatment group had four (4) replicates. About 14 days were allowed for adjustment to the feed as well as the environment before data collection commenced. The animals were housed in individual pen equipped with concrete floor, feeders and drinkers under a common roof, constructed to minimize possibility of injury from aggressive behaviour or escape, to provide adequate ventilation, to enable animal to gain weight and other performance traits that may be depressed as a result of over-crowding, to allow for protection from wastes and to make appropriate postural adjustments (Callahan *et al.*, 2017). Daily, 150g of the concentrate supplements was offered to the animals at about 8:00 hour, then at 10:00 hour, the corn cob basal diet was served to the animals and this was *ad libitum*. Feeding of the corn cob basal diet was done twice, the first feeding was at about 10:00 hour while the second feeding was at 14:00 hour to help reduce wastage of the forage and encourage intake. All groups got minerals block or salt lick in pens which have advantages both in improving texture of food and in health (Okoye *et al.*, 2016). Animals were provided with fresh feed and water daily in a consistent manner, on a regular schedule, to give



the animals the right to hygienic water and freedom from thirst (Babayemi and Bamikole, 2010) in accordance with the requirements established for each species by the NRC (2016) and as recommended for the geographic area. Feed intake was measured by subtracting the weight of the left-over feed from the total weight of feed supplied. The animals were weighed weekly in order to find out their body weight changes.

### **Sanitation, Health Management and Animal Welfare**

All animals in this trial were managed according to guidelines recommended in the Guide for the Care and Use of Agriculture Animals in Agriculture Research and Teaching to ensure the animal incurs no undue pain or stress (AVMA, 2020). Much attention as possible was shown to the needs and natures of animals (AVMA, 2019). The aim was to provide a platform geared towards educating the scientific world on global best practices as it concerns humane handling and use of laboratory/experimental animals for research purposes (James *et al.*, 2019). Faeces and urine were removed every day from the feeding pens to ensure adequate ventilation, less ammonia accumulation, adequate cleanliness of the experimental pens and ensure minimum discomfort of the experimental animals.

### **Experimental Design**

A one (untreated corn cob) by four (supplements) factorial experiment in a completely randomized design (CRD) was used for the experiment (Steel and Torrie, 1980). There were four (4) treatments with four (4) rams per treatment (total of 16 rams).

### **Data Collection and Laboratory Analysis**

#### **Faecal Collection**

During the collection period, daily feed intake and total faecal output from each animal was measured daily using a weighing scale and recorded. Collection of faeces was made according to the procedures described by Nisa *et al.* (2004). The material collected was weighed, placed in well-labeled plastic bags and stored in a freezer at -20 °C for subsequent chemical analysis. Total quantity of faeces voided by each animal was collected for 7 days during the

digestion trial, was weighed and each day's collection was bulked, air-dried at 55 °C mixed thoroughly and 5% of the air-dried faecal samples were sub-sampled out and kept and harness for estimating apparent total tract nutrient digestibility. Composite samples were dried at 60 °C, ground (1-mm screen using Cyclotech Mill; Tecator, Hoganas, Sweden) and then analyzed for dry matter (DM), ether extract (EE) and crude protein (CP) content (AOAC, 2016), neutral detergent fibre (NDF), acid detergent fiber (ADF) (Van Soest *et al.* (1991).

### **Rumen Liquor Collection**

Rumen liquor/fluid was collected in the 6<sup>th</sup> week of the experiment. Rumen fluid was collected in mornings around 8–10 am before feeding and 12-2 pm after feeding by stomach tubing (Shingfield *et al.*, 2002) for all experimental animals once in each sampling period. It consists of using an oro-ruminal probe and a suction pump. Approximately 35 mL of ruminal fluid were obtained from each animal before and 2 hours after morning feeding by aspiration method using stomach tube. The samples were strained through muslin cloth four and pH determined using a portable pH meter. Ten mL of each sample were frozen and stored for later determination of concentrations volatile fatty acids (VFA). The remaining 25 mL were acidified with a few drops of concentrated sulphuric acid to give a pH below 3, frozen and stored for later analysis of ammonia-nitrogen (NH<sub>3</sub>-N) concentration.

### **Measurement of Rumen pH**

Techniques for continuous measurement of the ruminal pH were adopted as in other series of scientific investigations (Alzahal *et al.*, 2007a and b). Immediately after sampling collection, the pH of the rumen fluid readings was recorded within two minutes of collection through the use of a portable handheld AGB-75 laboratory digital pH meter which had been stabilized in distilled water with specific pH recommendation (Okoruwa *et al.*, 2016).

### **Determination of Rumen Ammonia Nitrogen (NH<sub>3</sub>-N)**



For determination of ammonia nitrogen ( $\text{NH}_3\text{-N}$ ) in rumen fluid, a sample of 10 ml was conserved with 10 ml of 200 g/L NaCl and frozen at  $-20^\circ\text{C}$  for  $\text{NH}_3\text{-N}$  determination. After thawing,  $\text{NH}_3\text{-N}$  concentration was determined by direct distillation in Kjeldahl equipment according to Cajarville *et al.* (2006), and the results were expressed as mg/100 ml of ruminal fluid.

#### Determination of Total Volatile Tatty Acids (TVFAs)

Total volatile fatty acids production was determined by steam distillation process using markham micro-distillation apparatus as reported by Yusuf *et al.* (2013). To determine volatile fatty acids (VFA) concentration, approximately 6 ml of the liquid contents were transferred into 10 ml plastic tubes and centrifuged at 11,000 rpm for 10 min. Subsequently, 3 ml of the supernatant was removed and centrifuged again under the same conditions. Thereafter, a 0.1-ml aliquot of supernatant was pipetted into an auto-sampler vial containing 0.9 ml of internal standard (0.75 mM 3-methylvaleric acid). VFA levels were analyzed using capillary gas chromatography (GC, Hewlett Packard 5890). The supernatant fraction was analyzed chromatographically for VFA essentially by the method of Brighenti (1997) (using 2-ethyl butyrate as an internal standard, rather than isovaleric acid). The TVFAs were calculated in micromoles per milliliter of rumen fluid and the individual acids expressed as a percentage of the total molar concentration.

#### Chemical Analysis

Representative samples of feed and faeces were collected and analyzed for chemical analysis for ash, crude protein, NDF and ADF in samples of feed, remaining feed and faeces were carried out according to AOAC procedures (2019). Following formula was used to calculate the digestibility of each nutrient (Blanco *et al.*, 2014);

$$\text{Apparent digestibility (\%)} = \frac{(\text{Nutrient in feed}) - (\text{Nutrient in faeces}) \times 100}{(\text{Nutrient in feed})}$$

..... (3)

#### Statistical Analysis

The data obtained from the study were subjected to analysis of variance (ANOVA) procedure (Steel and Torrie, 1980). Significant means was separated using Duncan's Multiple

Range Tests (Duncan, 1955) using the SPSS (2006) package (statistical package for social sciences) procedure.

#### RESULTS AND DISCUSSION

The chemical composition of the feedstuffs is reported in Table 1. The dry matter content of the diets ranged from 94.64% to 96.30%. This is higher than 91.1 and 90.17 reported by Olayemi *et al.* (2020) for untreated and urea molasses treated corn cob when fed to broiler chickens. Moisture content ranged between 3.71% and 5.36% while the crude protein values varied from 10.76% to 13.86%. The CP values obtained in this study are higher than the report of some researchers in a similar work such as 4.00-8.83 reported by Binuomote *et al.* (2018) when West African dwarf (WAD) rams were fed corncob-poultry dropping mixture silage, and 7.7-11.06 reported by Olayemi *et al.* (2020) when broiler chickens were fed with untreated and urea molasses treated maize cob but it is comparable to 9.95-11.89 reported by Ajagbe *et al.* (2020) when growing West African Dwarf (WAD) goat were fed nitrogen supplemented cassava peel meals. The CP content of the diets was generally higher than 8%, below which Norton (2003) observed that feeds will not provide the required levels of ammonia for optimum rumen microbial activity. Values above 8% for CP obtained in this study may be attributed to the supplemental nitrogen used in this study. Crude protein and dry matter are inversely related (Huang *et al.*, 2015). The crude fibre (CF) content of the diets ranged from 21.18% to 31.09%. The CF values obtained in this study are higher than 3.53 and 3.44 reported for untreated and urea molasses treated corn cob by Olayemi *et al.* (2020) but fell within the range 16.83-32.45 reported by Binuomote *et al.* (2018) when West African dwarf (WAD) rams were fed corncob-poultry dropping mixture silage. The fibre fractions show that the diets have the potentials to support intestinal movement and proper rumen function. This implies that the fibre fractions of the diet would enhance fermentation in the fore stomach of the animals. Fasaie *et al.* (2015) opined that excess fibre fractions especially NDF reduces the rate of fermentation and reduce feed intake, but moderate fibre leads to rapid rumen fermentation and potential



acidosis. Value of ether extract (EE) obtained ranged from 5.87% to 10.81% which was higher than 2.35 and 2.17 reported by Olayemi *et al.* (2020), 3.02 and 6.84 reported by Gabriel *et al.* (2018), 3.82 reported by Asiamah (2018) and 1.05-3.05 reported by Binuomote *et al.* (2018). Ash content obtained ranged from 1.45% to 2.15% were lower than the values 9.65-37.45 reported by Binuomote *et al.* (2018), 4.29 reported by Asiamah (2018), but similar with 2.07 and 2.64 reported by Olayemi *et al.* (2020). Nitrogen free extract varied from 45.51% to 47.09%. Fibre fractions, which are acid detergent fibre and neutral detergent fibre ranged from 27.54% to 31.52% and 26.96% to 36.48% respectively while hemicellulose, cellulose and lignin ranged from 10.40%-14.58%, 6.75% to 9.13% and 8.57% to 9.81%, respectively. The nutrient composition values observed for the dietary supplements in this study are comparable to those reported by Guimaraes *et al.* (2014). Thus confirming the potentials of these supplements as sources of supplemental nitrogen to corn cob which possess nutrient levels that for improving rumen microbial activities. Therefore, these supplements have the potentials to generate a high level of ammonia in the rumen and promote an efficient digestion process.

The values for nutrient digestibility of Yankasa rams are presented in table 2. Nutrient digestibility in growing animals is the classical and direct method for estimating feed digestion by ruminants; hence studies on digestibility of ruminant feeds are very important as they allow for the estimation of nutrients actually available for ruminant nutrition (Yashim *et al.*, 2016). Digestibility values for dietary dry matter (DM), crude protein (CP), crude fibre (CF), neutral detergent fibre (NDF), acid detergent fibre (ADF), ether extract (EE), cellulose, hemi-cellulose and nitrogen free extract (NFE) were generally high and significantly ( $P < 0.05$ ) differed among the treatment. However, no significant ( $P > 0.05$ ) difference was observed among treatments in terms of on DMD and NFE digestibility. The digestibility of the nutrients obtained in this present study was comparably high. Increased nutrient digestibility indicates that the rumen is in better condition, leading to better fermentation (Putri *et al.*, 2021). The high nutrient digestibility obtained in this study might be due to the nature of diet,

palatability, protein level and energy content of the supplements. This may increase microbial population and also improves the rate of digesta. High digestibility improves ruminant productivity, because the nutrients can optimally utilize (Sharif *et al.*, 2019). This improvement may also be due to the resulting nutrient abundance above what was required for improving digestibility (Putri *et al.*, 2021). High-value digestibility reflects the contribution of specific nutrients to livestock. Meanwhile, feed which has a low digestibility indicates that the meal is less able to supply nutrients for basic life and livestock production purposes (Mirzah and Muis, 2015). Therefore, high dry matter digestibility (DMD) may indicate high palatability and acceptability of the diet. Gabriel *et al.* (2018) had posited that high nutrient digestibility indicated that the diets were palatable. The higher digestibility values might suggest the positive effects of supplementation on the Yankasa rams corn cob. More so, the dietary fibre in the supplements could be said to have no hindering effect on nutrient intake or their utilization. Ajagbe *et al.* (2020) asserted that the rumen bacteria were able to rapidly hydrolyze cellulose from the dietary supplements in this study there- by converting the end products to volatile fatty acids which form important part of ruminant energy intake. There was significant difference ( $P < 0.05$ ) on CPD digestibility among treatments. The current result was higher than the range value (47.5-61.9g/d) reported by Teklu Wegi *et al.* (2018) fed different varieties of faba bean (*Vicia faba L.*) straws supplement with concentrate mix for Arsi-Bale sheep. The apparent digestibility of CP in this study is higher than the results 60% of CP digestibility reported by Yeshambel Mekuriaw and Bimrew Asmare (2018) for Washera sheep supplemented with Chibha (*Ficus thonningii*) leaves. It is also higher than the value 69 and 71.9% reported by Almaz Ayenew *et al.* (2019) and Mezgebu Getent *et al.* (2019) for Gumuz lambs supplemented with Camel's Foot Tree (*Piliostigma thonningii*) leaf meal and toasted soybean grain, respectively. The inconsistency of CP digestibility in different studies might be attributed to the feed preparation and processing methods and the difference of sheep breeds used in respective trials. The NDF and ADF digestibility were better in rams fed T1 (81.36) and T3 (84.35),



respectively, compared with other rams. The difference observed in NDF and ADF digestibility could be due to microbial activity in the rumen and the composition of the diets (Gadzama *et al.*, 2017). The current value was similar with 74.48 - 81.36 and 83.41 - 84.35 of NDF and ADF value reported by Alemu Tarekegn *et al.* (2019) for Abergelle goat supplemented with cowpea hay. The inconsistency of findings might be related to the nature of feeds and processing methods, feeding practices and species and breeds of animals used in different experiments. The higher NDF and ADF digestibility observed in all treatments supplemented groups in the current study might be due to high feed intake and diets are rich in nitrogen that facilitates fermentation of roughage feeds in ruminants. The greater content of NDF could increase the time spent for rumination in the rams (Poczynek *et al.*, 2020). The improvement in ram's performance and overall increase in digestibility could be due to nutritional additive effect (Gadzama *et al.*, 2017). The study by Mezgebu Getent *et al.* (2019) indicated that DM intake was positively correlated with OM, CP and ADF intake and digestibility. Ephrem *et al.* (2015) also reported that different supplements used in different sheep breeds improved the digestibility of CP without affecting DM, OM, NDF, and ADF digestibility.

The results of rumen metabolites of the experimental Yankasa rams is presented in table 3. The rumen pH values range 7.17 - 7.63 before feeding and 6.34 - 6.53 2-hours after feeding are significantly ( $P < 0.05$ ) different across treatment, and are slightly higher than 5.90 - 6.45 reported (Kolo *et al.* 2018) when WAD goats were fed urea-fortified corn cob diets. The pH values obtained were slightly above the pH range (5.8 - 6.4) recommended for normal feeding practices for ruminants (Banakar *et al.*, 2018). This is in agreement with the reports of some researchers (Weng, 2013 and Zhang *et al.*, 2013) that if the rumen pH is in the range of 6.2 to 7.0, the ecological environment of rumen microorganisms could be relatively stable, which could ensure normal rumen fermentation. The higher apparent rumen pH observed in animals on diets before feeding and 2-hours after feeding could probably be due to less fermentable of feed components that were consumed by the animals. The

implication of these higher rumen fluid pH values observed was that ciliate protozoa population might have established well in such rumen environment and encourage fauna and faunation in the rumen (Okoruwa *et al.*, 2016). This result revealed that the rumen pH values were not affected by source of nitrogen. The higher apparent rumen pH observed in animals before feeding could probably be due to less fermentable of feed components that were consumed by the rams (Okoruwa *et al.*, 2016). The mean rumen pH was lower 2-hours after feeding because intake of feed has a major effect on rumen pH which generally declines after feeding (Maekawa *et al.*, 2002a). The significant decline in rumen pH at 2-hours after feeding could be as a result of high concentration of TFVAs, as it has been reported that high concentration of VFA has a reducing effect over rumen pH (Abubakar *et al.*, 2010). The observed reduction in the rumen pH 2-hours after feeding could be attributed to the reduced saliva secretions and increased volatile fatty acids (VFA) production in rams. Rumenal pH is mainly influenced by the intake of fermentable carbohydrates, rate of production, the time from concentrate feed supplementation to ruminal liquid collection, and the insertion depth of the rumen catheter, absorption and utilization of VFAs (Banakar *et al.*, 2018). Rumen pH is an important factor affecting fermentation in the rumen and influences its function (Dan Abba *et al.*, 2020). Rumen pH is a critical factor in the normal and stable functioning of the rumen because of its profound effect on microbial populations and fermentation products, and on physiological functions of the rumen (Kirwan *et al.*, 2021).

The ruminal concentration of ammonia nitrogen ( $\text{NH}_3\text{-H}$ ) is an effective indicator of microbial activity in the rumen (Adeyemi *et al.*, 2016; Khaing *et al.*, 2016). Rumen  $\text{NH}_3\text{-N}$  which ranged from 6.96 - 7.37 mg/100 ml of rumen liquor before feeding and 10.47 - 12.63 mg/100 mL 2-hours after feeding are significantly ( $P < 0.05$ ) different across treatment, and are similar to 11.10 - 12.15 before feeding and 9.5 - 11.5 2-hours after feeding reported by Babale *et al.* (2018) but slightly higher than 8.86 - 11.98mg/100 reported by Bata *et al.* (2020). The concentration of  $\text{NH}_3\text{-N}$  fell slightly below the required values (11.92-13.95 mg/100 mL) for optimal rumen microbial growth



(Ramaiyulis *et al.*, 2019). The differences observed could be attributed to several factors affecting  $\text{NH}_3\text{-N}$  concentration in the rumen which included animal breed, nutritional status, age of the animal and level of supplementation (Jokthan *et al.*, 2013). The rumen  $\text{NH}_3\text{-N}$  therefore increased 2-hours AF across dietary treatments. The  $\text{NH}_3\text{-N}$  was higher in rams fed 150gSDPL + 150gMO supplements before feeding and rams fed 150gSDPL+ 150gRB supplement 2-hours after feeding. This could be assumed that supplementation with poultry litter resulted in higher supply of N than required by the microbes. Okoruwa and Onuwahagbe (2019) asserted that high degradability and solubility of CP in the diet could likely release more  $\text{NH}_3\text{-N}$  in the rumen of the animals. Okoruwa and Onuwahagbe (2019) asserted that this higher  $\text{NH}_3\text{-N}$  concentration is associated with higher rumen TVFA which is an indicator of higher fermentation rate of the diet. On the other hand, the reduction of rumen  $\text{NH}_3\text{-N}$  accumulation could reflect to the depression of microbial activity known as proteolytic bacteria related to the improvement of nitrogen retention on test diets (Okoruwa and Onuwahagbe, 2019). Munza *et al.* (2021) reported that the pattern of rumen  $\text{NH}_3\text{-N}$  production was dependent on the pattern of intakes of basal diet, concentrate and total dry matter intake.

Total VFA concentration before feeding was not significant ( $P>0.05$ ) across dietary treatments. However, it was significant ( $P<0.05$ ) 2-hours after feeding due to supplementation of different types of protein concentration. The highest TVFA concentration (117.26) 2-hours after feeding was recorded for rams fed 150gSDPL + 150gRB supplementation which was ranked statistically similar ( $P>0.05$ ) with rams fed (150gSDPL + 150gMO supplement. Bello (2017), suggested that the increase in the treatment diets improved the anaerobic fermentation of the diet which could have stimulated the yield of more TVFAs. It is likely that the SDPL supplementation encouraged the amylolytic bacterial population noted for fermentation of experimental diets. Supplementary feeding with an appropriate amount of concentrate (which increases the

soluble carbohydrate content of the diet) was previously shown to lead to more ruminal VFA production by microbial fermentation, thereby providing energy to the host (Qiu *et al.*, 2019). However, the difference in proportions of VFA obtained could be linked to the difference in fermentation rate of neutral detergent fibre (NDF) and starch content in the diets (Wang and Wang, 2016). Rumen TVFA was noted in literature to depend on factors like digestibility, rate of absorption, rumen pH, rate of digestion passage from rumen to other parts of the digestive tract as well as the activities of microbial population (Kholif *et al.*, 2014). Volatile fatty acids contribute about 70% of the energy requirement for ruminants; hence they are classified as one of the universal end-product of anaerobic microbial fermentation of carbohydrates in the rumen (Okoruwa *et al.*, 2016).

## CONCLUSION

This study revealed that better nutrients digestibility and nitrogen utilization could be obtained by supplementing non protein nitrogen sources in the diets of Yankasa rams. Therefore, supplementing grounded corn cobs with non-protein nitrogen sources in the diet of small ruminants especially rams can improve intake, digestibility and protein quality of ram's diet. It is suggested that the use of supplemental nitrogen sources such as poultry litter should be given adequate consideration in ruminant production so as to achieve better productive performance especially rams in the tropics. Thus, maize cobs mixture with other energy supplements can be used as a low-cost diet for rams without adverse effects on growth performance. Utilization of AIBPs generated from farms and feed mill not only will solve our environmental problem but also convert low quality residues into valuable local feed for ruminants. It can be concluded that feeding of corn cob with supplemental nitrogen to rams offers a potential result in the productive performance of Yankasa rams based on their nutrient digestibility and rumen metabolites qualities.

**Table 1:** Chemical composition of Corncob-sun dry-poultry litter mixture with various energy supplements

Parameters	Diets
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	Corn cob (CC)	TRT 1 CC + MB + SDPL	TRT 2 CC + RB + SDPL	TRT 3 CC + MO + SDPL	TRT 4 CC + WO + SDPL
Moisture	4.57	4.19	3.71	4.57	5.36
Ash	1.80	1.74	1.45	1.89	2.15
CP	4.98	11.38	10.76	11.09	13.86
CF	35.08	31.09	26.42	24.56	21.18
DM	95.43	95.81	96.30	95.43	94.64
EE	4.80	5.87	10.70	10.81	9.96
NFE	48.76	45.72	46.98	47.09	45.51
NDF	41.22	36.48	31.06	28.89	26.96
Cellulose	10.10	9.13	7.77	7.10	6.75
Hemicellulose	9.91	10.40	14.58	14.40	13.34
Lignin	8.77	8.57	9.81	9.43	8.81
ADF	28.20	27.54	31.52	30.31	28.32

CP = Crude protein; CF = Crude fibre; DM = Dry matter; EE = Ether extract; NFE = Nitrogen free extract; NDF = Neutral detergent fibre; ADF = Acid detergent fibre; TRT = Treatment; CC = Corn cob

**Table 2:** Nutrient utilization and digestibility of Yankasa rams fed grounded corn cob supplemented with sun-dried broiler litter and different energy concentrate mixture

Parameters	Diets				SEM
	TRT 1 MB + SDPL	TRT 2 RB + SDPL	TRT 3 MO + SDPL	TRT 4 WO + SDPL	
DMD	67.71	67.34	66.62	67.78	0.83 <sup>NS</sup>
CPD	77.22 <sup>b</sup>	75.99 <sup>c</sup>	76.99 <sup>bc</sup>	80.59 <sup>a</sup>	0.53 <sup>*</sup>
EED	91.07 <sup>c</sup>	95.16 <sup>a</sup>	95.14 <sup>a</sup>	94.82 <sup>b</sup>	0.10 <sup>*</sup>
NFED	52.51	55.36	53.30	54.42	1.43 <sup>NS</sup>
NDFD	81.36 <sup>a</sup>	74.61 <sup>c</sup>	75.16 <sup>b</sup>	74.48 <sup>c</sup>	0.24 <sup>*</sup>
ADFD	83.41 <sup>b</sup>	83.55 <sup>b</sup>	84.35 <sup>a</sup>	83.71 <sup>b</sup>	0.20 <sup>*</sup>
CELD	81.50 <sup>a</sup>	74.72 <sup>b</sup>	75.16 <sup>b</sup>	74.70 <sup>b</sup>	0.30 <sup>*</sup>
HEMD	86.86 <sup>c</sup>	89.67 <sup>b</sup>	90.24 <sup>a</sup>	89.69 <sup>b</sup>	0.13 <sup>*</sup>

<sup>abc</sup>Means with different superscript within rows differed significantly (P<0.05), SEM = Standard Error of Mean. NS = Not significant, TRT = Treatment, MB = Maize bran, RB = Rice bran, MO = Millet ofal, WO = Wheat ofal, SDPL = Sun-dried poultry litter

**Table 3:** Rumen metabolites of Yankasa rams fed untreated corn cob with different energy sources

Parameters	Diets				SEM
	TRT 1 MB + SDPL	TRT 2 RB + SDPL	TRT 3 MO + SDPL	TRT 4 WO + SDPL	
pH bf	7.26 <sup>b</sup>	7.63 <sup>a</sup>	7.52 <sup>a</sup>	7.17 <sup>b</sup>	0.07 <sup>*</sup>
pH af	6.41 <sup>b</sup>	6.34 <sup>b</sup>	6.62 <sup>a</sup>	6.53 <sup>a</sup>	0.07 <sup>*</sup>
NH3-N bf	6.96 <sup>b</sup>	7.07 <sup>b</sup>	7.37 <sup>a</sup>	7.22 <sup>ab</sup>	0.13 <sup>*</sup>
NH3-N af	12.10 <sup>ab</sup>	12.63 <sup>a</sup>	10.47 <sup>c</sup>	11.56 <sup>b</sup>	0.41 <sup>*</sup>
TVFA bf	98.72	97.14	97.54	92.58	3.42 <sup>NS</sup>
TVFA af	109.58 <sup>b</sup>	117.26 <sup>a</sup>	109.26 <sup>b</sup>	113.17 <sup>ab</sup>	2.87 <sup>*</sup>

<sup>abc</sup>Means with different superscript within column differed significantly (P<0.05), SEM = Standard Error of Mean. NS = Not significant, TRT = Treatment, MB = Maize bran, RB = Rice bran, MO = Millet ofal, WO = Wheat ofal, SDPL = Sun-dried poultry litter, bf = before feeding, af = After feeding, NH3-N = Ammonia nitrogen and TVFA = Total volatile fatty acids.

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