Research Journals

Journal of Animal Science and Veterinary Medicine
Volume 9(5), pages 193-200, October 2024
Article Number: 62C9E37D2
ISSN: 2536-7099
https://doi.org/10.31248/JASVM2024.465
https://integrityresjournals.org/journal/JASVM

Full Length Research

Impact of organic ration formulation for sustainable and profitable small ruminants production in Nigeria

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Received 13th August 2024; Accepted 1st October 2024

ABSTRACT: The experiment was carried out at the Livestock Farm of Yobe State College of Agriculture, Science and Technology Gujba, Damaturu, Nigeria. Twelve (12) weeks feeding trial was conducted to evaluate the impacts of feeding formulated organic ration on the growth performance of Red Sokoto bucks. Four organic diets were formulated using clay (montmorillonite) at 0%, 1%, 1.5% and 2.0%. The diets were coded T1, T2, T3 and T4 respectively. Sixteen (16) Red Sokoto bucks were randomly assigned to the four experimental diets in a completely randomized design (CRD). Each treatment group was replicated four times with one buck per replicate. The proximate composition of formulated diets showed it contains 97.50% DM, 9.68% CP, 28.37% CF, 7.30% EE, 48.28% NFE and 3.87 Ash. The fibre fraction revealed 66.57% NDF, 18.83% ADF, 17.62% Cellulose, 45.88% Hemicellulose and 0.8% lignin. The parameters measured were live weight, total feed intake (TFI), average daily weight gain (ADG), and feed conversion ratio (FRC). There was a significant ($p<0.05$) difference in weight gain, and ADG, between all the treatments. The haematological parameters showed no significant ($p<0.05$) difference in RBC, Haemoglobin, MCV, MCH, MCHC and PCV. In nutrient digestibility, animals fed diets containing 1.0% level of clay were however significantly higher in terms of nutrient digestibility. Animals in treatment 2 served with 1.0% clay in their diet performed better. Therefore, feeding growing Red Sokoto bucks organic diet with1.0% clay (montmorillonite) inclusion improves their performance,

Keywords: Organic ration, production, profitable, small ruminant, sustainable.

INTRODUCTION

There is a current need to increase global livestock production in line with consumers' preferences for more sustainable and 'natural' products. Organic farming is considered among the potential production systems and market strategies that could be employed to cope with this change. Organic animal nutrition is an important pillar, as it has clear potential to significantly increase the sustainability of organic animal production, as it greatly influences feed efficiency and animal health. Under situations where animal health care is technically more challenging, due to limitations in the use of veterinary drugs (such as inorganic farming), the importance of feed is even higher. To properly address this issue, a well-established organic ration formulation must be the answer (Escribano, 2018).

For organic ration formulation to succeed, producers should know basic animal nutrition, be familiar with common nutrition terms, and understand the nutritional requirements of the animals at different stages of life. This begins with knowing the essential nutrients. The small ruminants need—energy (fat and carbohydrates), protein, vitamins, minerals, and water, and the source of all these nutrients must come from organic sources, which must be free from any sort of synthetic chemicals, such as inorganic fertilizer, pesticide, insecticide, genetically modified organism etc (Blanco-Penedo and Emanuelson, 2012). As a rule in both organic and conventional feed formulations, the ingredients are almost similar only that the ingredients in organic feed formulation must be produced organically, but in the case of minerals a substitute for synthetic minerals must be used such as clay (Blanco-Penedo and Emanuelson, 2012). In the case of minerals in organic feed formulation, clay is usually used as minerals of natural source hence we used montmorillonite clay as a source of minerals.

Clay is considered one of the ingredients that can be used in animal husbandry as a source of minerals and organic substances to optimize the performance of animals (Murray, 2007). The clay is made up of hydrated aluminosilicate of alkali and alkaline earth cations and plays an ion–exchange role to absorb molecules (absorption property) and exchange their constituent cations without undergoing structural changes (Karatzia *et al.,* 2011). Clay is a natural compound which performs body detoxification and mediates gastrointestinal infection against rumen disorder (Doyle, 2006). All clay minerals play a crucial role in ruminants. Montmorillonite attracts monovalent and divalent ions, which bind proteins and nitrogenous compounds, reducing protein degradation which increases bypass protein from the rumen (Sulzberger *et al.,* 2016). The mode of action of each is associated with their chemical structure and properties (Karatzia *et al*., 2011).

By adding clay to ration, toxic substances can be bound and immobilized in animal gastrointestinal tracts reducing their toxicity (Subramaniam and Kim, 2015). Clay has the ability to absorb ammonia produced in the rumen, and because of its great absorption capacity, it can protect animals from hazardous ammonia built-up by preventing excessive ammonia from building up in the rumen (Diaz *et al,* 2004). Montmorillonite mostly consists of silicon dioxide (SiO_2), magnesium oxide (MgO), aluminium (Al_2O_3) and sodium dioxide (Na_2O) (EFSA, 2013) and it is a proven safe feed additive for animals (EFSA, 2016). Montmorillonite is one of the frequent natural clays in Egypt used in animal diets to increase feed intake, nutrient digestibility, and growth rate (Saleh *et al.,* 1999; Salem *et al.,* 2001). The study evaluated the impact of organic ration formulation for sustainable and profitable small ruminant production (red Sokoto goat).

MATERIALS AND METHODS

Location of experiment

The study was conducted at the Animal Farm of Yobe State College of Agriculture, Science and Technology Gujba, Damaturu. Damaturu is located between latitude 11° 43’ and 37” North and longitudes 11° 58’ and 26" East with an elevation of 456 m above sea level. The area is characterized by a short period of rainfall (June – September) and a long period of dry season (October - May). With mean daily maximum temperature ranges from 29.2°C (July and August) to 43°C (March and April). Annual rainfall ranges from 500 to 1000 mm and usually from June to September (YSGHP, 2011).

Experimental feed sourcing, preparation and diet formulation

The feed ingredients were obtained from the organic farming unit of the college which included maize offal, poultry droppings, cotton seed cake, rice bran, cowpea hay, and clay (montmorillonite). One experimental diet was formulated with the following ingredients maize offal (40.65%), poultry droppings (15.70%), cotton seed cake (14.70%), rice bran (0.95%), cowpea hay (28.00%) and clay (montmorillonite). The clay (montmorillonite) was added at the rate of 0, 1.0, 1.5, and 2.0kg/100kg diet for diets 1, 2, 3 and 4 respectively. The experimental design is a completely randomized design (CRD). The gross compositions of the experimental diets are shown in Table 1.

Experimental animals and their management

Sixteen (16) red Sokoto bucks were purchased from village markets around Damaturu and used for the experiment. The animals were quarantined in the livestock farm of the College of Agriculture, Science and Technology Gujba, Damaturu. Treated against ecto and endo parasites with ivermectin (1ml per 10kg live body weight) and treated with oxytetracycline Hcl (a broad spectrum antibiotic) at a dosage rate of 2 ml/10kg live weight against possible bacterial infection. The faeces and urine of the animals were removed every day from the feeding pens to ensure adequate hygiene and minimal ammonia accumulation. Feed and water troughs were cleaned every morning before feeding. Before the commencement of the experiment, the animals were managed intensively and group fed with cowpea hay and wheat offal.

Feeding procedure

Four animals were allocated as a treatment in the feeding trials. Each animal was housed in a pen measuring 2 m × 1 m, and each group was assigned to one of the experimental diets and fed *ad libitum* in the morning and evening for 12 weeks (84 days). Water was offered *ad libitum*.

Table 1. Composition and calculated values of the organic experimental diet (%).

Ingredients (kg)	Treatments			
	1	2	3	4
Clay (montmorillonite)	0	1.00	1.50	2.00
Maize offal	40.65	39.65	39.65	39.65
Poultry dropping	15.70	15.70	15.20	15.70
Cotton seed cake	14.70	14.70	14.70	13.70
Rice bran	0.95	0.95	0.95	0.95
Cowpea hay	28.00	28.00	28.00	28.00
Total	100	100	100	100
Calculated values				
Crude fibre	23.37	24.46	24.23	24.56
Crude protein	12.21	13.11	12.03	12.12
Ether extract	7.30	4.27	5.11	5.54
Energy (Kcal/kg)	2095.12	2217	2122	2134

Data collection

The animals were weighed to balance the weight prior to the commencement of the experiment and subsequently on the same day of every week between 8:00-9:00 am after withdrawing feed for 14-16 hours to avoid error due to gut fill (Muhammad, 2005). Daily record of feed intake and weekly body weight was taken throughout the 12 weeks of the feeding trials.

Proximate and fibre analysis of the formulated organic diet

Thoroughly mixed representative sample of the formulated organic diet was analyzed for the proximate composition according to the AOAC (2000) procedure to determine the moisture content, crude protein (CP), crude fibre (CF), ether extract (EE) and Ash, while fibre fraction was analyzed according to procedure described by Van Soest *et al.* (1991).

Blood sample collection

Blood samples were collected from the animals in each group after the 12 weeks of experiments, the blood samples were collected from the jugular vein using a sterilized disposable 5 ml syringe and 23 gauge needle. The sample from each replica of the treatment was collected in tubes coated with ethylene diamine tetraacetic acid (EDTA). The blood samples in the EDTA bottle were centrifuged and processed for haematological parameters.

Analytical techniques

Haematological indices determination

The haematological parameters measured were packed cell volume (PCV), red blood cells (RBC) count, white blood cells (WBC) count, leucocyte differential count and haemoglobin concentration (Hb) in accordance with the methods outlined by Bush (1975).

Erythrocyte indices which include the mean corpuscular volume (MCV) and mean corpuscular haemoglobin concentration (MCHC) were computed in accordance with the standard formulae of Schalm *et al.* (1975) and Jain (1986).

Digestibility trial

At the end of the feeding trial, a digestibility trial was conducted using three animals from each treatment. The animals were fed the same experimental diets used in the feeding trial. The trial lasted for 14 days with 7 days for adaptation to harness bag and 7 days for faecal samples collection. The total weight of faecal output from each animal was recorded daily from both wet and in dry form and 5% of it was oven-dried at 80°C for dry matter determination and then stored for subsequent analysis

Statistical analysis

The data generated from the experiment were subjected to analysis of variance (ANOVA) using a completely randomized design (Steel and Torrie, 1980) and stat view

Table 2. Proximate and fibre composition of the formulated organic diet.

Parameters	Composition (%)
Dry matter (DM)	97.50
Crude protein (CP)	9.68
Crude fibre (CF)	28.37
Ether extract (EE)	7.30
Nitrogen free extract (NFE)	28.48
Ash	3.87
Fibre components	
NDF	66.57
ADF	18.83
Cellulose	17.62
Hemicellulose	45.88
Lignin	0.8

ADF- Acid detergent fibre, NDF- Neutral detergent fibre.

statistical package (SAS, 2002). Where significant differences exist, the Least Significant Difference (LSD) was used to separate the means as described by Steel and Torrie (1980).

RESULTS AND DISCUSSION

Proximate and fibre composition of the formulated organic diet

The proximate composition of the experimental diet is presented in Table 2. The result revealed that the experimental diet had 97.50% DM, 9.68% CP, 28.37% CF, 7.30% EE, 48.28% NFE and 3.87 Ash. The fibre fraction revealed 66.57% NDF, 18.83% ADF, 17.62% Cellulose, 45.88% Hemicellulose and 0.8% lignin. However, neutral detergent fibre (NDF) was observed to be higher in the fibre fraction followed by Hemi cellulose, Acid detergent fibre (ADF), Cellulose and Lignin in that order (Table 2).

The crude protein content of the diet obtained in this study was above 8% required to satisfy the requirement of ruminant animals (NRC, 1995) necessary to provide the minimum ammonia level required by rumen microorganisms to support optimum activity (Gatenby, 2002; Norton, 2003). And the range of 10-13% prescribed by ARC (1990) that is capable of supplying adequate protein for maintenance and moderate growth. The high level of crude protein could have influenced a higher intake of feed. High CP could increase voluntary feed intakes (Chriyaa *et al.* 1997). The crude fibre content obtained in this study was above the range of 15-20% recommended for improved intake and production in finishing ruminants (Buxton, 1996). The ether extract content of the diet was within the recommended range of 4-10% as reported by Preston (1995) and Campbell *et al.* (2006). Nitrogen-free extract obtained in this study was below the range of 52.23 - 58.07% obtained by Maigandi and Nasiru (2006).

The fibre fraction (ADF, NDF, cellulose and hemicellulose) obtained were higher in diets and that may affect DM intake as reported by Miessner *et al.* (1991). The nutrient detergent fibre (NDF) was below 60.0% suggested by Abolaji *et al.* (2007) as critical for limit for efficient utilization of roughages.

Performance characteristics of Sokoto red bucks fed with organic ration

The results (Table 3) indicated no significant difference in initial weight, final weight, and total feed intake (p>0.05). There was no significant difference between treatments 1 and 3, 2 and 4 in FCR (p>0.05). FCR values indicated good performance for animals in treatment 1 followed by animals in treatment 2. There was a significant difference (p<0.05) in weight gain, and ADG, between all the treatments. Animals in treatment 2 served with 1.0% clay in their diet performed better. This is in agreement with the finding of Helmy *et al.* (2022) who found that the inclusion of clay minerals at 1.0% in the diet of lactating boar goat positively affects their performance

Haematological profile of Sokoto red bucks fed with organic ration

The results (Table 4) indicated no significant difference in RBC, Haemoglobin, MCV, MCH, MCHC and PCV (p<0.05). There was no significant difference between treatments 1 and 4 in platelets (p<0.05). Platelet was significantly higher for animals that received 1.0 kg of clay in their ration (treatment 2). The non-significant difference in RBC, Haemoglobin, MCV, MCH, MCHC and PCV composition of the experimental animals irrespective of the level of clay supplement suggests that even the highest level of supplementation is not detrimental to the animals. The WBC is significantly higher in treatment 4. However, the WBC values reported in the present study were higher than 6.93 – 12.66 x10^9/l observed by Waziri *et al.* (2010). This variation could be attributed to the variation in the level of the clay added as proposed Valpotić (2018) who stated that clay was effective as an immunomodulatory agent by promoting the recruitment of circulating and intestinal lymphoid cells. In the platelets, there is no significant difference between treatments 1 and 4. Treatment 2 is significantly higher among the treatments.

The RBC values in these findings were within the normal range of 8.00-18.00x10^{12} reported by Oduye and Adadevoh (1976) for goat. This indicated that the goats were not anaemic and the haemoglobin was also adequate.

Table 3. Performance characteristics of Sokoto red bucks fed with organic ration.

Parameters	Treatments				SEM
	1	2	3	4	
Initial weight (kg)	14.70	14.40	14.33	14.18	0.25
Final weight (kg)	16.58	17.13	16.60	16.63	0.29
Weight gain (kg)	1.88[c]	2.80[a]	2.20[bc]	2.45[ab]	0.10
ADG (g/day)	22.30[c]	33.33[a]	26.19[bc]	29.17[ab]	1.24
Total feed intake (kg)	50.85	57.35	55.25	53.10	2.16
FCR	27.6[a]	20.48[b]	25.11[a]	21.7[b]	1.24

[a,b,c] values with different superscripts in the same row differ significantly ($p<0.05$) difference between means within the same rows. ADG- Average daily gain, FCR- Feed conversion ratio.

Table 4. Haematological profile of Sokoto red bucks fed with organic ration.

Parameters	Treatments				SEM
	1	2	3	4	
WBC ($x10^9l$)	68.67[c]	72[ab]	75[b]	80.57[a]	4.21
RBC ($x10^9l$)	7.93	10.18	10.42	8.99	0.53
Hb (g/dl)	8.47	9.27	8.87	9.4	0.49
MCV (fl)	24.13	27.67	25.8	23.23	1.69
MCH (pg)	9.47	9.5	9.37	9.37	0.51
MCHC (g/dl)	35.07	37.23	35.1	35.97	0.98
PLT ($x10^9l$)	416[c]	624.67[a]	567.67[b]	420.33[c]	41.98
PCV (%)	24.17	25.9	25.23	24.03	1.54

[a,b,c] values with different superscripts in the same row differ significantly $p<0.05$. PCV-Pack cell volume; RBC-Red blood cell; MCH-Mean corpuscular Haemglobin; MCV-Mean corpuscular volume; MCHC-Mean corpuscular Haemoglobin concentration; WBC-White blood cell. PLT-Platelets.

The Hb values obtained in this study were within the values of the normal range of 8-16g/dl reported by RAR (2009), and agreed with the values reported by Egbe-Nwiyi *et al.* (2000), Tambuwal *et al.* (2002), Opara *et al.* (2010) and Babeker and Elmansoury (2013). This indicated that the goats were not anaemic and that the oxygen-carrying capacity of the haemoglobin was also adequate.

The MCH obtained in this study agreed with what Oloche *et al.* (2017) obtained in red Sokoto bucks (7.65-9.15). The high values obtained in this study indicated that the animals were by no means anaemic.

The MCV values obtained in this study were in agreement with what Oloche *et al.* (2017) obtained (22.20-27.40 fl). The higher MCV values indicate macrocytosis (Aster, 2004).

The observed values for MCHC in this study were higher than the normal range of 32.00 - 34.6 g/dl reported by Daramola *et al.* (2005) for goats and 33.27 - 33.39 g/dl reported by Saka *et al.* (2016) for West African dwarf goats.

The PCV values obtained in this study were within the normal range (24 – 45%) of healthy animals (RAR, 2009; Kraszewski *et al.*, 2002; Greathead, 2006). And is in consonant with 25.7% obtained by Tambuwal *et al.* (2002) for red Sokoto goats.

Nutrient digestibility of red Sokoto bucks fed with organic ration

The result (Table 5) indicates no significant difference between treatments 2 and 3 in dry matter, no significant difference between treatments 2, 3, and 4 in crude protein, no significant difference between treatments 1, 2 and 3 in crude fibre, no significant difference between treatments 2, 3 and 4 in ether extract ($p>0.05$). And no significant difference between treatments 2, and 3 as well as 1 and 4 in nitrogen-free extract digestibility ($p>0.05$). While ash digestibility was significantly higher at treatment 2 compared to the other treatments ($p<0.05$). The significant decrease in DM, CF, ASH and NFE digestibility for animals fed higher levels of clay could explain the reduced LWG and ADG from other treatments with the exception of treatment 2. Animals fed diets containing a 1.0% level of

Table 5. Nutrient digestibility of Sokoto red bucks fed with organic ration.

Parameters	Treatments				SEM
	1	2	3	4	
DM digestibility	58.62^{c}	74,24^{a}	70.8^{a}	67.2^{b}	1.25
CP digestibility	75.45^{b}	82. 76^{a}	82.54^{a}	80.08^{a}	1.91
CF digestibility	85.16^{a}	87.6^{a}	85.56^{a}	78.12^{b}	1.61
EE digestibility	65.33^{b}	75.15^{a}	72.54^{a}	70.34^{a}	2.22
ASH digestibility	72.64^{c}	88.25^{a}	84.32^{ab}	80.34^{b}	1.92
NFE digestibility	65^{b}	75^{a}	73.12^{a}	68^{b}	1.89

^{a,b,c} values with different superscripts in the same row differ significantly (p<0.05).

clay were however significantly higher in terms of all nutrient digestibility (p<0.05). This could explain the reason why animals in the treatment have higher LWG and ADG. This is in agreement with the finding of Nadziakiewicza *et al.* (2019) who reported that Montmorillonite is a proven safe feed additive for animals, and is used in animal diets to increase feed intake, nutrient digestibility, and growth rate (Saleh *et al.,* 1999: Salem *et al.,* 2001).

Conclusion

From the study, the experimental animals on treatment 2 with 1.0% clay (montmorillonite) in their organic diet performed better with better ADG, feed efficiency, better haematological profiles and better nutrient digestibility. Therefore, an organic diet (as in treatment 2) with 1.0% clay (montmorillonite) is recommended for sustainable and profitable small ruminant production.

COMPETING INTERESTS

The authors have declared that no competing interests exist.

ACKNOWLEDGEMENTS

We acknowledge the support of the Tertiary Education Trust Fund (TETfund), the Organic Farming Unit of the College, the Animal Health and Production Technology Department and the authority of Yobe State College of Agriculture, Science and Technology Gujba.

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