Dietary effect of *Saccharomyces cerevisiae* with or without molasses in rice husk based-diet on performance and health status of goats

[1]Arilekolasi, T. A., [2]Omotoso, O. B., [2*]Faluyi, O. B., [2]Fajemisin, A. N. and [2]Alokan, J. A.
*Corresponding Author E-mail: faluyi2005@yahoo.com

[1]Department of Animal and Environmental Biology, Federal University, Oye, Ekiti State, [2]Division of Ruminant Nutrition and Management, Department of Animal Production and Health, Federal University of Technology, Akure, Nigeria.
[2]Division of Veterinary Science, Department of Animal Production and Health, Federal University of Technology, Akure, Nigeria.*

ABSTRACT

This study was conducted to investigate the impact of introducing *Saccharomyces cerevisiae* with or without molasses in a diet based on rice husk on the health status of goats. Thirty (30) West African Dwarf (WAD) goats with mean weight of 10.46 ± 0.06 kg were randomly allotted to five dietary treatments of six goats per treatment in a completely randomized design experiment for 84 days. The goats were fed five formulated diets of rice husks anaerobically fermented for 7days with *S. cerevisiae* with or without molasses at graded levels. Nutrient composition of feed, daily nutrient intake, apparent digestibility coefficients, weekly weight gain/change by the goats were evaluated. At the end of the feeding trial, faeces, urine and blood samples were collected and analysed using standard procedures. The efficacy of the diet containing a combination of *S. cerevisiae* and molasses in ratio 1:1 as a feed additive, coupled with fermentation was proven by the concomitant reduction in fibre content. All the growth criteria (feed intake, live weight gain and feed conversion ratio), blood profiles and serum minerals measured favoured goats fed this Diet 3. No mortality was recorded during the trial. Conclusively, introducing *S. cerevisiae* with molasses at equi-ratio nutritionally enhances optimal rice husk utilization in goats' nutrition and supported productive performance and their health status.
Keywords: blood profile; digestibility; fermentation; goat; performance.

INTRODUCTION

Livestock production plays an important role for the livelihood of farmers in rural areas, and it is undertaken in a multitude of ways across the planet, providing a large variety of goods and services, and using different animal species and different sets of resources, in a wide spectrum of agro-ecological and socio-economic conditions (Steinfeld *et al.,* 2006). Goats are cloven-footed animals which are called small ruminants, and belong to the genus, Capra. They play multiple roles in the livelihood of an average Nigerian, providing the majority of their cash income, dietary protein and organic fertilizer for crop production. More so, they could easily be integrated into different farming systems because of their small body size compared to cattle (Hirpa and Abebe, 2008).

However, in South West Nigeria, their productivity is constrained by shortage of good quality and quantity feed, especially during the long dry season which results in poor nutrition, hence their optimal performance is reduced. Rice husk has been nutritionally reported to contain 92.5 - 96.4% DM, 2.10 - 3.60% CP, 1.00 – 12.0% EE, 39.0 – 48.5% CF, 15.0-18.0% silica, 15.0 – 22.0% ash, 0.04% calcium and 0.06% phosphorus (Omotola and Ikechukwu, 2006; Aderolu *et al.,* 2007). But its high inclusion in livestock feed has not been encouraged due to its high fibre content, high silica/ash content and abrasive characteristics. Therefore, it has to stay a long time in the rumen to be degraded; which adversely affects its nutrient digestibility.

Molasses are a good source of trace minerals, used often to stimulate eating, reduces dustiness in feeds and serves as a pellet binder (Figueroa and Ly 1990), while yeast (*Saccharomyces cerevisiae*) is used as a leavening agent in baking bread and bakery products, converts the fermentable sugars into carbon dioxide and ethanol. *S. cerevisiae* is a single-cell microorganism found on and around the human body (Tony, 2013) and it is capable of breaking linkages between protein and fibre with the aid of fermentation thereby enhancing digestibility.

Blood metabolite profiling is a technique that is used to evaluate the concentration of blood compounds or 'metabolic signatures' that serve as markers to assess specific biochemical response of an individual. Blood metabolite profiling has also been suggested for use as a diagnostic tool for reproductive performance, metabolic disorders, and nutritional status of individuals (Aletor and Egberongbe, 1992).

Hence, this study seeks to assess the impact of introducing *S. cerevisiae* with or without molasses in a diet based on rice husk on nutrient intake, utilization, weight gain and blood profile in goats.

MATERIALS AND METHODS

Experimental site

The research was carried out at the Small Ruminant Unit of the Teaching and Research Farm of the Federal University of Technology, Akure located on Latitude 7^0 18' and Longitude 5^0 10'E (NMA, 2014) while the chemical analyses were carried out at the Nutrition Laboratory of the Department of Animal Production and Health of the same University.

Collection and processing of feed samples

Rice husk was collected from rice milling industry in Ogbese, Ondo State; yeast were sourced from an open market in Akure, Ondo State while salt, molasses, bone meal, vitamin mineral premix were sourced from a reputable feedmill industry in Ibadan, Oyo State, Nigeria.

Procurement and management of experimental goats

A total of thirty West African Dwarf (WAD) goats about 2 years age range, with an average body/live-weight of 10.46 ± 0.06 kg were purchased from an open market in Itaogbolu, Ondo State. The goats were stabilized (quarantined and acclimatized) for a period of twenty-one days during which they were vaccinated against Peste-Petit de Ruminante (PPR/Kata) using Tissue Culture Rinderpest vaccine at the rate of 1ml per 10 kg body weight of animal. They were also prophylactically treated against ecto- and endo- parasites using ivermectin at the rate of 1ml per 10 kg body weight of animal and were also treated against infections using oxytetracycline LA® at the rate of 1 ml per 10 kg of body weight of the animal before commencement of the feeding trial.

Diet formulation

Five experimental diets were formulated such that rice husk, salt, bone meal and vitamin-mineral premix were anaerobically fermented treated with or without *S. cerevisiae* and molasses for seven days in the proportion shown in Table 1. The diets had the yeast (*S. cerevisiae)* and molasses included at varying concentration levels: Diet 1 contained 4% yeast and 0% molasses; Diet 2 contained 3% yeast and 1% molasses; Diet 3 contained 2% yeast and 2% molasses; Diet 4 contained 1% yeast and 3% molasses; while Diet 5 contained 0% yeast and 4% molasses.

Table 1: Gross composition of experimental diets fed to WAD goats

Ingredients (%)	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Rice husk	93.00	93.00	93.00	93.00	93.00
Yeast	4.00	3.00	2.00	1.00	0.00
Molasses	0.00	1.00	2.00	3.00	4.00
Salt	1.00	1.00	1.00	1.00	1.00
Bone meal	1.00	1.00	1.00	1.00	1.00
Vitamin mineral premix	1.00	1.00	1.00	1.00	1.00
Total	100.00	100.00	100.00	100.00	100.00
Analyzed composition (%)					
Dry matter	92.90	92.62	92.79	91.18	90.89
Crude protein	8.94	9.99	11.32	8.67	7.98
Crude fibre	24.29	26.52	25.78	26.70	27.89
Ether Extract	4.14	4.89	5.30	5.37	5.65
Ash	9.25	9.29	9.33	9.54	9.84
Calcium	0.61	0.62	0.62	0.72	0.82
Phosphorus	0.41	0.41	0.41	0.42	0.43

Experimental layout and design

The goats were weighed and randomly allotted to the five dietary treatment of six goats per group. The animals were housed individually in pen measuring 1.8 x 0.5 m. After introduction of the test diets, an acclimatization period of 7 days was allowed before data collection. The animals were fed 5% of their body weight in the morning (8:00 am) and supplied water (*ad libitum*) during the experimental period of eighty-four days. The daily feed intake was determined by the difference between the quantity supplied and leftover. The animals were weighed using spring balance (hanging scale) on a weekly basis in the morning before feeding to determine any weight change over the course of the trial.

Digestibility trial

Total faeces and urine voided by each goat were collected and measured in the morning before feeding and watering during last 7 days of the experiment. The faeces was weighed and 10% of the total faeces collected from each animal was taken and oven dried at 105^0C for 48 hours to determine the moisture content of the faeces. These were all stored at room temperature until required for analysis. Urine was collected in a bucket placed under the

cages, into which 25% of concentrated H_2SO_4 was added to immobilize ammonia from being volatized from the urine. Apparent digestibility coefficients of the diets were calculated as difference between nutrient intake and excretion in the faeces expressed as percentage of nutrient intake.

$$\text{Apparent digestibility coefficient} = \frac{\text{Nutrients intake – nutrients in faeces}}{\text{Nutrient intake}} \text{ x } 100$$

Protein efficiency ratio (PER) was calculated as weight gain divided by protein intake per goat.

Blood collection and analysis

Blood sample of about 10 ml was collected from each animal through the jugular vein at the end of the experiment. The whole blood were used for haematological studies and packed cell volume (PCV), red blood cell count (RBC), haemoglobin concentration (HB), erythrocyte sedimentation rate (ESR) and white blood cell differentials were analysed as described by (Lamb, 1981). The Mean Corpuscular Haemoglobin Concentration (MCHC), Mean Corpuscular Haemoglobin (MCH) and the Mean Corpuscular Volume (MCV) were also calculated accordingly.

The serum samples were analysed for total protein, albumin, globulin, aspartate aminotransferase (AST), alkaline phosphatase (ALP) and minerals (Ca, P, Na) concentration using biochemical tests according to standard methods of Merck's Veterinary Manual (2010) and Cork and Halliwell, (2002).

Analysis for nutrient composition

Sub-samples of feed, feaces and urine were analysed for nutrients composition according to standard procedures of A.O.A.C. (2002).

Statistical analysis

The design of the experiment is completely randomized design (CRD) and all data collected were subjected to one–way analysis of variance (ANOVA) using SAS (2008) and significant differences were separated using Duncan Multiple Range Test of the same package set at $p<0.05$.

RESULTS

Nutrient composition and Performance indices by WAD goats fed experimental diets

As shown in Table 1, the nutrient content of the diets varied numerically depending on the level of *S. cerevisiae* and molasses inclusion. All the values obtained did not follow a particular trend. Diet 3 had the highest crude protein content (11.32%) with invariably lower crude fibre content (25.78%). Table 2

shows that the nutrient intake of the experimental goats was significantly (p<0.05) influenced by the level of yeast and molasses. The highest DM (486.36 g/d), CP (62.26 g/d), Ca (3.94 g/d) and P (2.46 g/d) intake was obtained for WAD goats fed Diet 3. The digestibility co-efficient values obtained in goats fed Diet 3 were the highest while least in those fed Diet 1. There was no significant variation at p<0.05 in the initial live-weight values. However, the obtained values for average daily weight gain (45.96) and protein efficiency ratio (0.74) were the higher than other test diets.

Table 2: Performance indices by WAD goats fed experimental diets

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	±SEM	P-value
Nutrient & mineral intake (g/d)							
Dry matter	462.71^{c}	465.56^{b}	486.36^{a}	467.39^{b}	466.66^{b}	4.04	2.00
Crude protein	53.53^{c}	56.75^{b}	62.26^{a}	57.15^{b}	52.69^{c}	0.82	0.03
Crude fibre	149.91^{b}	145.28^{c}	141.79^{d}	144.62^{c}	154.64^{a}	0.01	0.01
Ether extract	19.13^{d}	23.02^{c}	25.62^{b}	26.27^{b}	28.87^{a}	0.63	0.02
Calcium intake	3.36^{c}	3.38^{c}	3.94^{a}	3.47^{b}	3.35^{c}	0.10	0.01
Phosphorus intake	2.25^{c}	2.26^{bc}	2.46^{a}	2.28^{b}	2.26b^{c}	0.01	0.01
Digestibility coefficient (%)							
Dry matter	77.62^{d}	78.14^{c}	79.80^{a}	78.34^{b}	78.11^{c}	1.73	0.02
Crude protein	80.12^{b}	81.07^{ab}	82.22^{a}	80.12^{b}	81.42^{ab}	1.81	0.02
Crude fibre	78.02^{c}	78.44^{b}	79.12^{a}	78.02^{c}	78.06^{c}	5.10	1.12
Ether extract	68.17^{c}	79.15^{a}	79.18^{a}	77.88^{b}	78.01^{ab}	0.02	0.02
Calcium	80.18^{b}	80.20^{b}	82.23^{a}	82.50^{a}	81.10^{b}	2.04	0.01
Phosphorus	80.10^{d}	83.22^{c}	84.69^{a}	84.28^{ab}	84.17^{b}	3.08	0.01
Growth indices							
Initial weight (kg)	10.43	10.45	10.46	10.46	10.52	0.06	0.01
Final weight (kg)	13.59^{c}	13.73^{b}	14.32^{a}	13.82^{b}	13.74^{b}	1.04	0.01
Weight (kg)	3.16^{c}	3.28^{b}	3.86^{a}	3.36^{b}	3.18^{c}	0.02	0.01
Weight gain (g/day)	37.62^{c}	39.04^{b}	45.96^{a}	40.00^{b}	37.86^{c}	0.07	0.01
Feed conversion ratio	12.29^{c}	11.92^{b}	10.58^{a}	11.68^{b}	12.33^{c}	0.09	0.02
Protein efficiency ratio	0.70^{b}	0.69^{b}	0.74^{a}	0.70^{b}	0.71^{b}	0.01	0.01
Mortality	0	0	0	0	0	0	0.00

^{abcde}*Mean values within rows with different superscripts letters are significantly different (p<0.05)*

Haematological parameters of WAD goats fed experimental diets

All the blood variables examined did not follow a particular trend as revealed in Table 3. There were significant (p<0.05) variations in all the parameters observed except basophil which had numerically similar values.

The highest values of packed cell volume, red blood cell, white blood cell and haemoglobin except mean cell volume which was the least value were obtained in goats fed Diet 3.

Table 3: Haematological parameters of WAD goats fed experimental diets

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	±SEM	P-value	Reference value
Packed cell volume (%)	30.64^{c}	32.01^{b}	33.00^{a}	32.15^{b}	29.02^{d}	0.87	0.04	22-38
Red blood cell (x10^{6}/ml)	12.14^{c}	13.80^{b}	14.60^{a}	13.60^{b}	12.60^{c}	1.01	0.02	8.0-18.0
White blood cell (x10^{3}µl)	7.72^{b}	7.69^{b}	8.52^{a}	7.65^{b}	7.54^{b}	0.57	0.01	4.0-13.0
Haemoglobin (g/dl)	8.80^{c}	9.30^{b}	12.03^{a}	9.33^{b}	9.02^{c}	1.06	0.02	8.0-12.0
MCH (pg)	7.25^{b}	6.74^{c}	8.24^{a}	6.86^{c}	7.17^{b}	0.21	0.01	5.2-8.0
MCV (µ^{3})	25.24^{a}	23.20^{b}	22.60^{c}	23.64^{b}	23.03^{b}	0.83	0.03	16.0-25.0
MCHC (%)	28.72^{c}	29.05^{c}	36.45^{a}	29.02^{c}	31.08^{b}	1.41	0.02	30.0-36.0
Lymphocytes (%)	60.44^{c}	62.89^{b}	65.40^{a}	62.75^{b}	61.05^{c}	2.08	0.01	50-70
Neutrophils (%)	37.06^{c}	37.99^{b}	42.85^{a}	38.00^{b}	37.04^{c}	1.07	0.01	30-48
Monocytes (%)	3.34^{c}	3.82^{b}	4.32^{a}	3.91^{b}	3.25^{c}	0.49	0.01	0-4
Eosinophil (%)	2.00^{d}	2.22^{b}	3.01^{a}	2.26^{b}	2.14^{c}	0.09	0.01	1-8
Basophils (%)	0.50	0.50	0.50	0.50	0.50	0.01	0.01	0-1

^{abc}*Means without superscripts in the row are not significantly different (p>0.05).* MCHC = Mean Corpuscular Haemoglobin Concentration; MCH = Mean Corpuscular Haemoglobin; MCV = Mean Corpuscular Volume. Reference values adapted from Plumb (1999).

Serum metabolites of WAD goats fed experimental diets

The serum biomarkers and minerals indices were significantly (p<0.05) influenced by the dietary treatments except aspartate aminotransferase and serum potassium (Table 4) and did not have a positive linear progression. The serum total protein was highest in goats fed diet 3 and consequently, the highest albumin and globulin concentration of 55.31 and 18.87 g/l respectively. Goats fed test diet 1 had the least values of all the serum metabolite parameters observed. The serum glutamate oxaloacetate transaminase/aspartate aminotransferase (AST) levels were significantly (p < 0.05) influenced by the treatment. It progressively increased in goats fed diet 1 to those diet 4 but declined in goats fed diet 5. Alkaline phosphatase (ALP) concentration levels varied significantly and goats fed diet 3 had the highest value (106.71 IU/l) and least value (95.63 IU/l) was obtained in goats fed diet 1.

DISCUSSION

Nutrient composition and performance indices of WAD goats fed experimental diets

Judging from the results the high DM contents of the diets could be due to the coarseness/nature of the rice husk. However, the combined effect of yeast and molasses at ratio 1:1 enhanced nutrient composition where molasses served as a substrate to hasten fermentation by easily converting the carbohydrate content into lactic acid while the *S. cerevisiae* aided the fermentation.

Table 4: Serum metabolites of WAD goats fed experimental diets

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	±SEM	P value
Serum biomarkers							
Total proteins (g/l)	67.10^{c}	69.76^{ab}	70.45^{a}	69.14^{b}	67.00^{c}	2.03	0.20
Albumin (g/l)	52.02^{c}	52.80^{bc}	55.31^{a}	53.00^{b}	52.47^{bc}	1 .02	0.03
Globulin (g/l)	13.62^{c}	14.80^{b}	18.87^{a}	14.14^{bc}	13.79^{bc}	0.91	0.01
ASAT (IU/l)	92.30	94.93	95.00	95.16	90.37	3.06	0.02
AP (IU/l)	95.63^{c}	96.10^{bc}	106.71^{a}	96.71^{b}	96.82^{b}	1.43	0.01
Serum minerals (mmol/L)							
Calcium	1.56^{c}	1.58^{bc}	1.88^{a}	1.59^{bc}	1.61^{b}	0.08	0.01
Phosphorus	1.22^{c}	1.28^{b}	1.31^{a}	1.29^{b}	1.24^{c}	0.03	0.01
Sodium	136.70^{b}	138.10^{a}	138.40^{a}	138.10^{a}	138.00^{a}	1.28	0.03
Potassium	4.28	4.39	4.50	4.48	4.40	0.13	0.02
Magnesium	0.08^{d}	0.10^{c}	0.14^{a}	0.13^{b}	0.08^{d}	0.02	0.01

^{abc}*Means without superscripts in the row are not significantly different (p>0.05)*

Thus, the fibre content reduced more as the level of yeast increased in the diets. The calcium and phosphorus contents positively increased across the treatments with increased molasses concentration. The highest nutrient intake (except CF and fat) by WAD goats fed Diet 3 could be attributed to the synergistic effect of yeast and molasses in improving the N-source in the diet. The invariably high mineral intake suggests that essential macro-minerals were supplied to the animals. This was evident as goats fed Diet 3 had better Ca and P utilization than those fed others test diets. From this present study, digestibility coefficients by goats fed molasses-yeast rice husk based-diets especially at 1:1 proved the suggests the effectiveness of synergistic relationship between yeast and molasses in degrading the high fibre and silica contents and would not have to spend longer time in the rumen to be degraded; hence improve nutrients digestibility. McDonald *et al*. (2002) and Thuy Hang *et al.* (2018) opined that there is a positive relationship between digestibility of feed and protein intake. This present study agreed with this report as protein intake and digestibility were highest in goats fed Diet 3. This may be due to the fact that more rumen microbes were produced to

vigorously break down the fibre content for effective utilization in the gastro-intestinal tract (GIT) of the animal. Goats fed diet 3 had the highest daily weight gain (22.17% higher than those fed control diet) and better protein quality coupled with DM intake could be responsible for this as postulated by Fadiyimu *et al.* (2010). This was evident as PER was better in goats fed diet 3 compared to goats fed other diets. However, all the diets supported weight gain of the goats and no mortality was recorded during the trial.

Haematological parameters of WAD goats fed experimental diets

The obtained haematological variables are suggestive that there is no detrimental effect on the health status of the experimental animals when compared with the normal ranges for healthy goats as reported by Plumb (1999). This suggests that fermenting rice husk with molasses and *S. cerevisiae* for 14 days had health benefit on the goats. The considerably highest value of packed cell volume, red blood cell count, white blood cell count, and haemoglobin is an evidence of quality protein/nutrient utilization by goats in dietary treatment 3. Hence, this was subsequently reflected in output of the blood profile. Also, the significantly higher values of white blood cell obtained could be as a result of the animal processing a protective system suggestive of a well-adapted immune system (Tambuwal *et al*., 2002). Packed cell volume (PCV) is beneficial in assessing the protein status of the diets fed (Aletor and Egberongbe, 1992). The PCV level shows that the animals are not anaemic, and this can be attributed to the high nitrogen intake and metabolism by the animals especially those placed on diet 3. The haemoglobin concentration followed similar trend. Meanwhile, blood haemoglobin increased progressively with increase in the level of dietary protein. The values of red blood cell and haemoglobin reported could be due to age of the animals used in the study. Tambuwal *et al.* (2002) reported that age has a significant effect on haemoglobin and red blood cell in that oxygen carrying capacity of blood is higher in adult goats. However, the values recorded indicated no impairment to the health of the goats. The differential white blood cell count indicated no abnormal lowered or raised levels indicating that their immune systems were not compromised.

Serum metabolites of WAD goats fed experimental diets

Serum protein concentration is an indication of high quality feed (Aletor and Egberongbe, 1992). The high value of albumin obtained in the experimental goats suggests an increase in clotting ability of the blood thereby leading to prevention of haemorrhage (Robert *et al.,* 2003). Globulin are precursors of immunoglobulins (antibodies) which are known to fight infection, therefore the high globulin levels though within the normal range recorded in the experimental animals is indicative that they were able to fight infection. Low globulin level could lead to high morbidity and mortality rates

(Akinmutimi and Eburaja, 2010). However, an increased activity of globulin in serum is a well-known diagnostic indicator of liver injury (Oboh and Akindahunsi, 2005).

The level of serum glutamate-oxaloacetate transaminase/aspartate aminotransferase (AST) concentration in the experimental goats shows there is no liver degeneration in the animals since it is commonly measured clinically as a biomarker for liver health. The measurement of the AST level is also helpful for the diagnosis of cases of myocardial infarction and skeletal muscle disorders. On the other hand, the alkaline phosphatase (ALP) levels implied that the protein content of the diets were available for efficient metabolism and utilization, especially those fed diet 3. This is due to the fact that ALP is an enzyme that is used to break down protein in the animal body.

The serum mineral concentration of goats fed the experimental diets were within range for goats, and corroborates the findings of Daramola *et al.* (2005) who reported values of calcium (2.60-3.5 mmol/l), phosphorus (1.60-2.40 mmol/l), magnesium (0.08-2.0 mmol/l), potassium (4.0-6.0 mmol/l) and Sodium (136-154 mmol/l) in healthy goats. The serum minerals in goats fed diet 3 is suggestive that the diet would support improved health status of goats. This is because the concentration levels of calcium, phosphorus, sodium, potassium and magnesium recorded in goats fed diet 3 might have been able to prevent cellular toxicity, maintain fluid electrolyte balance and regulate metabolic processes including neural and muscular functions.

Conclusion

The combined effect of *S. cerevisiae* and molasses at 1:1 ratio in fermented rice husk based-diet led to better nutrient composition and utilization of the feed, improved apparent digestibility coefficients, weight gain and health status of the animals. This is ascertained judging by the haematological and serum biochemical indices measured which are diagnostic tools for evaluating the health status of animals. Diet 3 is therefore recommended for improved ruminant production in Sub-sahara Africa.

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