P-ISSN: 2659-1561
E-ISSN: 2635-3040

Research Article

Growth Performance and Nutrient Digestibility by Sheep Fed Diets Containing Yeast (*Saccharomyces cerevisiae*)

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Received: Jul 25, 2020 **Accepted:** Aug 3, 2020 **Published:** Aug 10, 2020

Abstract: The aim of this study was to determine the effects of varying dietary levels of yeast (*Saccharomyces cerevisiae*) on growth performance and nutrient digestibility by West African dwarf (WAD) sheep. Forty eight lambs (24 males and 24 females) were used in a complete randomized 2×3 factorial design. The sheep were assigned to high roughage and high concentrate diets supplemented yeast (0, 0.75 and 1.5 g of *Saccharomyces cerevisiae* per kg of the basal diets). Sheep fed HC diets supplemented with *Saccharomyces cerevisiae* had significantly ($p < 0.05$) higher average daily feed intake, average daily weight gain, and final body weight than those fed other treatment diets. Dietary inclusion of *S. cerevisiae* improved feed conversion ratio significantly ($p < 0.05$). Supplementation of *S. cerevisiae* to HC diet increased ($p < 0.05$) significantly the dry matter, crude protein, and crude fibre digestibility coefficients. It was concluded that *S. cerevisiae* can be added into HC diet at 0.75 g per kg of the diet for optimum performance of WAD sheep.
Keywords: Digestibility, growth, supplementation, sheep, yeast.

Introduction

Feed additive (probiotic) which is common for ruminants contains live yeast (e.g. *Saccharomyces cerevisiae*) which is commonly used because of its positive effects on animal performance (Ali and Goksu, 2013; Hassan and Saeed, 2013). A probiotic is defined as a live microbial food supplement that beneficially affects the host animal by improving the intestinal microbial balance (McDonald *et al.*, 2002). Probiotics supplementation in feeds enhances the growth of some strains of micro-organisms in the gut. *S. cerevisiae* can multiply rapidly in the rumen, thus enhancing the digestibility of fibre (Chaucheyras-Durand *et al.*, 2008). *S. cerevisiae* contain micro-nutrients which are known to enhance the growth of cellulolytic bacteria. According to Newbold *et al.*, (1996), *S. cerevisiae* save anaerobic microorganisms from the effect of oxygen toxicity by utilizing the remaining dissolved oxygen in the rumen. The pH of rumen in ruminants can be stabilized by live yeasts and thereby lowering the risk of acidosis (McDonald *et al.*, 2002; Chaucheyras-Durand *et al.*, 2008).

Yeast supplementation in the diets of ruminant animals increased feed intake (Robinson and Garrett, 1999), production of milk (Abd El-Ghani, 2004), weight gain (Salama *et al.*, 2002), feed digestion (Jouany *et al.*, 1998) and anaerobic and cellulolytic bacteria numbers (Newbold *et al.*, 1995). Supplementation of yeast in the diet of ruminants changes the patterns of volatile fatty acids (Arcos-Garcia *et al.*, 2000), and may supply unknown growth factors to the animal (Girard and Dawson, 1995). The West African dwarf sheep is a predominant sheep breed in Nigeria and data available on feeding yeast (*Saccharomyces cerevisiae*) to West African dwarf sheep is limited. The present study was aimed at

 P-ISSN: 2659-1561
E-ISSN: 2635-3040

evaluating the effects of varying dietary levels of yeast (*Saccharomyces cerevisiae*) on growth performance and nutrient digestibility by West African dwarf sheep.

Material and Methods

The experimental procedures complied with the provisions of the University of Nigeria, Nsukka Ethical committee on the use of animals for biometric research (2005).

Experimental animals and management

This study was conducted at the Sheep and Goat Unit of the Department of Animal Science Teaching and Research Farm, University of Nigeria, Nsukka, Enugu State, Nigeria. The experiment lasted 12 weeks. Forty eight lambs (24 males and 24 females) of average weight of 9.80±0.57 kg were assigned to six treatments in a completely randomized 2×3 factorial arrangement with high roughage (HR) and high concentrate (HC) diets supplemented with yeast at three different levels (0, 0.75 and 1.5 g of *Saccharomyces cerevisiae* per kg of the basal diets). They were randomly assigned to six treatment groups of eight sheep each per group. The HR diet was composed of forage: concentrate ratio of 60:40 while the forage: concentrate ratio of HC diet was 40:60. Table 1 shows the percentage and chemical compositions of the treatment diets. The six treatments were assigned the following diets: treatment 1 was a high roughage diet without *S. cerevisiae* supplementation; treatments 2 and 3 were high roughage diets supplemented with 0.75 g and 1.5 g of *S. cerevisiae* per kg of diet respectively; treatment 4 was a high concentrate diet without *S. cerevisiae* supplementation; treatments 5 and 6 were high concentrate diets supplemented with 0.75 g and 1.5 g of *S. cerevisiae* per kg of diet respectively. The diets were formulated to meet the recommended crude protein requirement of the animals. The animals used for the study were housed in individual cages and were given free access to feed and water.

Table 1. Ingredients and chemical composition of the high roughage and high concentrate diets

Item	High roughage diet	High concentrate diet
Ingredients (%)		
Panicum maximum hay	60	40
Palm kernel cake	5	24
Bambara nut waste	5	30
Brewer's spent grain	29	5
Salt	0.5	0.5
Vitamins and minerals premix	0.5	0.5
Chemical composition (%)		
DM	89.20	81.71
OM	96.27	90.93
CP	14.81	17.02
CF	18.39	12.73
EE	3.70	5.94
ASH	4.85	7.83
NFE	58.25	56.48
NDF	50.73	46.89
ADF	29.84	22.67

DM: Dry matter; OM: Organic matter; CP: Crude protein; CF: crude fibre; EE: Ether extract; NFE: Nitrogen free extract; NDF: Neutral detergent fibre; ADF: Acid detergent fibre.

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Growth performance

The daily feed intake by each animal was determined by calculating the difference in weight between feed offered and the left over feed the following morning. The average daily weight gain (ADWG) was calculated as the difference between the final body weight (FBW) and initial body weight divided by the number of days on feed. Feed conversion ratio was calculated by dividing average daily feed intake with average daily weight gain.

Digestibility trial

At the end of 12 weeks growth study four males were selected from each treatment group and kept in individual pens. Total collections of faeces were undertaken for seven consecutive days after adapting the lambs to the carrying of faecal bags for three days. The daily feed intake of each animal was estimated calculated by calculated the difference between the quantities of feed offered and the remnants the following morning. The daily faecal collections were weighed and mixed thoroughly by hand and subsamples representing 10% of daily faecal production from each lamb were frozen at –20°C.

Representative samples of each daily collection of diets, and faeces were dried at 60^0C to 70^0C for 48 h and ground through 1 mm mill screen openings and were stored for further analysis. The crude protein (CP), ether extracts (EE), dry matter (DM), crude fibre (CF) and organic matters (OM) contents of the samples were analyzed according to AOAC (1995) methods. Van Soest *et al.*, (1991) methods were used to determine the acid detergent fibre (ADF) and neutral detergent fibre (NDF) of the samples.

Statistical Analysis

The data that were collected were subjected to two way analysis of variance (ANOVA) for factorial arrangement in a completely randomized design (CRD) as described by Steel and Torrie (1980) using Statistical Package for the Social Sciences (SPSS, 2003). The effects of feed types and *S. cerevisiae* supplementation were included in the model. Duncan's New Multiple Range Test was used to separate significantly different means (Duncan, 1955). The effects of the treatment were significant at $p < 0.05$.

Results

The effects of *S. cerevisiae* supplementation on the growth performance of sheep

Table 2 shows the main effects of diet types (DT) and *S. cerevisiae* inclusion levels (CL) and their interactions on the growth performance of West African dwarf sheep.

The DT had significant effect ($p < 0.05$) on average daily feed intake (ADFI), final body weight (FBW) and average daily weight gain (ADWG) of sheep fed high roughage or high concentrate diets. DT did not affect the feed conversion ratio (FCR). Higher ($p <0.05$) ADFI, FBW, and ADWG were recorded for sheep fed the high concentrate diet compared to sheep fed the high roughage diet. *S cerevisiae* supplementation affected significantly ($p < 0.05$) the ADFI, FBW, ADWG, and FCR. The ADFI, FBW and the ADWG recorded for sheep fed the diets supplemented with *S. cerevisiae* were significantly higher ($p < 0.05$) than the values recorded for sheep fed the diets without *S. cerevisiae*. Lower ($p < 0.05$) FCR was recorded for sheep fed the diets supplemented with *S. cerevisiae* compared to that of sheep fed diets without *S. cerevisiae* supplementation.

DT X CL had significant effects ($p < 0.05$) on ADFI, FBW, and ADWG but had no effect on FCR. The ADFI, FBW, and ADWG values for sheep fed high concentrate diet supplemented with *S. cerevisiae* were higher ($p < 0.05$) than those of sheep fed other treatment diets.

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Table 2. Effect of diet types with or without *S. cerevisiae* supplementation on the growth performance of West African dwarf sheep

Items	ADFI (Kg)	FBW (Kg)	ADWG (Kg)	FCR
Main effect of roughage: concentrate ratio				
HR	0.28^{b}	14.00^{b}	0.05^{b}	5.88
HC	0.37^{a}	15.60^{a}	0.07^{a}	5.68
SEM	0.00	0.26	0.00	0.20
Main Effect of SC supplementation				
0g/kg	0.28^{b}	13.28^{b}	0.04^{b}	6.86^{a}
0.75g/kg	0.35^{a}	15.39^{a}	0.07^{a}	5.51^{b}
1.5g/kg	0.35^{a}	15.74^{a}	0.07^{a}	4.96^{b}
SEM	0.00	0.32	0.00	0.24
Interaction (Roughage : Concentrate ratio with SC supplementation)				
HR (SC-0g/kg)	0.24^{d}	13.26^{b}	0.04^{c}	6.50
HR(SC-0.75g/kg)	0.30^{c}	14.19^{b}	0.05^{b}	6.02
HR(SC-1.5g/kg)	0.30^{c}	14.56^{b}	0.06^{b}	5.13
HC(SC-0g/kg)	0.32^{b}	13.30^{b}	0.04^{c}	7.23
HC(SC-0.75g/kg)	0.40^{a}	16.59^{a}	0.08^{a}	5.00
HC(SC-1.5g/kg)	0.40^{a}	16.92^{a}	0.08^{a}	4.80
SEM	0.00	0.45	0.00	0.34

HR: High Roughage; HC: High Concentrate; HR (SC-0g/kg): High roughage with *S. cerevisiae supplementation* at 0g / kg of feed; HR (SC-0.75g/kg): High roughage with SC supplementation at 0.75g/kg feed; HR (SC-1.5g/kg): High roughage with SC supplementation at 1.5g/kg feed; HC (SC-0g/kg): High concentrate with SC supplementation at 0g/kg feed; HC (SC-0.75g/kg): High concentrate with SC supplementation at 0.75g/kg feed; HC (SC-1.5g/kg): High concentrate with SC supplementation at 1.5g / kg feed; ADFI: Average Daily Feed Intake; FBW: Final Body Weight; ADWG: Average Daily Weight Gain; FCR: Feed Conversion Ratio.
[a,b,c] Means on the same column with different superscripts differ significantly at ($p < 0.05$); SEM = Standard error of the means.

The effects of *S. cerevisiae* supplementation on nutrient digestibility by sheep

Table 3 shows the main effects of diet types (DT) and *S. cerevisiae* inclusion levels (CL) and their interactions on nutrient digestibility by West African dwarf sheep. The DT had no significant effect ($p<0.05$) on EE, Ash, NDF, and ADF digestibility coefficients of sheep fed the high roughage or the high concentrate diets, while DT affected ($p < 0.05$) the DM, OM, CP, CF and NFE digestibility coefficients. Higher ($p < 0.05$) DM, OM, CP, CF, and NFE digestibility coefficient were recorded for sheep fed the high concentrate diet compared to sheep fed the high roughage diet. *S cerevisiae* supplementation affected significantly ($p < 0.05$) the DM, OM, CP, CF, EE, NFE, NDF and ADF digestibility coefficient.

The DM and ADF digestibility coefficient recorded for sheep fed the diets supplemented with *S. cerevisiae* were significantly higher ($p < 0.05$) than the values recorded for sheep fed the diets without *S. cerevisiae*. Sheep fed the diets supplemented with 1.5g of *S. cerevisiae* per kg of diet had highest ($p < 0.05$) OM, CP, CF, NFE and the NDF digestibility coefficients, while lowest ($p < 0.05$) OM, CP, CF, NFE and the NDF digestibility coefficients were recorded for sheep fed the diets without *S. cerevisiae* supplementation. DT X CL had significant effects ($p < 0.05$) on DM, OM, CP, CF, NDF and ADF digestibility coefficients. DT X CL had no effect on EE, ash and NFE digestibility coefficients.

The DM, CP, and CF digestibility coefficient values of sheep fed the high concentrate diets supplemented with *S. cerevisiae* were significantly higher ($p < 0.05$) than those of sheep fed other treatment diets. Sheep fed the high concentrate diets supplemented with 1.5g of *S. cerevisiae* per kg of diet had higher ($p < 0.05$) OM digestibility coefficient than those of sheep fed the other treatment diets.

Sheep fed the high concentrate diets supplemented with 1.5g of *S. cerevisiae* and high roughage diet supplemented with 1.5g of *S. cerevisiae* per kg of diet had higher ($p < 0.05$) NDF digestibility coefficients than those of sheep fed the other treatment diets. Higher ($p< 0.05$) ADF was recorded for sheep fed the high roughage diet supplemented with 1.5g of *S. cerevisiae* per kg of diet compared to sheep fed the other treatment diets.

Table 3. Effect of roughage and concentrate ratios with or without *S. cerevisiae* supplementation on nutrient digestibility by West African dwarf sheep

Items	DM (%)	OM (%)	CP (%)	CF (%)	EE (%)	Ash (%)	NFE (%)	NDF (%)	ADF (%)
Main effect of roughage: concentrate ratio									
HR	78.20^{b}	78.84^{b}	73.14^{b}	74.49^{b}	73.33	62.73	71.33^{b}	66.51	67.03
HC	84.45^{a}	82.53^{a}	85.07^{a}	82.12^{a}	80.56	61.22	80.83^{a}	70.42	68.70
SEM	0.59	0.28	0.21	0.20	0.50	0.68	0.75	0.36	0.25
Main Effect of SC supplementation									
0g/kg	74.02^{b}	72.45^{c}	75.35^{c}	69.06^{c}	72.63^{b}	60.88	63.21^{c}	58.33^{c}	59.52^{b}
0.75g/kg	84.57^{a}	83.84^{b}	86.40^{b}	81.91^{b}	73.65^{b}	63.43	78.13^{b}	72.06^{b}	71.79^{a}
1.5g/kg	85.39^{a}	85.76^{a}	87.56^{a}	83.96^{a}	75.56^{a}	61.61	80.89^{a}	75.00^{a}	72.29^{a}
SEM	0.72	0.34	0.25	0.25	0.61	0.84	0.91	0.45	0.30
Interactions (Roughage : Concentrate ratio with SC supplementation)									
HR (SC-0g/kg)	68.21^{d}	69.21^{e}	72.83^{e}	64.94^{e}	72.48	61.05	58.84	53.17^{d}	56.30^{d}
HR (SC-0.75g/kg)	82.49^{bc}	82.76^{c}	84.47^{c}	77.67^{c}	72.77	64.06	76.76	71.51^{b}	71.62^{b}
HR (SC-1.5g/kg)	83.90^{b}	84.56^{b}	86.11^{b}	80.86^{b}	74.74	61.08	78.40	74.84^{a}	75.19^{a}
HC (SC-0g/kg)	79.83^{c}	75.70^{d}	77.86^{d}	73.17^{d}	72.78	60.71	67.59	63.50^{c}	62.74^{c}
HC (SC-0.75g/kg)	86.66^{a}	84.92^{b}	88.33^{a}	86.14^{a}	74.53	62.81	79.51	72.61^{b}	71.96^{b}
HC (SC-1.5g/kg)	86.88^{a}	86.97^{a}	89.00^{a}	87.06^{a}	76.38	60.13	83.39	75.16^{a}	71.40^{b}
SEM	1.01	0.49	0.36	0.35	0.87	1.18	1.29	0.63	0.43

HR: High Roughage; HC: High Concentrate; HR (SC-0g/kg): High roughage with SC supplementation at 0g/kg feed; HR (SC-0.75g/kg): High roughage with SC supplementation at 0.75g/kg feed; HR (SC-1.5g/kg): High roughage with SC supplementation at 1.5g/kg feed; HC (SC-0g/kg): High concentrate with SC supplementation at 0g/kg feed; HC (SC-0.75g/kg): High concentrate with SC supplementation at 0.75g/kg feed; HC (SC-1.5g/kg): High concentrate with SC supplementation at 1.5g / kg feed;
^{a,b,c} Row means with different superscripts differ significantly at ($p < 0.05$); SEM = standard error of the means.

Discussion

Growth Performance

Similar observation with the present study on ADFI and ADWG were recorded by Kumari *et al.*, (2012) when diets with different roughage to concentrate ratios were fed to male lambs.

 P-ISSN: 2659-1561
E-ISSN: 2635-3040

The higher ADWG in sheep fed HC diet could be attributed to the increased feed intake of sheep fed high concentrate diet (Kumari *et al.,* 2012). The result of the present study agrees with Tripathi and Karim (2010) who reported that the supplementation yeast culture in the diets enhanced feed intake on growing lambs. The enhanced feed intake might be as a result of increase in fibre digestibility due to increased total bacteria number, viable bacteria and total cellulolytic bacteria stimulated by yeast supplementation (Abd El-Ghani, 2004). However, the result obtained in this study is in contrast with Pienaar *et al.,* (2012) who reported that feed intake in the finishing diet of Mutton sheep in Mutton Merino lamb was not affected by yeast supplementation.

The increase in ADWG observed in the current study agrees with Whitley *et al.,* (2009) who observed an increase the weight gain of growing sheep fed diet supplemented with yeast. Supplementation of yeast in the diets can enhance the feed intake and absorption of nutrients thereby leading to higher ADWG (Whitley *et al.,* 2009). Haddad and Goussous (2005) indicated that feeding yeast culture to animals enhanced feed digestibility which resulted in higher ADWG and greater feed efficiency in fattening lambs fed 80% concentrate diet. However, the result disagrees with the report of Pienaar *et al.,* (2012) who showed that *S. cerevisiae* supplementation did not affect ADWG of animals fed such *S. cerevisiae*-supplemented diet. In consonance with the result of this study, Kumar and Ramana (2008) observed improved FCR with yeast culture in the diets. The enhanced FCR might be due to improved feed intake and nutrients digestibility which improved the growth of the animals resulting in higher efficiency of feed utilization.

Digestibility

The results of present study are consistent with Hassan and Mohammed (2014) who found that the digestibility coefficients of DM, OM, CP, EE, and NFE values improved significantly ($p<0.05$) with increase in the level of concentrate in the rations. The present result is in agreement with Yang *et al.,* (2001) who reported that total digestion was improved by reducing the ratio of forage to concentrate in diets. Our result support the findings of Haddad and Goussous (2005) who reported that feeding yeast culture increased the digestibility coefficients of DM, OM, CP, NDF and ADF, which resulted in higher ADG and greater feed efficiency in fattening lambs fed 80% concentrate diet. The result of the present study is in line with Gaafar *et al.,* (2009) who reported increase in digestibility of DM and OM due to the addition of *S. cerevisiae* to high concentrate diets.

Williams (2014) reported that yeast may stimulate rumen cellulolytic and proteolytic bacteria particularly when high concentrate (>50%) diets are fed to the animals and increasing the number of rumen cellulolytic bacteria lead to enhanced digestion. The increased digestibility can be due to stable rumen pH and removal of oxygen from the rumen in the yeast supplemented group. The stable rumen pH provides conducive environment for the growth of rumen microbes, particularly the cellulose degrading bacteria and fungi (Ghazanfar *et al.,* 2015). The stable pH also improved microbial protein synthesis in the rumen (Ghazanfar *et al.,* 2015). In contrast to our result, few researchers also reported no effect of yeast on the nutrient digestibility (Hadjipanayiotou *et al.,* 1997; Tripathi and Karim, 2010).

Conclusion

Result showed that sheep fed HC diets supplemented with *Saccharomyces cerevisiae* had higher ($p<0.05$) average daily feed intake, average daily weight gain, and final body weight than sheep fed other treatment diets. Dietary supplementation of *S. cerevisiae* improved feed conversion ratio significantly ($p<0.05$). The dry matter, crude protein, and crude fibre digestibility coefficients increased ($p<0.05$) due to the addition of *S. cerevisiae* to HC diet. We recommend the addition of 0.75g of *S. cerevisiae* per kg to the high concentrate diet.

Conflicts of interest: The authors declare no conflicts of interest.

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Citation: Osita, C.O., Ani, A.O. and Ogwuegbu, M.C. 2020. Growth Performance and Nutrient Digestibility by Sheep Fed Diets Containing Yeast (*Saccharomyces cerevisiae*). International Journal of Recent Innovations in Academic Research, 4(8): 12-20.