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EFFECTS OF *Saccharomyces cerevisiae* ON SOME PRODUCTION PARAMETERS AND FORAGE FRACTIONS DIGESTIBILITY IN WEST AFRICAN DWARF SHEEP FED *Panicum maximum* AND *Centrosema pubescens*

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ABSTRACT

The increased awareness in the use of organic and inorganic substances to manipulate rumen function for improved productivity and fermentative activity have provided avenues for the inclusion of various organic and inorganic substances such as various strains of yeast cultures in ruminant diets. In this study, we investigated the effect of varied doses of bioactive yeast, Saccharomyces cerevisiae (strain 1026-Allthech) on productive parameters (feed intake, water intake, weight gain, feed conversion ratio, and feed efficiency) and total tract digestibility of feed fractions, using Panicum maximum (PM) and Centrosema pubescens (CP) as basal diets in WAD sheep. Three inclusion levels of 0.4, 0.6 and 0.8 grams per kilogram body weight (gSC/kgbw) were administered to three randomized groups of five West African Dwarf sheep designated A, B and C respectively. Another group (D) of same number of animals served as the control. The degradability study was performed using the total faecal collection technique for PM and CP in all the groups. The results of the study showed that SC significantly ($p<0.05$) improved the apparent rumen degradability of the feed fractions of PM and CP as well as the productive performance parameters in a dose dependent manner relative to the control. It was concluded from this study that a maximum dietary inclusion of SC at 0.8 g/kgbw is not only safe, but can be effectively used to increase rumen degradability of feed fractions for enhanced productivity and performance of WAD sheep.

Keywords: *Saccharomyces cerevisiae*, rumen bioengineering, forage degradability, productive performance, WAD sheep.

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INTRODUCTION

West African dwarf sheep is one of the most predominant breed of sheep reared in the tropical rain forest region of Nigeria. Its production is faced with certain challenges ranging from inadequate feed stuff [1] due to prolonged dry season to poor protein quality and high fibre content of forages in the tropics [2]. The low productivity of these ruminants is because of the poor nutritional status in terms of feed quality

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[3]. Although native forages are the most widely available low cost feeds for ruminants in the tropics [4], they deteriorate rapidly especially during the dry season. Common forages popularly consumed by small ruminants in southeastern Nigeria are guinea grass (*Panicum maximum)* and the legume (*Centrosema pubescens*).

Legumes and grasses are the main sources of nutrients for ruminants. These feed resources conserve nutrients for long periods and even during harsh and unfavourable seasons like winter and harmattan (dry) when other resources are in short supply [5]. Legumes and grasses also have high rumen degradability potential as they supply nutrients more to rumen microbes than to the host animal. In other to improve nutrient availability to the host animal from legumes and grasses, they are usually supplemented with other slowly degradable feeds [6] or organic and inorganic substances in form of vitamins and minerals capable of engineering rumen fermentation positively.

Ruminants have a unique ability to convert feedstuff of low nutritional value or unfit for human consumption into useful end products that are utilized for productivity and growth. This is possible because of microbial fermentation taking place in the rumen and reticulum [7].

With the high cost and seasonality of feeds, livestock farmers have been challenged to search for alternative feed resources that can economically supplement the conventional feed ingredients in rations without adverse effects on the health and performance of the animals [8,9] or to manipulate the rumen for enhanced fermentation activities. As a result, several organic and inorganic compounds have been used to 'engineer' the activities of the microbes and improve rumen function generally [10].

One of such organic substances used for rumen bioengineering is bioactive yeast. A lot of research has been carried out with yeast to determine its effect on the various rumen function and productive parameters of ruminants as well as the effect and efficacy of the various species and even their strains [11]. Most of these earlier works were done using exotic breeds of sheep. Most works on yeast in the tropics have been directed towards poultry with little or no emphasis on other livestock [12,13]. *Saccharomyces cerevisiae* and *Aspergillus oryzae* among the yeasts commonly used in farm animal diets.

In order to understand the productive implications of bioactive yeast on WAD sheep nutrition, this study was designed to investigate the effect of *Saccharomyces cerevisiae* (strain Yea sacc 1026-Allthech) on forage fractions digestibility and some production parameters.

MATERIALS AND METHODS

Experimental Animals

Twenty adult female WAD sheep used for this study were sourced from Ibagwa and Orba markets respectively in Nsukka and Udenu Local Government Areas of Enugu State. They were quarantined for 14 days and acclimatized for another 21 days at the Veterinary Teaching and Research Farm, University of Nigeria, Nsukka. The sheep were treated prophylactically for ectoparasites and endoparasites using ivermectin at 200 i.u/kg (ivomec®, Argenta Manufacturing Limited, Auckland, New Zealand) subcutaneously and levamisole Hydrochloride bolus at 7.5 mg/kg respectively. They were also given tissue culture vaccine (NVRI, Vom, Nigeria) against pestes des petit ruminantes. The sheep were ear tagged and housed individually, under shed, in well-ventilated wooden metabolic crates at the Veterinary Teaching and Research Farm, University of Nigeria, Nsukka. They had an average body weight of 12.78 ±1.95 kg after acclimatization.

Experimental design

The study was divided into two experimental protocols (EPs). In each EP, the WAD sheep were randomly divided into four groups (A, B, C and D) of five animals each and the study lasted for a period of 4 weeks. In EP I, fresh *P. maximum* (PM), was fed alone *ad libitum* for 4 weeks to all the groups while in

EP II fresh *C. pubescens* (CP), was fed alone *ad libitum* for the same 4 weeks after a cross over period of 4 weeks. In both protocols, three dose levels of *SC*: 0.4, 0.6 and 0.8 grams of *S. cerevisiae* per kilogram body weight (g*SC*/kgbw) were administered to the animals in groups A, B and C respectively. Group D served as control. Faecal samples were collected daily from each animal in the groups. Samples were analyzed to determine the total tract digestibility of dry matter, organic matter, crude protein, crude fibre, neutral detergent fibre and acid detergent fibre [14]. Live body weight was determined weekly. Water intake was determined using Forbes [15] equation:

Total water intake (TWI) = 3.36 DMI – 0.99 (Forbes, 1985) where DMI is dry matter intake in kg/animal.

$$\%\text{DMI} = \frac{\%\text{DM}}{100} \text{ X TFI}$$

Feed efficiency, which is the reciprocal of feed conversion ratio, was calculated according to the following equation:

$$\text{FE} = \frac{\text{Live weight gain (kg)}}{\text{Quantity of feed consumed (kg)}} \times 100$$

DATA ANALYSIS

The results of the study for each parameter studied were analyzed using a statistical package, SPSS version 16.0. Means were taken to be statistically significant at $p < 0.05$ whereas separation of the means was done using the Duncan's Multiple Range Test [16].

RESULTS

Table 1 shows the chemical composition (%) of the forages used for the experiment with *CP* having higher dry matter and crude protein values of 47.12 and 18.95 respectively compared to *PM* with values of 46.35 and 14.53. The neutral detergent fibre (NDF) and acid detergent fibre (ADF) values of *PM* were 75.28 and 43.45 respectively while those of *CP* were 68.50 and 37.23 respectively. The crude fibre values of *PM* and *CP* were 58.00 and 47.77 respectively. The organic matter value of *PM* and *CP* were 28.65 and 27.03 respectively.

Table 2 shows the digestibility of the various feed fractions at different oral dose levels of *S. cerevisiea*. The DM digestibility of *PM* at 0.4, 0.6, and 0.8 g*SC*/kgbw were 39.66±1.39%, 49.23±1.13% and 51.17±0.83% respectively compared to the control value of 36.15±0.69%. Similarly, the DM digestibility of *CP* at 0.4, 0.6 and 0.8 g*SC*/kgbw were 68.42±0.67%, 72.59±0.69% and 76.29±0.99% respectively compared to the control value of 65.92±1.09%. There was significant ($p < 0.05$) difference in DM digestibility between the treatment groups and the control for both the *PM* and *CP* with their highest values observed at 0.8 g*SC*/kgbw. The digestibility pattern of all the forage fractions increased in a dose dependent manner above that of the control group. Generally, there was significant differences ($p < 0.05$) between the treatment groups and the control group in both EPs.

Table 3 shows the effects of feeding various levels of *SC* on the feed intake (FI), water intake (WI), weight gain (WG), feed conversion ratio (FCR) and feed efficiency (FE) of WAD sheep. At 0.4, 0.6 and 0.8 g*SC*/kgbw, 31.28±0.76, 35.57±0.48 and 37.03±47kg/animal respectively were the mean feed intake compared to the control value of 31.12±0.31kg/animal for *PM*. The FI was significantly ($p < 0.05$) higher in the treatment groups compared to the control group. In EP II, at 0.4, 0.6 and 0.8 g*SC*/kgbw; 22.48±1.14, 25.32±0.81, and 27.80±2.89 kg/animal respectively were the mean values for feed intake. There was significantly ($p < 0.05$) higher FI by the treatment groups compared to that of the control

group. In both diet groups, the effects were dose dependent with greater effects seen in groups fed higher doses of SC.

Table 1: Chemical Composition of the Experimental Diets

Chemical Constituent (%)	*P. maximum*	*C. pubescens*
Dry matter (DM)	46.35	47.12
Organic Matter	28.65	27.03
Crude protein	14.53	18.95
Crude Fibre	58.00	47.77
Fats	2.38	1.6
Ash	6.63	6.37
Calcium	4.0	4.12
Potassium	0.51	0.89
Phosphorus	4.77	7.22
Sodium	0.53	0.58
NDF	75.28	68.50
ADF	43.45	37.23
Hemicellulose	50.20	39.04
Cellulose	42.34	37.11

Table 2: The Mean (±SEM) of the effects of *Saccharomyces cerevisiae* on Total Tract Digestibility of Dry matter (DM), Organic Matter (OM), Crude Protein (CP) and Crude Fibre (CF) of WAD sheep fed *Panicum maximum* and *Centrosema pubescens*

Parameters	Diet	Treatments			
		A	B	C	D
DM (%)	*PM*	39.66 ± 1.39^{a}	49.23 ± 1.13^{b}	51.17 ± 0.83^{b}	36.15 ± 0.69^{c}
	CP	68.42 ± 0.67^{a}	72.59 ± 0.69^{b}	76.29 ± 0.99^{c}	65.92 ± 1.09^{a}
OM (%)	*PM*	55.08 ± 1.02^{a}	58.30 ± 0.82^{b}	65.76 ± 0.69^{c}	53.66 ± 0.93^{a}
	CP	70.20 ± 0.47^{a}	73.32 ± 0.73^{b}	76.71 ± 1.07^{c}	64.53 ± 0.47^{d}
CP (%)	*PM*	64.55 ± 1.05^{a}	71.66 ± 0.95^{b}	72.03 ± 2.22^{b}	61.89 ± 0.87^{a}
	CP	73.26 ± 0.44^{a}	77.80 ± 0.94^{b}	81.43 ± 0.77^{c}	67.23 ± 1.02^{d}
CF (%)	*PM*	49.67 ± 0.40^{a}	53.37 ± 1.14^{b}	58.24 ± 0.68^{c}	47.30 ± 0.65^{a}
	CP	51.63 ± 0.81^{a}	57.07 ± 0.86^{b}	64.09 ± 1.89^{c}	49.50 ± 0.91^{a}

A = 0.4 g*SC*/kgbw; B = 0.6 g*SC*/kgbw; C = 0.8 g*SC*/kgbw and D = Control; ^{abcd}Means within rows with different superscripts are statistically different at $p < 0.05$.

At 0.4, 0.6, 0.8 g*SC*/kgbw and the control; 0.49±0.01, 0.68±0.02, 0.74±0.014 and 0.38±0.01kg/animal respectively were the mean weekly weight gained for *PM*. For *CP*, at 0.4, 0.6, 0.8 g*SC*/kgbw and the control; 0.50±0.014, 0.75±0.024, 0.89±0.02 and 0.37±0.012kg/animal respectively were the mean weekly weight gained. There was significant ($p < 0.05$) difference in weight gain between the treatment groups and the control for both forages. There was significant ($p < 0.05$) variation in water intake between the treatment groups and the control in both EPs. Among the experimental groups, water intake appeared to be related to the concentration of yeast added with the 0.8 g*SC*/kgbw group having the highest water intake.

In EP I, the feed conversion ratio (FCR) values at 0.4, 0.6, 0.8 g*SC*/kgbw and the control group were 64.19±1.85, 52.42±1.01, 49.85±1.29 and 81.97±1.13 respectively. The FCR was significantly ($p<0.05$) lower in treatment groups compared to that of the control. In EP II, the FCR were 45.47±1.82, 33.87±1.81, 31.26±3.55 and 59.50±2.90 at 0.4, 0.6, 0.8 g*SC*/kgbw and the control group respectively. The FCR was significantly ($p<0.05$) lower in the treatment group than the control.

In EP I, the feed efficiency (FE) values at 0.4, 0.6, 0.8 g*SC*/kgbw and the control group were 1.56±0.5, 1.98±0.2, 2.0±0.00 and 1.04±0.4 respectively. The FE was significantly ($p<0.05$) higher in the treatment groups than the control. In EP II, the FE values at 0.4, 0.6, 0.8 g*SC*/kgbw and the control group were 2.1±1.0, 3.20±2.0, 3.2±0.4 and 2.0±0.00 respectively. There FE was significantly ($p<0.05$) lower in the treatment groups than the control group.

DISCUSSION

This study has provided information on the effect of *Saccharomyces cerevisiae* (bioactive yeast) on productive performance and some forage fractions degradability in West African dwarf (WAD) sheep fed *Panicum maximum* and *Centrosema pubescens*. The study showed that varied doses of bioactive yeast affected positively some forage fraction, total tract digestibility and production parameters of WAD sheep in a dose dependent manner.

Table 3: Effects *Saccharomyces cerevisiae* on Feed Intake (FI), Water intake (WI), Weight gain (WG), Feed Conversion Ratio (FCR) and Feed Efficiency (FE) of WAD sheep fed *P. maximum* and *C. Pubescens*.

Parameter	Diet	Treatment			
		A	B	C	D
Feed intake (kg/Animal)	*PM*	31.28 ± 0.76^{a}	35.57 ± 0.48^{b}	37.03 ± 47^{b}	31.12 ± 0.31^{a}
	CP	22.48 ± 1.14^{a}	25.32 ± 0.81^{ab}	27.80 ± 2.89^{b}	22.02 ± 0.58^{a}
Weight gain (kg/Animal)	*PM*	$0.49\pm0.011^{a*}$	$0.68\pm0.02^{b*}$	$0.7440\pm0.014^{c*}$	$0.38\pm0.01^{d*}$
	CP	$0.50\pm0.014^{a*}$	$0.75\pm0.024^{b*}$	$0.89\pm0.02^{c*}$	$0.37\pm0.012^{d*}$
Water Intake (l/Animal)	*PM*	47.72 ± 1.18^{a}	54.30 ± 0.72^{b}	56.87 ± 0.77^{c}	47.47 ± 0.47^{a}
	CP	34.48 ± 1.83^{a}	39.05 ± 1.27^{ab}	43.00 ± 4.57^{b}	33.875 ± 0.9^{a}
FCR	*PM*	64.19 ± 1.85^{a}	52.42 ± 1.01^{b}	49.85 ± 1.29^{b}	81.97 ± 1.13^{c}
	CP	45.47 ± 1.82^{a}	33.87 ± 1.81^{b}	31.26 ± 3.55^{b}	59.50 ± 2.90^{c}
FE	*PM*	$0.0156\pm0.005^{a*}$	0.0198 ± 0.002^{b}	0.0200 ± 0.00^{b}	0.0104 ± 0.04^{c}
	CP	$0.021\pm0.01^{a*}$	0.032 ± 0.02^{b}	0.032 ± 0.04^{b}	0.020 ± 0.00^{a}

A = 0.4 g*SC*/kgbw; B = 0.6 g*SC*/kgbw; C = 0.8 g*SC*/kgbw and D = Control; ^{abcd}Means within rows with different superscripts are statistically different at $p < 0.05$; *Means within same column for a particular parameter with this superscript are not significantly different at $p < 0.05$.

In this study, the result of the proximate analysis (Table 1) of the forages indicated that *C. pubescens*, a legume had a higher crude protein value of 18.95% compare to that of *P. maximum* with a crude protein value of 14.53%. This finding is in conformity with the earlier report of Morrison [17] who reported that the average crude protein content of legumes and legume containing pastures were higher than those of grasses alone and pastures without legumes. It is particularly important to note that these values fell within the recommended 15.22% protein level in ruminant diets [6].

The digestibility of the forage fractions was significantly enhanced by the different levels of *SC* (especially at the 0.8 g*SC*/kgbw concentration) in the treatment groups compared to the control in this study (Table 3). This can be buttressed by the assertion that probiotics improve nutrient digestibility [18],

degradation of fibre [19] and ruminal digestion [20] more likely by increasing pH in the rumen [21,22], enhancing growth and/or cellulolytic activity of rumen bacteria [23] and preventing ruminal acidosis by balancing the volatile fatty acids (VFAs) ratios in the rumen [24]. Haddad and Goussous [18] also reported that the supplementation of yeast culture (YC; Diamond V® YC) in the diets of *Awassi* lambs resulted in higher dry matter (DM), organic matter (OM) and apparent crude protein (CP) digestibility. Similarly, neutral detergent fibre (NDF) digestibility was also higher in the yeast culture supplemented group. Krehbiel *et al.* [25] reported that feed additives and direct-fed microbes improved digestibility of the diet. This might be attributed to rumen microbial stimulatory effect, oxygen sequestration and pH modulatory effect of yeast. Newbold [26] reported that up to 16 L of O_2 can enter the rumen daily through water intake, rumination, and salivation and inhibit the growth of obligate cellulolytic anaerobes like *Fibrobacter succinogens*. Yeasts can make the rumen environment more conducive for anaerobic, autochthonous microbes by scavenging O_2 [27]. Many studies have shown that addition of yeast decreased the redox potential of the rumen under *in vitro* and *in vivo* conditions [27,28].

Furthermore, the findings of this study can be supported by the report of Aka *et al.* [13] that organic matter degradability depended on both dose of yeast administered as well as the length of incubation (in hours) for both forages (*P. maximum and C. pubescens*). They observed that as the dose and length of incubation increased, the degree of forage degradability also increased. However, this study did not consider the length of yeast incubation in hours but forage degradability was found to be dose dependent over a period of 4 weeks of *in vivo* yeast administration.

The significant increase in feed intake in the treatment groups of both the *P. maximum* and *C. pubescens* compared to the control (Table 3) can be attributed to the improved cellulolytic bacterial activities and the positive effect of probiotic on ruminal pH. Probiotics supplementation has been found to increase feed intake [30,31,32]. Similarly, Chademana and Offer [33] reported a promoting role of probiotics on dry matter intake (DMI) and fibre degradability. This might be because of increased population and activity of cellulolytic bacteria in the rumen of sheep fed probiotics supplemented diets [34].

The increased weight gain (WG) in this study was found to be dose dependent. The significant improvement in WG in the *SC* treated group compared to the control might be due to improved rumen microbial ecology, enhanced nutrient synthesis and bioavailability. Some authors had earlier reported that probiotics improve microbial ecology, nutrient synthesis and their bioavailability resulting in better weight gain in farm animals [35,36,37]. Haddad and Goussous [18] also observed that the supplementation of yeast culture (YC; Diamond V® YC) in the diets of *Awassi* lambs resulted in higher weight gain. Similarly, Jang *et al.* [38] found that the probiotics supplementation tended to increase weight gain in lambs. Higher weight gain in lambs fed diets containing probiotics could also be due to augmented microbial protein synthesis leading to more amino acids supply at post-ruminal level [39]. Better weight gain may also be related to higher consumption and better efficiency of feed utilization in the probiotics treated groups [31].

Feed efficiency was higher in the treatment groups compared to the control. This again might be linked to better utilization of forages by ruminants which could have been stimulated by *SC.* Robinson [40] and Abdelrahman and Hunaiti [41] reported that feed additives like probiotics improve FCR and FE. FCR is inversely related to FE therefore, as the FE was enhanced by the *SC*, the FCR was reduced which is good for enhanced productivity of animals. This implies that less quantity of feed will be consumed and the weight gain will still be maintained; unlike when high quantity of feed will be consumed and the weight gain will not be proportional. *SC* therefore enhanced the conversion of nutrients in the diets into usable form by the animals and thus avoided wastages.

Water intake (WI) was higher in the treatment group than the control probably due to the higher DMI observed in the treated group. Forbes [15] reported an increased water intake as the dry matter intake increased.

Weight gain, water intake, FCR and FE of *C. pubescens* treated group were higher than those of *P. maximum* treated groups in this study probably due to the higher crude protein content of *C. pubescens* (18.95%), absence of lignin, high soluble carbohydrate, high degradability, and reduced loss of energy due to low methane production. The high crude protein content of *C. pubescens* makes more dietary protein available for the synthesis of rumen microbial organisms thereby increasing their availability for more efficient post ruminal digestion/absorption and the consequent utilization by the body. Furthermore, lignin inhibits cellulolytic activity therefore their absence in legumes pave way for better degradability of legume.

The higher feed intake of *P. maximum* experimental protocol may be linked to the presence of anti-nutritional factors, poor palatability and unpleasant odour of legumes [42,43,44].

The higher degradability of the legume than grass diet observed in this study may be attributed to reduced loss of energy due to methane emissions which rendered more energy available for the rumen microbial fermentative activity. More methane is produced when feeding is restricted to grass compared to legumes [45]. It has also been shown that as the digestibility of a feed increases, the amount of energy available to the animal also increases and therefore the methane emitted per kilogram of production for example growth decreases [46]. Rowlinson *et al*. [45] also reported that diets with a high proportion of concentrates (e.g. legumes) that promote a high propionate type of ruminal fermentation are conducive to reducing ruminal methane production. Therefore, increased digestibility of diets often means less methane emissions per unit of production and less energy loss due to methane production. Similarly, the absence or very low concentration of lignin in legume as opposed to its higher concentration in *P. maximum* enhances its degradability, as lignin is hard to breakdown by cellulolytic bacteria. Therefore, the observed differences in the effect of *SC* on *PM* and *CP* may not only be attributed to *SC* alone as plant factors probably played some roles. For instance, the age of *PM* influences its degradability as older forages have more lignin, which interferes with rumen bacterial attachment to substrate and its subsequent degradation [47].

In conclusion, the study has shown that the addition of *Saccharomyces cerevisiae* to the diet of WAD sheep has a positive effect on their production parameters and the digestibility of the forage fractions. As a result, the inclusion of *SC* up to a maximum of 0.8 g*SC*/kgbw in WAD sheep diet may serve as an additive capable of improving WAD sheep production. However, further studies need to be carried out using higher doses of *SC* in WAD sheep.

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