PERFORMANCE AND METHANE ESTIMATION IN YANKASA RAMS FED TOTAL MIXED RATION (TMR) CONTAINING TREATED SUGARCANE BAGASSE (*Saccharum officinarum*) SUPPLEMENTED WITH YEAST OR ENZYME

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DECLARATION

I declare that this thesis entitled "**Performance and Methane Estimation in Yankasa Rams Fed Total Mixed Ration (TMR)Containing Treated Sugarcane Bagasse(*Saccharum officinarum*) Supplemented with Yeast or Enzyme.**" has been written by me in the Department of Animal Science, Ahmadu Bello University, Zaria. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this thesis was previously presented for another degree or diploma at this or any other Institution.

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Signature Date

CERTIFICATION

This thesis entitled "**Performance and Methane Estimation in Yankasa Rams Fed Total Mixed Ration(TMR) Containing Treated Sugarcane Bagasse (*Saccharum officinarum*)Supplemented with Yeast or Enzyme**", by Mujtaba Abubakar MIJINYAWA met the regulations governing the awardof Doctor of philosophydegree in Animal Science of the Ahmadu Bello University and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to my parents,Alhaji (Bar.) Mijinyawa Abubakar and HajiyaZainabAbdullahi.

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ABSTRACT

Two studies were conducted to evaluate the feeding value of urea treated sugarcane bagasse with varying inclusion of yeast and enzyme in total mixed ration (TMR) on performance of Yankasa rams. In the first study, twenty (20) growing Yankasa rams were used, the rams were allotted to four (4) dietary treatment in a completely randomised design.The feeding and metabolism trial lasted for 90 and 21 days respectively. A commercial baker's yeast was included at the rate of 5, 6 and 7g/kg respectively and without yeast as control, the diets were offered at 3% body weight. Data generated were analysed using general linear model procedure of statistical analysis system (SAS) and significant differences were compared using Tukey test and contrast analysis. The second study was conducted to investigate performance and methane estimation in Yankasa rams fed diets with varying levels of enzyme in treated sugarcane bagasse with or without yeast supplementation. Twenty-four (24) Yankasa rams with mean live weight 18 ± 0.2 kg were used for the study. The rams were allotted to treatments in a 2×3 factorial arrangement in a completely randomized design to evaluate the effect of inclusion levels of enzyme (2, 4 and 6g/kg) in treated bagasse with or without yeast at 5g inclusions levels. The feeding trial lasted for 90 days. Data collected were analyzed using the general linear model procedure of SAS and significant differences were compared using Duncan Multiple Range Test. Results of the first study showed that, the Crude protein (CP) content of experimental diet varied between 13.0% and 13.75% while neutral detergent fibre (NDF), acid detergent fibre (ADF), and acid detergent lignin(ADL) ranged from 68.30% to 69.04%, 32.60% to 33.53%, and 11.28% to 33.52% respectively. The result of the feeding trial showed that there was significant ($P<0.05$) difference in feed intake, final weight gains and average daily gain. Rams fed TMR with 7g inclusion level of yeast had significantly ($P<0.05$) higher weight gain, average daily gain and better feed conversion ratio. Results of apparent nutrient digestibility showed that rams fed TMR with 7g inclusion level had significantly ($P<0.05$) higher dry matter digestibility (DMD), crude protein (CPD), acid detergent fibre (ADFD), neutral detergent fibre (NDFD) and acid detergent lignin (ADLD) which were at par with rams fed TMR with 0g inclusion level. Results for rumen indices infer that there was a significant ($P<0.05$) difference in pH and TVFA, rams fed 7g inclusion level of yeast had higher TVFA compared to rams in other treatment group. Blood glucose was also significantly ($P<0.05$) different. Total protein, blood urea nitrogen and creatinine were similar ($P>0.05$) between the treatment groups. Methane production varies significantly ($P<0.05$) based on the model tested. Results of the second study indicated that Crude protein (CP) of the total mixed ration (TMR) ranged from 13.75% to 14.585%. while Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) ranged from 65.95% to 68.32%, 32.82% to 34.81% and 11.34% to 12.21%, respectively. There was significant ($P<0.05$) difference in feed intake, weight gain and average daily gain (ADG). Rams fed TMR with yeast had 15% higher values of ADG and 11% lower (better) FCR compared to rams fed TMR with no yeast. Inclusion levels of enzyme had no effect ($P>0.05$) on performance. Nutrient digestibility coefficient differed significantly ($P<0.05$) across all

parameters measured. Rams fed TMR with yeast and 2g inclusion level of enzyme had higher organic matter digestibility (OMD), crude protein digestibility (CPD), neutral detergent fibre digestibility (NDFD), acid detergent fibre digestibility (ADFD) and acid detergent lignin digestibility (ADLD) which were similar with those rams fed TMR with no yeast and 2g/kg inclusion levels of enzyme. Nitrogen balance followed similar trend with nutrient digestibility coefficient. pH, NH_3-N, and TVFA differed significantly. Total protein and blood glucose differs significantly ($P<0.05$) with increasing level of enzyme in TMR while creatinine decreased with increase in inclusion level of enzyme. Methane production was statistically similar ($P>0.05$) but rams fed TMR with yeast and 2g/kg inclusion level of enzyme had the least quantity across all the models tested. TMR containing yeast and enzyme had effect on growth performance, which aid in adequate fibre digestion and other nutrient digestibility coefficient, increased TVFA with minimal methane production. Therefore, it was concluded thatyeast inclusion at 7g/kg improved the growth performance by 34%, better nutrient digestibility and nitrogen retentionand also addition of enzyme (Fullzyme®) at 2g inclusion level supplemented with yeast at 5g/kg inclusion level in bagasse based TMR can be used to enhance performance of Yankasa rams without adverse effect. Finally, it was recommended that yeast should be included in TMR containing urea treated sugarcane bagasse at 7g/kg for improve growth performance. Moreover, enzyme should be included in TMR at 2g/kg inclusion level.

CHAPTER ONE

1.0 INTRODUCTION

The major limitation to ruminant livestock production in the tropics is lack of availability of quality feed especially during the dry season period.Smith *etal.* (1995) observed that dry season feeding of ruminant animals has always been a constant problem to livestock farmers as feed supplies are limited both in quantity and quality.In the tropics, cereal crop residues such as maize, sorghum, millet stover and rice straw are produced in large quantities and could be used as ruminant livestock feed (Ehoche, 2002) especially when treated.

Bagasse is a fibrous sugarcane by-product containing high fibre (43%) and low nitrogen (0.2%), it has limited use in animal feeds without any proper treatment (Ramli *et al.*, 2005). However, its low digestibility limits its use in the row state (Anakalos and Anakalo, 2009). If Bagasse is used as a basal diet, it is important to give the correct supplementation in order to obtain satisfactory physical and economic responses. The supplementation must take account of the productivity of the animals (e.g. growing, fattening, and lactating, etc.), (Mahala *et al*., 2007).Various methods have been employed in order to improve intake and digestibility of these poor quality roughages as feed for ruminant livestock. Mijinyawa *et al*. (2016) reported an increase in performance of bucks fed urea treated sugarcane bagasse supplemented with enzyme.

One of the ways in which the low nutritive value of cereals crop residue(rice straw and stover) could be improved is through treatment with chemicals (Alkali, Acid, Ammonia, Lime and Urea). Urea is one of the commonest and cheapest chemicals to use. Ehoche (2002) reported that urea treatment of crop residues improves nutritional value of the residues and other fibrous by-products thereby reducing feed cost with practical application at the smallholder level in developing countries.Also, Nayawo (2017) reported improvement in performance of rams fed urea treated rice straw with Gamba hay.

Feed additives are important components used in improving nutritional quality of feed which is influenced not only by nutrient content but also by other aspects such as hygiene, digestibility, palatability and pH stabilization (Yirga, 2015). These additives comprise of probiotics, antibiotics and enzymes. Exogenous enzymes have been reported to enhance quality and digestibility of fibrous forage which helps to deliver practical benefits to ruminant production systems. In this regard, cellulases and xylanases are respectively amongst the two major enzyme groups that are specified to break $\beta_{1\text{-}4}$ linkages joining sugar molecules of cellulose and xylans found in plant cell wall components (Dawson and Tricarico, 1999; Beauchemin *et al*., 2003). Several studies with exogenous enzymes have made mention of the increase of microbial activities in the rumen, which resulted in an enhancement of animal performance. Probiotics are live microorganism that when administered in adequate amounts confer benefit to the host. They have also been reported to influence the production of livestock animals in terms of digestibility, growth rate, pH, and efficiency (Rahman *et al*., 2013; Mookiah *et al*., 2014). *Saccharomyces cerevisiae* is one of the common probiotics used in ruminant diets and known to improve better nutrient digestion, prevent acidosis, leading to improve production and productivity (FAO, 2016).

The efficiency of energy and protein utilization in the rumen is relatively low and can be improved by the stimulation of several metabolic pathways, including the inhibition of methane production and deamination. This low efficiency not only reduces production performance, but also contributes to the release of pollutants to the environment (Tamminga, 1996).

1.1 Justification of the Study

Ruminant animals are great contributors to the human food chain due to their ability to utilize complex polysaccharides in plant cell walls (cellulose, hemicelluloses and pectin), which are otherwise non digestible to any of the mammalian digestive enzyme and turn these into meat and milk for human consumption.Digestion of these polysaccharides in ruminant diets is attributable to anaerobic biodegradation of these compounds into their respective monomers by microorganisms (bacteria and fungi) present in the rumen. Several attempts have been made to manipulate the rumen microorganism for better performance using different types of strategies.

One of the ways of improving the quality of feed is the use of chemical treatment and addition of additives like probiotics and enzyme. Results with exogenous enzymes addition in ruminant systems are variable and somewhat inconsistent (Beauchemin *et al*., 2003; Colombatto *et al*., 2003), making their biological response difficult to predict. Some studies have shown substantial improvement of feed digestibility and animal performance traits (Lewis *et al*., 1999; Rode *et al*., 1999; Yang *et al*., 1999; Nowak *et al*. 2003; Cruywagen and Goosen 2004; Mijinyawa *et al*., 2016), while others reported either negative effects or none at all (Vicini *et al*., 2003; Bowman *et al*., 2003; Baloyi, 2008).Also, the use of probiotics in ruminant diets has been shown to increase milk yield, feed intake, growth rate and rumen fermentation in dairy calves (Stella *et al*. 2007; Boyd *et al*. 2011; Le *et al*. 2017).

Moreover, ruminant animals are often debated as one of the contributing factors in global climate change due to the emission of methane (CH_4) as a by-product of fermentative digestion of feedstuffs in the fore stomach. In addition, production of methane by ruminants causes a significant amount of feed energy loss which could be used for animal growth and production if methane production is prevented.However, improving feed quality is one of the

proven methods to reduce CH_4 production (Leng, 1993). Therefore, with this regard, this study tends to investigate the use of treated sugarcane bagasse supplemented with yeast or enzyme to evaluate the performance of Yankasa rams and at the same time estimate the level of methane produced as a result of ruminal fermentation.

1.2 Aim and Objectivesof the Study

The study was targeted towards enhancing utilization of sugarcane bagasse to reduce dependence on conventional sources for fattening which could reduce the cost of fattening small ruminants.

Specific objectives are to

1. Evaluate the growth performance and feed efficiency of Yankasa rams fed treated bagasse in a total mixed ration (TMR) supplemented with yeast or enzyme
2. Determine the effect of TMR containing treated bagasse with yeast or enzyme supplementation on rumen and blood metabolites of Yankasa rams
3. Determine the economics of fattening Yankasa rams on treated bagasse with yeast or enzyme supplementation in a TMR.
4. To estimate the level of methane produced by Yankasa rams fed treated bagasse supplemented with yeast or enzyme.

1.3 Research Hypothesis

Ho

1. TMR containing treated bagasse with yeast or enzyme supplementation have no effect on growth performanceand feed efficiency of Yankasa rams
2. TMR containing treated bagasse with yeast or enzyme supplementation have no effect on rumen indices and blood metabolites of Yankasa rams

3. Feeding Yankasa rams on TMR containing treated bagasse with yeast or enzyme supplementation have no economic benefits
4. TMR containing treated bagasse with yeast or enzyme supplementation have no effect on ruminal methane production in Yankasa rams

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CHAPTER TWO

2.0 Literature Review

2.1 Small Ruminant Production in Nigeria

The population of the major domestic animal species found in the semi-arid zone of West Africa region is said to have increased in the last 30 years (Ben, 2002). According to Williams *et al.* (2001) the population of cattle, sheep and goat increased by 0.5, 2.2, and 1.7% per year respectively between 1961-63 and 1991-93.Nigeria is endowed with estimated 19.5 million cattle, 72.5 million goats, 41.3 million sheep, 7.1 million pigs, 278,840 camels, 145 million chickens, 11.6 million ducks, 2.1 million turkeys and 974,499 donkeys making the nation the topmost Livestock producer in West Africa (FMARD, 2016). Sheep and goats are widely distributed in Nigeria in rural, urban and peri-urban areas representing about 63.7% of total grazing domestic animals in Nigeria (Gefu, 2002). Small ruminants remain popular among the rural populace and resource-poor people. Their importance is primarily assonated with their small size, which is significant for the advantage of mankind as it favours low investments, small risk of loss and preference over large ruminants for food and reproductive efficiency and economic use of available land (Omoike, 2006). Boyejo and Adedoyin (1994) also reported that sheep, goats rearing are a common feature in most rural households in Nigeria and are important items in religion festivals in Western Nigeria.

Ruminant livestock are kept worldwide for their numerous economic and social contributions to humanity.Nigeria is endowed with estimated 19.5 million cattle, 72.5 million goats, 41.3 million sheep, 7.1 million pigs, 278,840 camels, 145 million chickens, 11.6 million ducks, 2.1 million turkeys and 974,499 donkeys making the nation the topmost Livestock producer in West Africa (FMARD, 2016).Small ruminants remain popular among the rural populace and resource-poor people.Their importance is primarily associated with their small size, which is significant for the advantage of mankind as it favours low investments, small risk of

loss and preference over large ruminants for food, reproductive efficiency and economic use of available land (Omoike, 2006).

Small ruminant production systems in Nigeria are basically classified into three production systems namely; extensive, in which they are allowed to roam and fend for themselves intensive, intensive in which they are kept in total confinement and semi intensive (Gefu, 2002). Ahmed and Egwu (2014) observed that sheep production system is predominantly extensive and semi-intensive. The most predominant system practiced in the rural areas is the extensive system(Gefu, 2002). Also, Alawa (2002) reported that the bulk of sheep and goat production in Nigeria is of traditional free-range type.

2.2Problems Associatedwith Small RuminantProduction

Livestock productivity in Nigeria takes a seasonal fluctuating pattern following the variability of available feeds. Consequently, livestock experience a drastic loss in weight and milk production during the seven months of dry season in the major livestock producing areas of the Sudan savannah and Sahel regions. There are in turn serious management problems due to feed shortage during the dry period (Lakpini *et al.*, 1992).

One of the major factors limiting the productivity of small ruminants in developing countries is the over-dependence on low digestible feeds which at certain periods of the year cannot meet even the maintenance requirements of these animals. The incidence of tse-tse fly is another factor affecting the production and distribution of animals. Cattle, sheep and goat distribution in Nigeria is limited by tsetse fly incidence and by the availability of forage, the semi-arid ecological zone is virtually tsetse fly free, but has the lowest forage resources, carry over 70% of the total population of livestock in Nigeria are concentrated in the guinea and Sudan zones (Gefu 2002).Daniel (2007) reported problems of small ruminant producers were

disease, feeding problem, accommodation constraint, inadequate capital, destructive habit of the animals and predators, among others.

2.3 Feed Resources of small Ruminants

Livestock feed may be defined as any dietary substance that nourishes the animal's body for maintenance and reproduction. These feeds are either roughages (forages) or concentrates (Lamorde, 1993). According to Lakpini (2002), feeds are substances voluntarily taken in by animals to provide nutrients such as energy, protein, mineral and vitamin metabolized in the body to maintain the body, produce body tissue, fluids and by-products. The feed resources available for small ruminants are natural pastures, sown pastures, browses, crop residues and by-products. The availability and quality of these resources vary, but can be adequately utilized for sustainable small-ruminant production and productivity when they are properly selected and combined according to their nutritional characteristics.

2.3.1 Forages

According to Babayemi *et al*. (2014) forages are plants that are cultivated for their vegetative portions and are used in fresh or preserved forms for feeding livestock. Forage is the major nutritional resource for ruminants particularly in sub-Saharan African countries and most of the forages that provide animal nutrition are supplied by the natural vegetation and generally referred to as natural pastures. The semi-arid ecological zone of Nigeria has the lowest forage resources, yet is hosting over 90% of the cattle and 70% sheep and goats population (RIM, 1992). The zone is characterized with sporadic year round shortage in the supply of pasture both in quality and quantity despite the abundant supply during the late rainy and early dry season; and livestock farmers experience a shortage of forage for feeding livestock (Muhammad *et al*., 2008).

Fodder trees and shrubs constitute a vital component in livestock production in the arid and semi-arid tropical zones of Africa where about 52% cattle, 57% sheep, 65% goats and numerous camels are found (Dicko and Sikena, 2003). The excess of pasture produced during the rainy season is conserved for redistribution over the year. Hay and silage making are the two conventional forage conservation methods. There are inherent difficulties in conservation of forage as hay (Amodu*et al.,* 2008); the right time climate suited for hay making coincide with the time when forages are of low quality while making of good quality hay during the rainy season when they are of optimum nutrient concentration is practically impossible due to humid condition (Kallah *et al*., 1997).

2.3.2 Crop Residues

Crop residues are post-harvest roughages after harvesting and threshing the cereal crops,(Ahmed and Kibon 2015). Kallah, (1992), define crop residues as the post-harvest roughage materials or plant materials left after the removal of the primary food from the crop plant.They include the residues made up of stalks, husks and cobs from maize, sorghum, millet, rice, wheat, sugarcane etc. The authors further stated that residues are also obtained from legume crops such as groundnuts, cowpeas, soybeans and other leguminous crops which include haulms, cowpea husks, groundnut pods and vines. In addition, crop residues of cotton, cassava, and other types of beans may also be available for use by the farmer (Adamu and Odion, 1998). Crop residues are characterized by high content of fibre usually above 40%, low content of nitrogen (0.3-1.0%) and low content of essential minerals such as Sodium (Na), phosphorous (P) and calcium (Ca) (Adegbola, 1998).Crop residues have been estimated to account for about 25 % of the total feed energy suitable for ruminant livestock in both developed and developing countries. They are potentially rich sources of energy, because up to 80 % of their dry matter consists of polysaccharides (Meng, 2002), but usually underutilized because of their low digestibility, which limits feed intake (FAO, 2002).

Tchinda *et al*. (1993) reported native pasture and crop residues to be the most widely available low-cost feeds for ruminants in the tropics.

The potential of cereal crop residues as animal feed is enormous if all the different types of cereal crops are considered and if appropriate methods of improving their nutritional value are employed. Because of the importance attached to crop residue as feed resource, price is normally attached to it. The pricing of crop residues differs from place to place depending on animal population and between season, type of crop residue and time of the year. In drought years, they may cost as much as the grain while in favourable years they may cost as much as 25% of the grain values (Singh and Tarawali, 1997).

2.3.3 Agro Industrial by Products

Forage and crop residues account for 26% and 24% of feed energy resources available to ruminants in the world, Muhammad *et al*. (2008). The principal residue for feeding sheep and goats are the agro-industrial by-products from oil seeds processing and grain milling as well as other residue of food crops such as sugarcane waste. The composition and usefulness of these products vary with the milling efficiency and level of husk present. Agro-industrial by-products in Nigeria vary from primary processing of farm produce wastes to wastes from agro-allied industries.The use of Agro-industrial by-products as livestock feed is becoming increasingly popular in Nigeria.The sustainability of grain offal (dusa) and crop residues in feeding ruminant is also documented (Ahamefule *et al.*, 2002).

In Nigeria, large quantities of agro-industrial by-products are produced and many of them have potentials as non-conventional feedstuffs (Adeniji and Ehimere, 2003). Such by-products include corncobs, cassava peels, rice polishing, rice husk and brewers' grain. Brewers' spent grains, the by-product of the grains fermented during beer making process have been used as feedstuffs to both ruminants and monogastric animals and is considered to

be a good source of un-degradable protein and water soluble vitamins which stimulate appetite and feed intake(Ekanem, 2012).

2.3.3.1 Sugarcane by-products

Sugarcane might haveoriginated in some of the large Island of *Oceania*, most probably in New Guinea, where various farms of thick, tall, tropical cane have been grown from ancient times (Singh *et al.*, 2004). The generic name of sugarcane is *saccharum* and oldest cultivated species include many varieties, they are of excellent quality and thick widely grown throughout the tropical world for chewing, juice production and the manufacture of brown unrefined sugar. Some of the main by-products that are available from sugarcane industry are: Bagasse, Sugarcane tops, Molasses and Press mud (Ranjhan, 2001). Other locally available sugarcane by-products are sugarcane scrapping and sugarcane peels.

Bagasse

Bagasse is one of the most important by-product of the sugar industry. It is the residual fibre resulting from the extraction of sugarcane juice. Bagasse is used primarily as fuel in sugar industry; pulp and paper manufacture (Ranjhan,2001). It is a good source of cellulose but poor in protein (1.3%CP) and high (16%) in lignin. The proximate composition of bagasse is 90% dry matter, 2.5% crude protein, 39.7% crude fibre and 4.8% ash (Ranjhan and Pathak, 1998).

Bagasse is a high fibre, low protein product of very low digestibility which is sometimes mixed with the cane molasses for cattle feeding (Ranjhan,2001).However, digestibility of unprocessed bagasse is low because it contains high lignin content (Bhatti and khan, 1996) Tomato pomace contains 14.3% DCP and 65%TDN. After drying and grinding, it can be used as a part of animal feed up to 35% level (Baiti *etal*., 2013). It can replace satisfactory

wheat bran on equivalent weight bases up to one third portion of a concentrate mixture (Ranjhan, 1997)

Molasses

Molasses is another by-product of sugar industry which contains about 50% sugar. The production of molasses is dependent on the production of cane sugar. It is about one third of the quantity of sugar and about 3% of sugarcane. The approximate composition of molasses is as follows: 20.6%water, 60.8%total sugar, 3.2%crude protein, 2.2%soluble gums, 8.2%ash, and 5.0%free acids.Molasses has been mainly used in animal feeding at 5 to 10% level (Ranjhan, 2001).Molasses has been used for many years as a cheap source of energy in the ration of farm animals. Molasses contain about 3.25% crude protein. Molasses has been used in animal feeding at levels of 5- 10%. These levels are mostly used as: a carrier for urea impregnation of poor quality roughages, a binder for commercial pelleted feeds for the convenient and economic feeding of livestock and as a sweetener for increasing the voluntary intake of compounded feeds (Ranjhan, 2001).Molasses is by far the most important by-product of sugarcane because of its high minerals content, energy value and palatability. In ruminant diets, molasses has been utilised at level ranging from 0 to 60% in two growth trials with cattle (Baiti*et al.*,2013).

Press mud

It is obtained during the process of precipitation. The quantity of press mud depends upon the process used for the precipitation of impurities (it is 3% in the sulphitation factories and 7% in the carbonation factories) the organic matter content in the press mud is about 64% of dry weight and is a rich source of calcium. This industrial waste is mostly used as soil conditioner, soil fertilizer and for wax production.In animal production it has been used as

feed ingredient, notably for ruminants, because of its sugar and mineral content and as compacting agent for ensiling (Van der poel *et al.,* 1998).

Sugarcane tops

Represents 15-25% of the aerial part of the plant. Generally, the cutting point is at the highest fully formed node (Suttee, 2000). Sugarcane tops from sugar production are harvested at maturity, which coincides with the dry season, but tops from sugarcane grown for animal feeding can be harvested at an immature stage. Sugarcane tops have an energy value 0.12-0.15 MJ/kg on DM basis, comparable to that of good grass, but their protein content is as low as 5-7% (Charray *et al.*, 1992). The proximate composition of sugarcane tops was reported by Ranjhan (1997) as 90% dry matter, 6.4% crude protein, 32% crude fibre and 4.9% ash.

2.4 Nutritive Value of sugarcane Bagasse

Bagasse is produced from sugar plant and it is used mainly for burning energy. One way or another can be used as a feedstuff even though it is low in crude protein and digestibility (1.4 and 15-25%) but high in crude fibre, neutral detergent fibre and acid detergent fibre respectively(Chullanandana, 2000). Bagasse is composed of lignocellulosic materials that protects itself from rumen micro-organism digestion.

Reddy *et al.* (1993) evaluated that, the nutritive value of ground sugar cane bagasse without or with subsequent pelleting, and fed to sheep and goats. It was concluded that sheep DM intake was higher than goats. Pelleting significantly increased the digestibility of CP and gross energy (GE). However, digestibility of cell wall constituent was higher in the grounded diet. Sheep had higher digestibility of all proximate constituents, GE and neutral detergent soluble than goats. Pelleting had no effect on nutritive value. Goats had higher digestible

crude protein and total digestible nutrient compared with sheep on the combined diet and on bagasse alone.

Gado (1999) studied the effects of treating rice straw or bagasse with steam and (*Trichoderma reesie*) on its chemical composition. The author found that, crude protein (CP), crude fibre (CF), ether extract (EE), neutral detergent fibre (NDF), acid detergent fibre (ADF), cellulose and hemicellulose were lowered in both of treated rice straw and bagasse due to treatment. Table 2.1 illustrates the chemical composition of sugarcane bagasse reported by some authors.

Table 2.1. Chemical composition of sugarcane bagasse as reported by some authors

Authors (%)	DM	CP	CF	EE	ASH	NFE	ADF	NDF
Mijinyawa *et al*. (2016)	95.38	2.69	19.46	0.67	2.66	74.52	19.86	41.88
Shakweer (2003)	94.57	2.66	36.78	4.05	7.56	48.75	65.77	80.95
Bassuny *et al.* (2003)	88.63	2.26	51.78	3.83	5.31	36.82		
Boraei (2003)	89.14	3.95	27.85	1.85	9.95	56.40		

2.5 Problems Associated with Feeding Bagasse

Bagasse can be used as feedstuff even though it is low in crude protein and digestibility (1.4%CP, 15-25%), but it had high in CF, NDF, ADF (Chullanandana, 2000). Bagasse consists of lignocellulosic materials that protected it from rumen micro- organism's digestion. The major constraints in utilization of bagasse are its low palatability and digestibility, which is due to the physical configuration and chemical complexes of its structural carbohydrates i.e. cellulose, hemicellulose and lignin. The former two are potentially digestible depends upon access to them by rumen microbes. In general, less than half the nutrients in bagasse are digested by the animals due to high degree of lignification of the material.

2.6 Methods of Improving Low Quality by-products and Residues

In the tropics, livestock suffer from shortages of feed supply especially during the long dry season despite the vast amounts of crop residues. Most of these are consumable and utilized by ruminant animals without proper processing, some of which can be carried out by small-holder farmers themselves. Processing of feed involves the use of any treatment which alters the composition of that feed by physical, chemical or biological action (El- Shobokshy *et al.*, 1989). However, alterations in composition do not simply means improving the nutritional value of the feed but, also include a large range of other improvements such as detoxification, change in particle size, and improving palatability. The main treatments for improving the voluntary intake and nutritive value of crop residues and by-products are physical, chemical and biological, of which one or more can be applied. Several efforts have been made in order to improve the nutritive values of low quality roughages which are characterized by low digestibility as well as low voluntary intake.

2.6.1 Physical Treatment

Physical treatments, such as grinding, soaking, pelleting,milling and chopping have been applied to agro –industrial waste to increase available surface area and to disrupt the crystalline structure of cellulose micro fibrils. Considering the surface area effect, the smaller the particle size, the greater the surface area and the greater the digestibility (McDonald *et al.*, 1988). The treatment is generally aimed at reducing the particle size of the material (Lufadeju, 1988). Reduction in particle size offers several advantages; increases ease of handling, facilitates better storage, reduces wastage, reduces selective eating by animals and improves feed intake and digestibility (kallah, 1992) as relatively larger surface area becomes available for microbial activities.Liu *et al.* (1999) reported that the use of steam treatment in a high pressure vessel at different pressures and for a range of different treatment times increased the degradation *in vitro* in rumen fluid after 24 h and the rate of degradation,but could not enhance the potential degradability of the fibrous fractions (NDF, ADF and hemicellulose). Physical treatments of crop residues have received an appreciable amount of research. Many of these treatments are not practical for use on small-scale farms, as they require machines or industrial processing

2.6.1.1 Effect of physical treatment on growth performance

Particle size reduction enhances access of nutritional components such as starch and protein to digestive enzymes through increasing the number of particles and the surface area per unit volume (Koch, 1996; Goodband *etal.*, 2002). Physical form of forage may influence productive performance through the influence on mastication, microbial fermentation in the rumen, and the rate of passage and digestion in the gastro-intestinal tract (Lu *et al.*, 2005). Omokanye *et al.* (2001) found that chopping of browse species before offering enhanced intake by around 60%. According to Mui *et al.* (2000) when sugar cane stems were chopped

into small slices (1-3 cm lengths) feed intake was increased compared to 15 and 20 cm cutting lengths.

2.6.1.2 Effect of physical treatment on nutrient digestibility and nitrogen balance

It has been observed that grinding and pelleting of grass hay decreased dry matterdegradability in cows from 73 to 67%, which was mainly due to a decrease in total retention time of the solids from 73 to 54 hours and decreased fermentation rate (9.45.1%/h) and resulting in an increased intake (Stensig *et al.*, 1994). Liu *et al*. (1999) reported that the use of steam treatment in a high pressure vessel at different pressures and for a range of different treatment times increased the degradation in vitro in rumen fluid after 24hrs and the rate of degradation, but could not enhance the potential degradability of the fibrous fractions (NDF, ADF and hemicellulose).

2.6.2 Biological Treatment

Biological treatment of crops residues and fibrous by-products is based on the use of certain microorganisms that are very efficient in lignin metabolism but with low degradation rates of cellulose and hemicelluloses. Biological treatments of some agricultural by-products become essential in order to degrade lignocellulosic materials and improve its crude protein content. It is well known that some micro-organisms, including cellulose enzymes from anaerobic bacteria and white rot fungi (*Pleurotus ostreatus*) can degrade lignin in the cell walls, while numerous attempts have been made to improve digestibility of plant residues (Abdel-Aziz and Ismail, 2001).

2.6.2.1 Effect of Biological Treatment on nutrient composition

Dhanda *et al.* (1994) observed a reduction in CF, NDF, ADF, cellulose, hemicellulose and lignin levels as a result of treating wheat straw by rot fungi *spp*. In addition, a considerable degradation in wheat straw was achieved by the influence of *Pleurotus ostreatus* enzymes and cell wall components were also decreased with time. The most pronounced changes (after 120 days of incubation) were occurred in NDF (34%), ADF (15%) and lignin (4%). Mohamed (1998) indicated that, the chemical composition of sugar can bagasse was improved after being treated with fungi (*Trichoderma reesie*). The CP and CF of treated sugar cane bagasse were 7.30 and 31.07 % respectively, while such values were 2.35 and 41.3 for untreated sugar cane bagasse. Eun *et al*. (2006) noticed that, the fungal treatment of banana wastes, corn stalks, rice straw and wheat straw with *Trichoderma viride* and *Penicillium funiculusms* significantly ($P<0.05$) increased the CP content. Also, Belewu (1998) reported that treatment of Sorghum Stover with *Trichoderma harzanium* enhanced the crude protein of the substrate while the crude fibre content was reduced. Biological treatment of crop residues needs controlled conditions which are difficult to achieve at farmers' level.

2.6.2.2 Effect of Biological treatment on nutrient digestibility and nitrogen balance

Enzyme treatment alone or in combination with other treatments can increase the degradability of cereal straw by the rumen microorganisms (Liu and Ørskov, 2000; Eun *et al*., 2006; and Fazaeli *et al*., 2006). In addition, using fibrolytic enzymes in ruminant feed have shown improvements in the average daily gain of steers (Beauchemin *et al*., 2004), fleece weight, wool production of lambs and in milk yield of dairy cows (Yang *et al*., 2000).Eun*et al*.(2006) found that, the white rot fungi have the capacity to attack lignin polymers, open aromatic rings and release low molecular weight fragments. Also,Fazaeli *et al*. (2006) fermented cotton stalks by white rot fungi (*Trichoderma viride*) and reported that,

apparent nutrients digestibility values of DM, OM, CP, CF, EE, NFE, NDF, ADF, hemicellulose and cellulose of fungal treated cotton stalks diet (25% treated cotton stalks + 25% wheat strw+50% concentrate mixture) were significantly higher than the control diet (25% untreated cotton stalks + 25% wheat straw + 50% concentrate mixture).

Eun *et al*. (2006) treated banana wastes with *Trichoderma viride* (T1) and *Pinicillium funiculusms* (T2) and found a significant increase ($P<0.01$) of apparent nutrients digestibilities for DM, OM, CF, NFE, ADF, hemicellulose and cellulose. Also, CP, EE and NDF digestibilities increased ($P<0.05$) for fungal treated banana wastes (FBW) ration (30% FBW) for T1orT2 + 70% concentrates) comparing with the control ration (30% untreated BW+ 70% concentrates).The DCP and TDN values were (9.36and 9.89%) and (60.52 and 65.69%) for T1 and T2, respectively.

2.6.2.3 Effect of biological Treatment on rumen metabolites

Studies (Li *et al*., 2010) have shown the improvement in feeding value of rice straw by ensiling. Some commercial lactic acid bacteria (LAB) have been developed to be used as additives in order to improve the quality of rice straw silage. The application of LAB to whole crop rice could increase lactic acid and crude protein concentration and lower the pH value, butyric acid and ammonia nitrogen concentrations (Li *et al*. 2010). Moreover, Li *et al*., (2010) reported that *Lactobacillus plantarum* could lower the pH value and butyric acid concentrations, while increasing lactic acid, crude protein and acetic acid in rice straw silage. Inoculation of rice straw with LAB could also increase digestibility of DM and NDF and decrease NDF and ADF concentrations (Li *et al*., 2010)

Fazaeli *et al*. (2006) used untreated cotton stalks (control, T1), treated with fungus by *Trichoderma virde* (T2), treated cotton stalks with *Saccharomyces cerevisiae* (T3) and combined fungi + yeast 50% for each (T4). The author found that, the pH values of all biological treatments (T2, T3 and T4) decreased ($P<0.01$) than those of the control. The T3 showed lower ($P<0.01$) value followed by T2 and T3. Ruminal pH was affected by the time of sampling. All biological treatments had significantly increased ($P<0.01$) TVFA's values than the control. The T4 showed the highest ($P<0.01$) values followed by T3 and T2. However, T3 was higher ($P<0.01$) than T2. Ruminal ammonia-N was affected by the time of sampling.

Deraz and Ismail (2001) reported that, the biological treatment (*Coriolus versicolor, Pleurotus ostreatus* and *Phanerochaete chrysosporium*) of cotton stalks significantly ($P<0.05$) increased the rumen liquor pH values which were 7.13, 6.92 ,6.89 and 6.89, respectively. Ruminal NH_3-N was 9.00, 9.50,9.00 and 8.90 mg/l00mI, and total volatile fatty acids (TVFA's) were 8.83, 7.45, 10.05 and 7.19 m eq/100 ml, respectively. Also,Li*et al.*, (2010) indicated that, feeding goats biologically treated cotton stalks significantly decreased the ruminal pH values and significantly increased TVFA's and NH_3-N at 3 hrs after feeding than those fed the untreated cotton stalks.

2.6.2.4 Effect of biological treatment on blood metabolites

Fazaeli *et al*. (2006) indicated that, the values of serum total proteins were higher ($P<0.01$) with fungal, yeast and combined fungi plus yeast (6.80, 6.84 and 6.93 g/dl, respectively) than value of untreated cotton stalks (6.65). Also, the same trend was observed for serum albumen and Albumin Globulin ratio, urea nitrogen and serum Creatinine concentration. The values of serumglutamic oxaloacetic transaminase (GOT) and glutamic pyruvic transaminase (GPT) concentration for biological treatments were higher ($P<0.01$) than value for the control. The

values of serum GPT were 24.41, 25.17, 25.68 and 22.66 (u/ml) of fungi, yeast and combined fungi and yeast treatments and control, respectively.

Fazaeli*et al.* (2006) reported that, the effect of biological treatments on blood serum protein fractions (total protein, albumin, globulin and A/G ratio) for treatments (T2, T3 and T4) were higher ($P<0.01$) than values of their control(T1). Also, values of serum Urea-N concentration of biologically treated diets (T2, T3 and T4) were higher ($P<0.01$) than value of their control (T1). The values of serum creatinine concentration ranged from 1.06 in T1 to 1.25 (mg/dl) in T4. Values of serum creatinine for biological treatments (T2, T3 and T4) were higher ($P<0.01$) than value for their control. There were significant ($P<0.01$) differences among the overall means of serum GOT and GPT concentration for different treatments. The values of serum GOT ranged from 39.42 in T1 to43.66 (units/L) in T4. Values of serum GOT and GPT activity of biologically treats diets (T2, T3 and T4) were higher ($P<0.01$) than value for their control.

Deraz and Ismail (2001) compared the effect of feeding fermented cotton stalks with *Coriolus versicolor*, *Pleurotus ostreatus* and *Phanerochaete chrysoporium* with untreated cotton stalks. The results showed that blood serum levels of total protein were 6.03, 6.06, 6.15 and 3.16 g/100ml; for albumin were 3.05, 3.10, 3.20 and 3.16g /100 ml; for globulin were 2.98, 2.96, 2.95 and 2.97g /100 ml and for urea 24.11,23.85, 24.31 and 24.40 mg/100ml, respectively. Blood serum aspartate amino–transferase (AST) and alanine amino-transferase (ALT) levels were not affected by fungal treatment being; 36.00, 36.67 and 36.33 unit/ml for AST; and were 27.00, 26.33 and 29.00 unit/ml, which are within the normal range.

2.6.3Chemical Treatment

Chemical processing may include structure changes in the starch and disrupting the protein matrix, resulting in changes in digestibility and metabolic end product. Several chemicals have been used to enhance the quality of crop residues and Agro-industrial by-products. The choice of a particular chemical depends on its effectiveness in improving digestibility and or intake, cost of treatment, availability and freedom from chemical residues that could be toxic to animals directly or animals and man through faeces and urine polluting soils and water courses. In addition, the chemical should be non-hazardous to handle by man and non-corrosive to machinery (Owen *et al.,* 1984). Abd El-Aziz *et al.* (1994) fermented rice and bean straws and sugar cane bagasse with *P. ostreatus* and found that the NDF and hemicellulose contents in the spent rice straw were decreased by 14.85 and 65.59% respectively. On the other hand, ADF and cellulose contents were higher by 9.26 and 10.08%, respectively. Also, the hemicellulose content of spent bean straw and spent sugar cane bagasse decreased by 21.9 and 13.66%. They added that, NDF, ADF and cellulose contents were increased from 10.45 to 13.2% 20.24 to 29.25% and 37to 36.26%, in the same order.

2.6.3.1 Alkali Treatment

Chemical treatment through the use of alkali such as Sodium hydroxide (NaOH), Potassium hydroxide (KOH), Calcium hydroxide ($Ca(HO)_2$) has been shown to improve digestibility of poor roughage considerably (Klopfenstein, 1978). These alkalis act as delignifying agents by breaking the bond between lignin and hemicelluloses or cellulose (El- Shazly and Nagal, 1981). The alkali treatment is a powerful swelling agent for cellulose, hemicellulose and lignin. It neutralizes free uronic acid groups, and saponify uronic acid esters and acetyl groups which would perhaps be account for the solubilisation of silica and hemicellulose.

When sugar cane bagasse was treated with 5% NaOH; DM digestibility coefficient and nutritive value were decreased. They also found that feed intake was the maximum with 37% bagasse in the ration (Nour *et al.,* 1987).NaOH (caustic soda) have limited acceptability in a growing economy like Nigeria. This is due to its high cost and corrosive nature.

2.6.3.2 Acid Treatment

Highest values of DM digestibility were recorded with rations containing rice straw treated with H_2SO_4 than the one treated with NH_3. But the lowest value of DM digestibility was recorded with untreated rice straw ration and the same trend was also observed with OM digestibility, while the CF digestibility recorded the highest values with treated rice straw (Azzam, 1992). The author also found that, DM, OM, CF, CP, and NFE digestibility's were improved in sheep fed sulphuric acid treated rice straw or sulphuric acid and anhydrous ammonia treated rice straw than that of the control (untreated rice straw).

2.6.3.3 Urea Treatment

The use of urea-ammonia treatment to improve the quality of crop residues is cheap and therefore has practical application at small holder level in developing countries (Ehoche, 2002). Urea is widely used as a fertilizer (46% N), whereas it is a natural source of ammonia and easy to handle and transport. Urea treatment of crop residues is a cheap and safe way of improving their nutritive values for ruminant livestock. However, only a small portion of the nitrogen is lost as ammonia during aeration. Urea is broken down to ammonia in the rumen with an energy source, and the ammonia is then used by the microbes in the rumen to produce microbial protein.

Trials at the National Animal Production Research Institute (NAPRI), Shika, have shown significant importance in the rumen degradation of urea treated Gamba hay when 40g of urea was dissolved in 600g of water and sprayed on 1kg of hay sealed in polythene bags for

21days (Lufadeju *et al.*,1986) when urea is added to animal feed it breaks down in water to produce ammonia gas, it is therefore necessary to allow the feed to aerate for a while so as to disperse the free ammonia before it is fed to livestock (Chesworth,1992). Ammonia is the actual toxic agent in urea poisoning, it is most toxic at high ruminal pH owing to the increase permeability of the rumen wall to ionized ammonia compared with the ammonium, which predominated at low pH (Mc Donald *et al.,* 1995).

***Effect of urea treatment on nutrient composition*:**

Improvement in nutritional value of crop residues and other by-products following urea ammonia treatment has been reported in several studies (Abdu, 1998; Ehoche, 2002). Ngele (2008) reported an increase in CP from 4.4% in untreated rice straw to 12.4% in 4% urea treaded rice straw. Also, Rajeev *et al.* (1996) treated rice straw with 6 % urea solution and kept for two months along with a sample of untreated rice straw. The authors found an increase in crude protein from 3.5 to 17.1 %. Furthermore, Abdu *et al.* (2012) reported that, urea treatment increased CP content from 8.75% to 14.38% when maize Stover was treated with urea solution.

***Effect of urea treatment on growth performance and nutrient digestibility*:**

Ali (1995) reported that, the CP and OM digestibility of 3% urea treated rice straw increased when fed to Zaraibi bucks and Rahmani sheep than those fed untreated rice straw. Fouad *et al.* (1998) investigated the effect of treating six different roughages either biologically or with urea on animal performance. The roughages were offered *ad libitum*, whereas concentrate portion was fed at 1% of body weight. Results obtained showed that, the ADF digestibility coefficients were almost similar between urea and fungal treatments. Whereas NDF digestibility was significantly higher ($P<0.05$) for urea treatment. Nutritive value as DCP% was not different, whereas TDN was significantly higher for urea treatment. Also, Urea treatment of straw was reported to have increased digestibility and improved milk yield in

Maradi (Red Sokoto) goats (Djibrillou *et al.,* 1998).Some authors have reported and shown that treatment of crop residues with urea improved organic matter digestibility, crude protein, NDF and ADF (Hossain *et al*., 2010; Sarnklong *et al*., 2010; Huyen *et al*., 2012; Gunun *et al*., 2013). Treatment with urea can lead to a high nitrogen loss in urine; due to the ammonia being converted from the NPN of the urea used in the treatment along with that produced in the liver (Santos *et al*., 2014; Yulistiani *et al*., 2015)

***Effect of urea treatment on rumen metabolites*:**

Variations in the proportion of concentrate in the ruminant diets led to unfavorable ruminal environmental conditions for fermenting roughages which are usually associated with reduction in the voluntary intake (Gabr 2000). So, rumen parameters which are known to affect rate of fermentation in the rumen must be taken into consideration when one planning for formulating rations of different roughage: concentrate ratios aiming to obtain a suitable pH, NH_3-Nconcentration in the rumen and considerable formation of TVFA's, because all of these factors reflects on the animal products performance and its health.

Hassona *et al*. (1995) reported that, NH_3-N concentration in ruminal fluid of Rahmani lambs and Zaraibi kids were significantly increased by advancing time and reach to the peak at 1 hr after feeding. They also showed that there was a sharp decline in NH_3-N concentration observed at 3 and 4 hrs post feeding with Rahmani lambs and Zaraibi kids. But the moderate effect was resulted with sulphuric-urea treatment. They added also that growing Zaraibi kids were significantly higher in ruminal NH_3-N concentration in all treatment and different times than those scored with Rahmani lambs. Also, Ali (1995) showed that, the peak of ruminal NH_3-N concentration of Zaraibi kids and Rahmani rams fed 3% urea treated rice straw were (52.83 and 52.24 mg/100 ml, respectively) at 1 hr, post feeding then gradually decreased until 6 hrs post feeding (29.40 and 25.11 mg / 100 m1, respectively).

***Effect of urea treatment on blood metabolites*:**

Hassan (2014) reported BUN of (5.26-7.50mmol/L) after feeding Red Sokoto Bucks with graded levels of Lablab (*Lablab purpureus* L. sweet) hay as supplement to a basal diet of maize (*Zea mays*) stover. Aliyu *et al*. (2012) reported blood urea nitrogen values of 14.00 - 22.40mg/dl from ram lambs fed urea and/or poultry droppings treated *Pennisetum pedicellatum* (kyasuwa). Taiwo and Ogunsanmi (2003) reported total protein of various small ruminants in the range of 5.5-10.0g/dl. Similarly, Aliyu *et al.* (2012) obtained total protein value that ranged between 5.2-6.02g/dl from an experiment with ram lambs fed urea and/or poultry droppings treated *Pennisetum pedicellatum* (kyasuwa).

2.7 Feed Additives in Ruminant Nutrition

Feed additives are products used in animal nutrition to improve the quality of feed and the quality of food from animal origin, or to improve the animals' performance and health. They are categorised into Technological additives (e.g. preservatives, antioxidants, emulsifiers, stabilising agents, acidity regulators, silage additives); Sensory additives (e.g. flavours, colorants); Nutritional additives (e.g. vitamins, minerals, amino acids, trace elements); Zootechnical additives (e.g. digestibility enhancers, gut flora stabilizers); Coccidiostats and histomonostats (additives used in poultry diets for health reasons)

In recent years, zootechnical additives have shown vast growth in the research field and, consequently, in the feed market. Their suggested mode of action varies, but in general, they aim to manipulate the rumen fermentation environment to achieve greater efficiencies.

This range of feed additives has potential to deliver improvements in ruminant nutrition such as increase feed conversion efficiency (FCE) and productivity, stabilise rumen pH to reduce

acidosis risk, increase dry matter intake (DMI), reduce methanogenesis, enhance rumen development, reduce pathogen load and shedding, improve meat quality, enhance rumen stability during dietary transitions, buffer against dietary health risks (e.g. mycotoxins)

2.7.1 Probiotics

The word "probiotic" has had several different meanings over the years and even at present it is used by differentpeople to mean different things. Parker in 1974 defined it as "organisms and substances which contribute to intestinal microbial balance". Later (Fuller, 1989) this was modified to read "live microbial feed supplement which beneficially affects the host animal by improving its intestinal microbial balance". This modified definition removed the word "substances" which could have included antibiotics. It also stressed the viable nature of the preparations. There is now evidence that, in order to be effective, microorganisms should be viable. Havenaar and Huis in 't Veld (1992) have attempted to extend the definition in such a way they propose that probiotics should be defined as "a mono or mixed culture of live microorganisms which, applied to animal or man, affect beneficially the host by improving the properties of the indigenous microflora". "A probiotic is a preparation consisting of live microorganisms or microbial stimulants which affects the indigenous microflora of the recipient animal, plant or food in a beneficial way".

All these definitions refer to microorganisms and would include bacteria, yeasts, fungi, viruses and bacteriophages. All these groups of organisms with the exception of the animal and plant viruses have been shown to have beneficial effects when administered to animals. The microorganisms included as probiotics are usually assumed to be non-pathogenic components of the normal microflora, such as the lactic acid bacteria. However, there is good evidence that non-pathogenic variants of pathogenic species can operate in much the same way as traditional probiotics. For example, avirulent mutants of *Escherichia coli,Clostridium*

difficile, and *Salmonella typhimurium* can also protect against infection by the respective virulent parent strain.

2.7.2 Yeast as a Probiotic

The use of *saccharomyces cerevisiae* as a probiotic, when added to feed in small amounts, began during 1940s and 1950s (Beeson and Perry, 1952). Products containing *saccharomyces cerevisiae* have been used to improve daily gain and milk production in ruminants (Wallace, 1994). The increasing concern regarding the use of antibiotics has led to even greater interest in probiotics as feed additives. Various models have been designed to explain the effects of yeast in the rumen (Newbold *et al*., 1996). Data indicate that supplementation of yeast in the ruminant diet may improve feed intake (Robinson and Garrett, 1999; Williams *et al*., 1991), milk production (Abd El-Ghani, 2004; Wang *et al*., 2001), weight gain (Salama *et al*., 2002), digestion (Kamel *et al*., 2004; Jouany *et al*., 1998; Wohlt *et al*., 1991), numbers of anaerobic and cellulolytic bacteria (Mathieu *et al*., 1996; Newbold *et al*., 1995), ruminal pH value (Doreau and Jouany, 1998; Jouany *et al*., 1998; Mathieu *et al*., 1996), and alter the patterns of volatile fatty acids (Arcos-garcia *et al*., 2000). Over the past few years, there has been increasing interest in comparing the effects of *S. cerevisiae* live cell products to s. cerevisiae culture products on ruminal fermentation. The yeast culture is produced by fermenting selected liquid and cereal grain raw ingredients with baker's yeast (*Saccharomyces cerevisiae*) and drying the entire culture medium without destroying components associated with the yeast, such as B vitamins and other fermentation products. While the yeast culture supplements do contain some viable s. cerevisiae cells, the yeast live cell supplements contain higher amounts of yeast with a minimal amount of carrier. Live yeast cells and yeast culture have similar effects on ruminal fermentation (Lynch and Martin, 2002)

2.7.2.1 Effect of yeast on performance

Effect of addition of *Saccharomyces cerevisiae* (SC) at level of 0, 2.5, 5 and 7.5 g/day was studied using Chall sheep fed total mixed ration (TMR) containing barely (48%), wheat bran (16%), shelled corn (5%), mineral-vitamin mix (1%) and of alfalfa hay (30%); Results revealed that sheep in a 5 g/day SC group consumed higher ($P<0.01$) amount of feed during the experimental period (Khadem, *et. al*., 2007). Similar results were observed with sheep (Arcos-Garcia, 2000) and dairy cattle (Dann, *et. al*., 2000). Kim, *et. al*., (2006) showed that addition of yeast to dairy cows consuming concentrates diet increased DMI. It was concluded that in dairy cows an improvement by around 4% of the milk yield, often associated with increased feed intake (Ali-Haimoud-Lekhal, *et. al*., 1999). In another study Önol, *et. al*., (1998) demonstrated that supplementing sheep diets with *Saccharomyces cerevisiae*(SC) increased the total dry matter intake (TDMI) by 18.2-36.8 %. Gaafar, *et. al*. (2009) noticed that the intake of TDN and digestible CP (DCP) were increased significantly ($P<0.05$) due to baker's yeast supplementation. Fadel Elseed and Abusamra (2007) concluded that yeast supplementation improved the performance of goats' kid due to increased daily DOMI. The enhancement of DOMI by addition of yeast is consistent with the finding of Quigley, *et. al*. (1992) and Lesmeister, *et. al*. (2004) with dairy calves, Kim, *et. al*. (2006) and Dann, *et. al*. (2000) with dairy cows and Haddad and Goussous (2005) with lambs. All these studies indicated that digestion of diets was improved with the presence of *Saccharomyces cerevisiae*(SC). Robinson (2002) summarized studies that have been published between 1981 and 2002 concerning the effect of yeast products; He concluded that most published studies showed consistent, although small (i.e., 2.0 to 3.7%), improvements in DMI. On contrarily, to

the previous positive trend, Angeles, *et. al*. (1998); Hadjipanayiotou, *et. al*. (1997) reported that SC had no effect on the feed intake of sheep, dairy cattle and dairy ewes and goats, respectively. Garg, *et. al*. (2009) observed that the DMI was 72.13 and 74.33 g/kgW0.75 for sheep fed unsupplemented groundnut haulms based blocks and those fed the same basal diet supplemented with SC, respectively. Moreover, others have found decreased DMI when brewer's yeast was added to the diet of dairy calves (Seymour, *et. al*., 1995).

Several studies observed that fungus probiotics increase the growth rate of calves and lambs (Cole, *et. al*.,1992; Kmet, *et al*., 1993). The tendency of younger animals to be more efficient at converting CP into muscle was reported previously (Gerrard and Grant, 2006). In sheep studies, ADG of sheep fed ground nut haulms based blocks supplemented with SC was significantly higher (88.57 g) as compared to unsupplemented group (80.26 g), whereas, FCR was similar (Garg, *et. al.*, 2009). Fadel Elseed and Abusamra (2007) showed that unsupplemented Nubian goat's kids had lower ($P < 0.01$) ADG than those with 2.5 and 5 g/day yeast.In a study conducted by Zhang *et al*., (2005), supplementation of 0.5% baker's yeast in the basal diet of poultry gave similar effect due to the rich source of B-complex, protein, and minerals in the yeast.On the contrary, no improvement was observed when yeast product was included in diets of early weaned pigs which could probably be due to the different strain of yeast used which was brewers dried yeast (*Saccharomyces pastorianus*) (White *et al*., 2002).The response of animals to yeast product in the feed might be different due to the yeast product itself either in the dried or fermented form (Gao *et al*., 2008), methods of application either in feed or drinking water, breed and age of birds, and level of biosecurity (Stanley *et al*., 2004; Gao *et al.*, 2008). Also Macedo *et al.* (2006) found that differences were not observed ($p>0.05$) between Yeast Culture and Control sheep on body weight (36.00 vs 36.75 kg), dry matter intake (68.10 vs 69.50 kg), average daily gain (290 vs

300 g/d) and feed conversion (4.22 vs 4.15 g DM/g gain) and concluded that adding yeast culture did not improve production performance of intensively fattened Pelibuey sheep.

2.7.2.2 Effect of yeast on nutrient digestibility and nitrogen balance

Studies have demonstrated that yeast supplementation can influence digestive processes in the rumen (Jouany, 2001; Mruthunjaya, *et. al*., 2003; Galip, 2006; Chevaux and Fabre, 2007). In these studies, the total extent of DM digestion was not drastically altered. However, the initial rate of digestion was readily influenced by the addition of yeast. This is a characteristic of yeast supplementation that has been measured in both in vitro (Dawson and Hopkins, 1991) and in vivo (Smith, *et. al*., 1993; Kumar, *et. al*., 1997) studies. The obtained results indicated that the addition of SC in recommended doses showed a positive effect on ruminal digestion (Doleźal, *et. al*., 2005).

Galip (2006) suggested that the ruminal digestion would be more easily affected by dietary SC addition when rams consumed a diet rich in forage. The positive effect of SC addition to berseem hay, given as a sole diet fed to sheep, may be attributed to the stimulation of the proliferation of rumen microorganisms, which in turn was associated with enhancement of cell wall digestion (Kamel, *et. al*., 2000). However, different results were reported by Newbold, *et. al*., (1995) who found that the degradation of hay in the rumen of sheep fed a mixed forage: concentrate diets was not influenced by yeast supplementation over 72 hrs of the incubation period. Kholif and Khorshed (2006) found similar results, were no differences in the in vitro digestion of DM after 24 and 48 hrs when baker's yeast was included. Gaafar, *et. al*. (2009) observed that yeast supplementation increased ($P<0.05$) digestibility of DM, OM, CP, NDF and ADF of tomato pomace, where the gross digestibility derived from the supplementation was superior for a 4 g yeast group compared to the control group. In

addition, sheep fed yeast had a marked increase in energy digestibility of tomato pomace at 4 g level (Paryad and Rashidi, 2009). Fadel Elseed and Abusamra (2007) observed that the yeast supplementation increased OMD by 12.1% and 10.1% and NDFD by 13.3% and 10.5% by Nubian goat's kids fed sorghum hay supplemented with 2.5 and 5 g/day SC, respectively as compared with the control diet.El-Ashry *et al*. (2001) found that adding live dried yeast to the buffaloes calve diet improved the digestibility coefficient of OM, CP, CF, EE and NFE. The same trend was recorded for digestible crude protein (DCP).

2.7.2.3 Effect of yeast on rumen metabolites

Numerous studies documented positive effects of yeast cultures not only on the rumen environment but also on the improvement of microbial activities, leading to stabilizing ruminal fermentations and in addressing ruminal disorders. The observed benefits of supplementing yeast included higher pH, increased number of cellulolytic and lactate utilizing bacteria in the rumen (Callaway and Martin, 1997), and reduced acetate to propionate ratio (Lynch and Martin, 2002; Erasmus, *et. al*., 2005). There is also an increasing amount of evidence that live yeast stabilises ruminal pH and decreases the risk of acidosis (Chaucheyras-Durand *et al*., 2008; Marden *et al*., 2008). Other available data indicated that in the rumen fluid of animals receiving supplemental yeast, the TVFA and the percentage of propionic acid (Sullivan and Martin, 1999) and acetic acid (Nursoy and Baytok, 2003) were increased, the concentration of ammonia was decreased (Nursoy and Baytok, 2003; Strohlein, 2003), while, Chademana and Offer (1990) showed that the molar proportion of propionic acid was increased and acetic acid was decreased when yeast was included in the high concentrate diet. Others reported increased TVFA, and decreased the NH_3-N (Enjalbert, *et. al*., 1999). Doleźal, *et. al*. (2005) reported that the yeast supplementation showed a positive effect ($P<0.01$) on production of TVFA (127.6 vs. 84.0 mmol/L), and the utilization of ammonia was higher ($P<0.01$) in experimental groups (8.40) than in the control (9.06

mmol/L). However, Kholif and Khorshed (2006) found no alteration in ruminal NH_3-N concentration due to the addition of yeast; Moreover, they found no differences in the concentrations of acetate, propionate, butyrate and ruminal pH and the digestion of DM after 24 and 48 hrs when baker's yeast was included. Similarly, in experiments of Biricik and Yavuz (2001) no significant differences were observed in ruminal pH, VFA and NH_3-N levels.Newbold, *et. al*., (1995) showed a small decrease (8–15%) in NH_3-N concentration by inclusion of the *Saccharomyces Cerevisiae* in a diet. Similar decreases have been reported in other studies (Erasmus, *et. al*., 1992; El Hassan, *et. al*., 1996). Though, the addition ofyeast has been shown to decrease the concentration of NH_3-N in the rumen, as a result of its direct effect on reducing the degree of protein degradation (El-Waziry, *et. al*., 2000; Kamel, *et. al*., 2000; Eweedah, *et. al*., 2005), Guedes, *et. al.*, (2008) reported that the inclusion of *Saccharomyces Cerevisiae* increased ($P<0.01$) ruminal pH, decreased ($P<0.01$) lactate concentration and the acetate: propionate ($P<0.01$) ratio, but had no effect on ammonia N concentration. The SC addition at 1 g/day increased VFA concentration vs. the control diet ($P<0.01$); Further it reduced acetate: propionate ratio and increased fibrolytic activity of rumen bacteria. Regarding the diurnal changes of ruminal fermentation occurred due to yeast inclusion. Guedes, *et. al*. (2008) demonstrated that changes of rumen fermentation occurred from 0 to 8 hrs post-feeding, as expected, increasing ($P<0.05$) from 0 to 2 and/or 4 hrs after feeding followed by a decrease to 8 hrs. Mathieu, *et. al*. (1996) reported that rumen pH dropped rapidly during the first hours following feeding, reaching a minimum 3 hrs after the meal and then increasing progressively.

Galip (2006) stated that when *Saccharomyces cerevisiae* was added to the forage-enriched ration, ruminal pH was significantly decreased at 2 hrs ($P<0.05$) and in parallel, ruminal VFA concentrations tended to increase ($P<0.01$). Ruminal NH_3-N concentrations were significantly increased at 4 hrs ($P<0.05$) by dietary SC supplementation whatever the ratio

forage/concentrate of the diet. At 3 hrs post feeding, the TVFA of rumen fluid was increased ($P<0.01$) from 91.26 to 103.34 mmol/l in control vs. 2.5 g SC groups, the ruminal NH_3-N of sheep was decreased ($P<0.01$) from 15.96 to 12.89 mg/100 ml in control vs. 2.5 g SC groups; The highest and the lowest ruminal pH values ($P<0.01$) were recorded for sheep in 2.5 g SC and control groups, respectively (Khadem, *et. al*., 2007). Ahmed and Salah (2002) found that the maximum values of rumen NH_3-N concentrations of sheep fed different levels of SC were found at 1 hr post-feeding being a little higher with the control group. After the first hour, NH_3-N concentrations started to decline linearly to reach the minimum at 6 hrs post-feeding. At 1 hrs after feeding, group of sheep with the higher level of yeast (8g/day) had the highest TVFA concentration followed by those in group with the lower level of yeast (4g/day), whereas sheep of the control group was the lowest one, the same trend was observed at 3 and 6hrs after feeding; The TVFA concentration at 3hrs post-feeding was the highest ($P<0.05$) of all sampling times, the increase in TVFA concentrations post-feeding leads to decrease the pH values of rumen liquor, especially at 3hrs.

2.7.2.4 Effect of yeast on blood metabolites

In lactating buffalo, El-Ashry *et al* (2001) found that total proteins, albumin and globulin concentrations increased insignificantly from 6.64 to 7.09, 3.30 to 3.50 and 3.34 to 3.37g/dl, respectively, when added 10 g/h/day Baker's yeast (*Saccharomyces cerevisiae*) while GOT and GPT activities were not significantly affected due to treatment. In male lambs, Saleh *et al.* (2004) found that total proteins, albumin, globulin and urea concentrations increased insignificantlywhile GOT and GPT activities were not significantly affected by the yeast supplementation. In Barky male lambs, El-Ashry *et al*. (2003) reported that serum total proteins, albumin and globulin increased significantly from 7.93 to 8.26, 4.31 to 4.45 and 3.61 to 3.98 g/dl, respectively while urea concentration was not significantly affected with yeast supplements.Kholif *et al*. (2005) found that, serum total proteins and albumin were

increased (P<0.05) with yeast treatment compared with other treatments, however, serum globulin and Albumin globulin ratio were not affected by treatments.

Milewski and Sobiech (2009) demonstrated that dietary supplementation with dried yeast caused an increase in the concentrations of glucose (BG). The higher BG concentrations in ewes fed yeast supplemented diet have been observed throughout the entire experimental period. These results are consistent with the findings of Lesmeister, *et. al*. (2004). The authors showed that live *Saccharomyces cerevisiae*(yeast) significantly (P<0.05) increased the production of propionic acid, the main substrate for glucose synthesis in ruminants; Higher BG concentration in ewes fed supplemental dried yeast could be related to elevated concentrations of mannan-oligosaccharides (MOS) which are precursors of VFA, and stimulate an increase in energy metabolism parameters. Several experiments reported that neither live yeast cultures nor dried yeast had a significant effect on the blood total protein (BTP) levels in calves and neonatal dairy calves (Lesmeister, *et. al*., 2004) or early lactating dairy goats (Stella, *et. al*., 2007). The slightly lower blood triglyceride (BTG) levels observed in experimental ewes correlated with higher BG concentrations, and seemed to be beneficial (Milewski and Sobiech, 2009). A negative energy balance is often observed in high producing ruminants, leading to the mobilization of reserve fat and a temporary rise in blood triglycerides (BTG) (Lesmeister, *et. al*., 2004). The little effect observed for *Saccharomyces cerevisiae* supplementation on BTG level in experimental ewes indicated that the administered SC supplement exerted a favorable influence on energy metabolism parameters (Milewski and Sobiech, 2009), they also suggested that yeast supplementation had a protective effect on renal function as evident from a decrease in blood urea nitrogen (BUN) and creatinine concentrations; Moreover, Dietary supplementation with yeast had no effect on hepatic function (Piva, *et. al*., 1993). While, Ahmed and Salah (2002) observed a significant

decrease in the activity of liver enzymes in cows fed supplemental dried yeast, which indicated an improvement in the physiological condition of the liver and an increase in hepatic metabolic reserve. On the other hand, the beneficial effects of dietary yeast supplementation on the proportions of the different protozoa types in rumen, lead to positive effects on metabolic activities characterized by increases of BTP, BUN and calcium concentrations and decrease of BTG concentration in rams (Galip, 2006).

In rabbits, Habeeb *et al*. (2006) reported that the levels of T3 and T4 hormones as well as liver immunity function (i.e. total proteins, albumin and globulin), serum total lipids and triglycerides concentrations increased significantly while Urea-N and Creatinine (liver function) and cholesterol (heart function) concentrations as well as Serum Glutamic Oxaloacetic Transaminase (SGOT) and Serum Glutamic Pyruvic Transaminase(SGPT) activities (liver function) were not significantly ($P>0.05$) affected with adding Active dried yeast (ADY) to the diet of growing rabbits. Adding ADY caused a significant increase the levels of both T4 and T3 hormones which lead to increase the protein and fat biosyntheses. At the same time, ADY improved the appetite of rabbits and increase the digestion of food and consequently improved the utilization of the diet which leads to increase the feed intake which leads to increase the blood metabolites. Consequently, ADY have a positive effect on protein and fat metabolism as well as thyroid hormonal secretions and in the same time had no adverse effect on liver, kidney and heart functions.

The increase in cellulose digestion due to adding yeast may be responsible in the increase of the volatile fatty acids production which is the building blocks for the protein, fat and vitamins synthesis necessary to allow the increase in weight gain and feed efficiency (Habeeb, 2017). In addition, yeast is considering the source of B-complex vitamins which represent the digestion and appetite stimulating vitamins. These vitamins make as important co-enzymes like Nicotine-amide Adenine Dinucleotides (NAD) and Flavin Adenine

Dinucleotides (FAD) which responsible on biological oxidation to produce the necessary ATP for protein, fat and carbohydrate biosynthesis. Moreover, yeast offers several important nutritional benefits such as naturally high levels of protein (45% minimum), a wide array of amino acids (16 total amino acids), a high concentration of the B vitamins and several minerals necessary for maintaining healthy animals (10 essential and trace minerals) (Habeeb *et al*., 2017).

2.7.2.5 Effect of yeast on methane production

Methane emitted from ruminants is one of the majorgreenhouse gases that has a global warming potential 25 times higher than that of carbon dioxide (IPCC, 2007) and represents an energy loss for the host animal of 2 to 12 per cent of dietary energy (Johnson and Johnson, 1995). Although hydrogen (H_2) is one of the major end products of fermentation by protozoa, fungi and pure monocultures of some bacteria, it does not accumulate in the rumen, because it is immediately used by other bacteria which are present in the mixed microbial ecosystem (Moss *et al*., 2000).Methane is produced as a by-product of anaerobic fermentation in thereticulo-rumen of ruminants in a large part, due to the activity of methanogenic archaea. Due to the complexity of the rumen microbial ecosystem, other microorganisms also regulate and alter methane production (Morgavi *et al*., 2010).Across species, enteric CH_4 production accounts for about 2% to 12% loss of feed gross energy (Johnson and Johnson, 1995). Reducing this energy loss is a way to improve production efficiency in livestock (Shibata and Terada, 2010).Johnson and Johnson (1995) further reported that appropriate measures to improve animal production could decrease total enteric CH_4 emission by 10% to 30%.

The *S. cerevisiae* is the most commonly used direct fed microbial in ruminant production and which is more extensively studied for its effect on rumen methanogenesis. The *S. cerevisiae*supplements can beneficially modify rumen microbial activities, fermentative and

digestive functions in the rumen (Denev *et al*., 2007). Yeast have also been reported to have the potential to alter the fermentation process in the rumen in a manner that reduces the formation of methane (CH_4) gas (Chung, *et al*., 2011). In a previous study, commercial yeast product slightly decreased CH_4 in growing beef cattle, while neither the short chain fatty acids amount nor the profiles changed (McGinn,*et al*., 2004). The cells of *S. cerevisiae* provide growth factors for rumen microbes, including organic acids and oligosaccharides, B vitamins, and amino acids, which stimulate microbial growth in the rumen, thereby indirectly stabilizing ruminal pH (McDonald,*et al.*, 2011).

Chaucheyras *et al*. (1995) have also reported that addition of yest strain have shown to improve hydrogen utilisation and acetate production by a ruminal acetogen bacterial isolate in vitro even in the presence of methanogens.McGinn *et al*. (2004) used a commercial yeast product and reported a 3% decrease in CH_4 emission as a percentage of gross energy from beef cattle, Chung *et al*. (2011) supplemented a novel S. cerevisiae to nonlactating Holstein cows and reported a 7% decrease in CH_4 emissions, Gong *et al*. (2013) reported a 25% decrease in CH_4 abatement in vitro when corn-soybean based diet was supplemented with *S. cerevisiae*(1.8×10^{10} live cells/g) per kg diet, compared with a 10% decrease by a commercial *S. cerevisiae* product.

Previous studies have indicated that the CH_4 mitigation efficacy of *S. cerevisiae* is strain specific (McGinn *et al*., 2004) and CH_4 abatement using yeasts reported so far for cattle were below 10% (Wallace and Newbold, 1993; Chung *et al*., 2011).Consistently, live yeast has been shown to increase microbial biomasses (Hristov *et al*., 2013). Hristov *et al*. (2013) mentioned that the stimulation of microbial synthesis by live yeast, particularly *S. cerevisiae* has the chance to decrease CH_4 production. The exact mechanisms of *S. cerevisiae* on rumen fermentation characteristics are not well understood (Hristov *et al*., 2010). However, potential benefits of *S. cerevisiae* may reside in its capability to adjust rumen pH (Desnoyers *et al*.,

2009), potentially decreasing lactate production (Marden *et al*., 2008; Pinloche *et al*., 2013) and thereby help to maintain populations of cellulolytic bacteria (Alzahal *et al*., 2014). Live yeast addition *in vivo* increased colonization of the bacteria *F. succinogenes* and *R. flavefaciens*, depending on the feedstuff (Chaucheryras *et al*., 2016).

In the same vein, Gong *et al*. (2017) reported that additionof dietary *S. cerevisiae* to diets of pigs decreased daily enteric CH_4 emission by 25% ($P<0.05$) due to the higher DM and NDF digestibility in the animals supplemented with yeast.

2.7.3 Enzymes

Enzymes are biological catalysts or protein substances that speed up the rate of reaction without themselves being consumed in the reaction. Enzymes are involved in the breakdown of all complex feed molecules into their smaller base chemical constituents such as glucose, amino acids in both bacteria and the host ruminant (Mulder *et al*., 1991). All enzymes belong to the protein family, but many of them are unable to function as a catalytic agent except when they are linked with a non-protein component called coenzyme (Feng *et al*., 1996). Enzymes binds temporarily to one of the substances in the reaction they catalyse, and usually only act on a specific substrate, depending on the type of enzyme, it will then break specific bonds in the substrate, release the now cleaved substrate molecule and be ready to bind to another molecule (Beauchemin *et al*., 2003).

Enzyme supplementation in ruminants may be complex, but this should not deter investment in research and development. Improvements in the efficiency of feed utilization as the result of feed enzymes will increase production profitability and waste minimization in a large, and as yet relatively untapped, ruminant feed enzyme market. Like monogastrics, ruminants can benefit from products that improve starch, protein and fibre digestibility. However, before

beneficial enzymes can be included in the diet, a reliable method of applying feed enzymes to ruminant feed is required that accounts for the fermentation processes of the rumen.

2.7.3.1 Ruminant Response to Exogenous Enzymes

Enzyme supplementation in ruminants may be complex, but this should not deter investment in research and development. Improvements in the efficiency of feed utilization as the result of feed enzymes will increase production profitability and waste minimization in a large, and as yet relatively untapped, ruminant feed enzyme market. Like monogastrics, ruminants can benefit from products that improve starch, protein and fibre digestibility. However, before beneficial enzymes can be included in the diet, a reliable method of applying feed enzymes to ruminant feed is required that accounts for the fermentation processes of the rumen. Researchers in the 1960s examined the use of exogenous enzymes in ruminants (Burroughs *et al.,* 1960; Rovics and Ely, 1962; Rust *et al.,* 1965), but responses were variable and no effort was made to determine the mode of action of these products. Furthermore, production of exogenous enzymes was expensive at that time and it was not economically feasible to apply these preparations at the concentrations necessary to elicit a positive animal response. Recent reductions in fermentation costs, together with more active and better-defined enzyme preparations, have prompted researchers to re-examine the role of exogenous enzymes in ruminant production (Chen *et al.,* 1995; Beauchemin *et al.,* 1997; McAllister *et al.,* 1999).

Research with feed enzymes in ruminant diets has found them to be unreliable (Perry *et al.,* 1966; Bowman *et al*., 2003; Baloyi, 2008) and, until recently, the cost of development and production of enzymes for ruminants was prohibitive. Part of the slow uptake of enzyme

technology by ruminant feed manufacturers is due to the fact that there is no simple fool proof recipe for applying enzymes and securing a profitable response. A lack of understanding in the way enzymes act in ruminant feed and the complex digestive tract of ruminants means that there are many unidentified or misunderstood factors influencing feed enzyme efficacy in ruminant animals.

2.7.3.2 Effect of exogenous enzymes on performance and nutrient digestibility

Rodriguez *et al.* (2002) reported that enzymes increased the dry matter (DM) and organic matter (OM) intake, nitrogen intake showing tendency to increase NDF intake. Feng *et al.* (1996) reported that intake of DM was increased by exogenous enzymes with dry forages, but not fresh forages. However, exogenous enzymes directly fed to the animal, or added to the feed did not change DM intake (Lewis *et al.*, 1996 and Rode *et al.*, 1999). Krause *et al.* (1998) reported that when exogenous enzymes sprinkled on forages, intakes of NDF and ADF were lower than expected because of the relatively high proportion of forage.

Muwalla *et al.* (2007) conducted a study to evaluate the effect exogenous enzymes on high concentrate diet in Awassi lambs, a local breed of Jordan. The authors demonstrated the results that the supplement of these exogenous enzymes in the high concentrate diet have no effect on the intake of DM, OM, crude protein, and NDF because all the results were similar for lambs fed diet with or without the exogenous enzymes. Metabolizable energy intake was also not affected by the enzyme supplementation. Such results may be due to the lower fibre content of the high concentrate diet and fibrous portion which was the actual target substrate of the exogenous enzymes. Miller *et al.* (2008) conducted a study to determine effects of a xylanase/endoglucanase exogenous enzyme products in growing lambs and fed barley or

sorghum grain-based diets and reported that exogenous enzymes did not change voluntary feed intakes in the lambs.

Hristov *et al.* (2000) reported that exogenous polysaccharide degrading enzymes could potentially improve nutrient digestion of ruminants, post ruminally not only by modifying the feed but also enzyme resistance to proteolysis. Kung *et al.* (2000) reported that treatment of feeds with enzymes just prior to feeding can improve digestibility via a number of different mechanisms including direct hydrolysis, enhanced microbial attachment, changes in gut viscosity, complementary actions with ruminal enzymes, changes in the site of nutrient digestion and improvements in palatability and changes in patterns of feed consumption could also occur.

Eun *et al.* (2006) conducted an in vitro experiment using six enzymes products and showed that ammonia pre-treatment or supplemental exogenous enzyme preparations enhanced in vitro degradation of rice straw, but the effectiveness of exogenous enzymes was enhanced when they were used with ammoniated rice straw rather than with untreated rice straw. The mechanism whereby ammonia pre-treatment improved the efficacy of exogenous enzymes for enhancing feed digestion remains uncertain. The possible reason discussed by the scientist is the synergy between ammonia pre-treatment and exogenous enzyme addition for in vitro degradation of rice straw that ammoniation may disrupt the lignin-carbohydrate complex thereby increasing the accessibility of fibre to exogenous and endogenous enzymes. But the ability of exogenous enzymes to cleave the esterified bonds within Iignin-carbohydrate complexes may be limited, and therefore, their effect on the extent of *in vivo* digestibility may also be limited. Furthermore, the scientist added that enzymes may increase the availability of soluble carbohydrates to the microorganisms.

Studies reported that adding exogenous enzymes to forage diets can improve fibre digestibility (Feng *et el.,* 1996). The results of adding exogenous enzymes to high grain diets have been surprisingly more consistent than those for high forage diets. Krause *et al.* (1998) reported a 28% increase in OM digestibility using a similar enzyme product added to a high concentrate diet. Cruywagen and Zyl, (2007) also reported that adding enzyme in the forage diet improved the lamb growth rate and feed conversion ratio. The authors suggested that enzymes can be widely introduced in the animal feed industry. Muwalla *et el.* (2007) reported that the supplement of exogenous enzymes in the high concentrate diet have no effect on the final body weight, average daily gain, and feed to gain ratio for Awassi lambs. Miller *et al.* (2008) reported that xylanase/endoglucanase exogenous enzyme product supplementation did not improve live weight gain, feed conversion efficiency or wool growth performance in growing lambs fed barley or sorghum grain-based diets.

Schingoethe *et al.* (1999) conducted an experiment to evaluate the response of an enzyme product sprayed on forage just before feeding. The authors reported that cows fed enzyme treated forage that were less than 100 days postpartum produced about 10% (2.3-4.0 kg/day) more milk than cows fed the control diet. Lewis *et al.* (1999) treated forage with a cellulase/xylanase mixture supplying enzyme as1g/kg of total mixed ration (TMR), on DM basis) and observed that cows in early lactation produced 6.3 kg/d (16%) more milk. However, higher and lower levels of the same enzyme product were less effective. Rode *et al.* (1999) applied an enzyme product to the concentrate portion of a diet (supplying 1.3 g/kg of TMR on a DM basis) and observed a 3.6 kg/d or 10% increase in milk production for cows in early lactation. Yang *et al.* (2000) added an enzyme mixture to the concentrate, and cows in early lactation produced 2 kg/d or 5.9% more milk. However, there was no response when the same enzyme was added to the TMR.

Application of a different mix of fungal enzyme preparations (Cellulase A, Xylanase B, Finn feeds International Ltd. Marlborough, UK) at rates up to 5.0 L /tonne, however, increased the final weight and ADG of feedlot cattle given diets based on alfalfa silage (Michal *et al.*, 1996; Pritchard *et al.,* 1996) or barley silage (McAllister *et al.,* 1999). Treatment of 82.5% corn diets with "multiple stabilized enzymes" increased ADG and feed conversion by feedlot cattle by 10 and 7.5%, respectively (Weichenthal *et al.,* 1996), and similar improvements in feed efficiency have been reported for cattle fed sorghum-based diets treated with amylase (Krause *et al.,* 1989; Boyles *et al.,* 1992).

2.7.3.3 Effect of exogenous enzymes on rumen and blood metabolites

According to Mijinyawa (2016). Exogenous enzyme supplementation had no effect on pH, and temperature, however differences were observed in total volatile fatty acid and rumen ammonia nitrogen. The author reported higher values for total volatile fatty acid and rumen ammonia nitrogen when he fed bucks with treated or untreated bagasse with or without enzyme supplementation.The higher values of rumen ammonia nitrogen and total volatile fatty acids could be attributed to the fact that urea present in the diet is quite soluble in the rumen and rapidly converted to ammonia leading to an increase intake in energy and activity of rumen microorganism for active digestion and production of total volatile fatty acids. Fouda (2008) also showcased similar results of rumen fluid pH and rumen ammonia nitrogen when the author fed mixed rations containing 30% treated or untreated bagasse to rams.Fanimo *et al*. (2007) reported that blood urea level is influenced by quantity, quality and proximity of the proceeding meal which increases mostly after eating.

2.7.3.4 Effect of exogenous enzymes on methane production

Enzyme additives are concentrated fermentation products that contain fiber-digesting enzymes (e.g., cellulases, hemicellulases). The focus to date has been on developing enzyme

additives that improve fiber digestion (Beauchemin *et al.*, 2003), but it may also be possible to develop enzyme additives that reduce CH_4 emissions. Enzymes that improve fiber degradation typically decrease the acetate:propionate ratio in rumen fluid (Eun and Beauchemin 2007), which is thought to be the primary mechanism whereby enzymes decrease CH_4 production.In the same vein, Arriola *etal*. (2011) observed a decrease in the acetate:propionate ratio in the rumen fluid and reported a decrease in methane production. However, McGinn *et al*. (2004) found no effect of enzyme on fiber digestibility and methane production in steers fed barley silage-based diet whereas Beauchemin *et al*. (1999) and Yang *et al*. (1999) reported no effect of fibrolytic enzymes on rumen fermentation.

In a recentstudy,Nel *et al*. (2020) evaluated the use of essential oils in combination with exogenous enzymes, The treatments consisted of control (T1); enzyme (cellulose-xylanase mixture, 1:1 w/w, 1.5 mL/g DM)(T2); enzyme combined with Next Enhance® (cinnamaldehyde with diallyl disulfide and diallyl trisulfide, 43:3.85 w/wt) (T3); enzyme and cinnamon oil (T4); enzyme and garlic oil(T5) and enzyme with cinnamon and garlic oil, 1:1 w/w) (T6) at 2, 4, 8, 12, 24, 36, and 48 hours of incubation. The author reported that the inclusion of additives affected cumulative gas production ($P<0.05$)but only slightly affected methane production after 48 hours of incubation. The study further indicated that T5 and T6 both reduced gas production compared with T2. Also, combiningessential oils with an enzyme reduced methane production compared with T2 after 48 hours of incubation.

On the other hand,cellulase and amylase were reported to improve methane production.This phenomenon can be attributed not only on the increments of reducing sugar and oligosaccharide concentrations but also on the disrupted lignocellulosic barriers, indicating that the hydrolytic enzymes could penetrate the lignocellulosic structure and cause hydrolysis (Mosier *et al*., 2005; Wilson *et al*., 1999). Kupski *et al*. (2018) similarly found enhanced activities of the cellulolytic complex to achieve starch and protein digestibility. Zhao *et al*.

(2018) also found that the methane yield of corn straw could increase by 10.7% by using an enzyme extracted from the *T. harzianum* culture. In the same vein, Weide *et al*. (2020) used enzyme mixtures to improve the methane production of agricultural wastes, but the derived increases (2.7 to 9.4%) in the biogas yields were not detectable in most cases after 60 days of BMP tests.

Moreover, Geraldo *et al*. (2007) reported an increase in VFA production and production of acetate which in turn was associated with increased methane production as a result of the application of exogenous fibrolytic enzymes and their mixtures. Chung *et al*. (2012) also reported that increasing the dosage of enzyme supplementation linearly increased enteric CH_4 production of dairy cows when compared with the control.

2.8 Methane Production in Ruminants

Methane that is emitted from livestock originates in the fore stomach, also called the rumen, of ruminants. This source of methane is called enteric methane ($CH_{4)}$. Typically, about 6 to 10% of the total gross energy consumed by the dairy cow is converted to CH_4 and released via the breath. Reducing CH_4 losses is an environmentally sound practice that can improve production efficiency (Karen*et al*., 2008). The digestion process enables ruminants to convert forages into usable energy; a portion of the feed energy (3 to 12%) is used to produce enteric CH_4, and is released into the atmosphere as the animal breathes. Enteric CH_4 emission is produced as a result of microbial fermentation of feed components. Methane, a colorless, odorless gas, is produced predominantly in the rumen (87%) and to a small extent (13%) in the large intestines (Torrent and Johnson, 1994).

Moss *et al*. (2000) established that CH_4 production can be calculated from the stoichiometry of the main VFA formed during fermentation, i.e., acetate (C2), propionate (C3) and butyrate (C4) as follows: $CH_4 = 0.45\ C2 - 0.275\ C3 + 0.40\ C4$. Thus, the molar percentage of VFA influences the production of CH_4. Acetate and butyrate production results in CH_4 production,

while propionate formation serves as a competitive pathway for H_2 use in the rumen. With an increased molar proportion of propionate, the molar proportions of acetate and /or butyrate are reduced.

2.9 Methods of Measuring Methane Emission

2.9.1 Respiration chamber

The classical standard for ruminant CH_4 measurement by nutritionists is the respiration chamber, or calorimeter. Respiration calorimetry techniques such as whole animal chambers, head boxes, or ventilated hoods and face masks have been used effectively to collect most of the available information concerning CH_4 emissions in livestock. The predominant use of calorimeters has been to measure gaseous exchange as part of energy balance measurements, CH_4 loss being a necessary part of this procedure. There are various designs of calorimeters (Blaxter, 1962), but the most common one being the open circuit calorimeter. The principle behind open-circuit indirect-respiration techniques is that outside air is circulated around the animal's head, mouth and nose and well mixed inside air is collected. The animal is placed in opencircuit respiration chamber for a period of several days, the inputs (feed, oxygen, CO_2) and outputs (excretion, oxygen, CO_2 and CH_4) were measured from the chamber. The chamber should be well sealed and capable of a slight negative pressure. This ensures that all leaks will be inward and not result in a net loss of CH_4. Air conditioning, dehumidification, feeders, waterers and a method by which faeces and urine could be removed are necessary in order to create a comfortable environment within the chamber. Animal movement and normal behaviour should beprovided for as much as possible however, some degree of restraint is necessary within the chamber.

2.9.2Tracer Gas Techniques

Methane emission from ruminants can also be estimated by using the ERUCT (Emissions from Ruminants Using a Calibrated Tracer) technique. The tracer can either be isotopic or

non-isotopic. Isotopic tracer techniques generally require simple experimental designs and relatively straightforward calculations, at least for the lower number pools (Johnson and Johnson 1995). Isotopic methods involve the use of (3H) methane or (14C) methane and ruminally cannulated animals (Murray *et al*., 1975). Using the continuous infusion technique, infusion lines deliver the labeled gas to the ventral part of rumen and sampling of gas takes place in the dorsal rumen. After determining the specific activity of the radio-labeled methane gas, total methane production can be calculated. It is also possible to measure CH_4 production from a single dose of injection of tracer (France *et al*., 1993). France *et al*. (1993) described models for up to three and higher CH_4 pools.

2.9.3 Using Prediction Equations Technique

Feed characteristics can also be used to calculate CH_4 production. Number of empirical regression equations, based on the results of calorimetric experiments, has been developed. The Blaxter and Clapperton (1965) equation is the basis from which most all estimates of CH_4 production from ruminants have been derived.

CH_4 (% GE) = 1.30+0.112 D+L (2.37-0.50 D)

Where, D = energy digestibility at maintenance level of feeding; L = feeding level

The relationship was derived from a series of CH_4 production measurements from mature sheep fed a range of diets.

Shibata *et al*. (1992) also developed set of equations after trials with Holstein heifers, Corriedale wethers and Japanese goats and concluded that CH_4 production from ruminants fed below 1.5 times maintenance can be predicted from DMI alone (r = 0.992)

CH_4 (L/day) = 0.0305 DMI (g/day)-4. 441

From the results obtained from 190 energy balance trials with dairy cattle, beef cattle, sheep and goats. Shibata *et al*. (1993) developed a quadratic equation for CH_4 production (Y, L/day) Y = -17.766+42.793 X-0.849 X2 (r = 0.966) Where, X = DMI (kg/day)

Pelchen and Peters (1998) developed equations for sheep from 1,317 sets of data from the literature. There was a wide range of diet types, including a few from animals fed fresh herbage. By grouping the sets of data according to criteria such as digestibility (75) and crude fibre (30) they derived regressions for predicting CH_4 emission (g/d) with R^2 = 0.7- 0.85. Dynamic and mechanistic models to predict CH_4 from ruminants have also been established to simulate ruminal fermentation under a variety of nutritional conditions (Mills *et al*., 2001). Benchaar *et al*. (1998) showed that mechanistic models allow the prediction of CH_4 production more accurately than simple regression equations, under a large variation of diet composition.

Johnson *et al*. (1993) compared the actual CH_4 measurements and those predicted by Blaxter and Clapperton equation. The equation predicted CH_4 production to range from 6 to 10% with most points in the 6 to 8% range. Actual CH_4 measurements ranged from 2 to 11%. Although these models have usefulness in the prediction of CH_4 production from animals under the conditions from which the equations or models are developed, they are of limited use in the prediction of CH_4 production when intake is unknown or when the rumen is disturbed (Johnson *et al*., 2001). Blummel *et al*. (2005) after comparing CH_4 production in sheep measured in open circuit respiration chamber with that calculated from VFA profile in IVGPT concluded that the large variation in CH_4 production from arange of diets renders these equations less useful which assume constant relationships of CH_4 production. Equations for predicting CH_4 emissions were developed mostly from data using the respiration calorimetry chamber to define the relationship between energy intake and CH_4 production are based mainly on the diet characteristics. The environment inside the respiration chamber is controlled and the animals are under feed restriction during measurement. Therefore, the data from the chamber cannot be applied under every farm situation, especially where animals are

grazing and pasture quality is changing. Also, they are not accurate enough for use in determining small differences between animals in experiments.

2.9.4 In Vitro Techniques

Although in vivo studies using actual animals are ultimately needed, however an in vitro simulation of the rumen can often be effective and efficient because of its relative readiness and cheapness of operation. It can also be used to define the effects of a specific factor which might be concealed in an in vivo study behind the complexity of a lot of related factors in the rumen environment.

2.9.4.1 Rumen simulation technique (RUSITEC)

In the RUSITEC, solid feeds are confined in nylon bags that are normally replaced by new bags once a day. The amount of ration is small (10-25 g DM/day/L of vessel), and the set points of the liquid dilution rate are also small (2- 5%/h) as compared with the actual *in vivo* values.

Bhatta *et al*. (2006) observed that RUSITEC ($P<0.01$) underestimated CH_4 production as compared to that estimated by SF_6 technique. Eun *et al*. (2004) reported that CH_4 estimated from head space gas in dual-flow fermenters was significantly lower than CH_4 estimated from the stoichiometric calculation at a dilution rate of 3.2 %/h from diets ranging in concentrate and roughage ratio.

2.9.4.2 In vitro gas production technique (IVGPT)

Czerkawski and Breckenridge (1969) developed a gas measuring manometric apparatus to investigate the effect of fatty acids on the fermentation of sugar-beet pulp and sucrose by mixed rumen microorganisms. Although the manometric methods permits a quantitative determination of acids and gases evolved during the fermentation, and allow incubation of a large amount of sample (Hungate *et al*., 1955), the number of samples that could be handled is less. Getachew *et al*. (1998) concluded that manometric methods of gas measurement do

not have wide acceptability in routine feed evaluation since there was no provision for the mechanical stirring of the sample during incubation. Getachew *et al*. (2005) conducted a study with total mixed rations of dairy animalsand reported similarity between measured and calculated CH_4values with IVGPT and suggested that CH_4 production can be calculated if only gas and VFA production is measured. Blummel *et al*. (2005) suggested that CH_4 production in forage fed ruminants could be predicted by a simple in vitro technique that measured gas production and true substrate degradability, if feed intake is known.

In a series of experiments methane production from goats measured in open circuit respiration chamber from 19 diets were compared with that estimated by IVGPT. Methane production estimated from the cumulative gas collected after 48 h in vitro incubation was similar to that measured in respiration chamber in samples D1 to D9 and significantly ($P<0.05$) higher in D10 to D19. It was concluded that for diets containing low fibre and with higher digestibility, 36 hrs incubation produced good estimate to CH_4 compared to that measured in respirationchamber. These results indicate that IVGPT could be used to estimate the CH_4 production from a range of diets to have a database and to plan mitigation strategies in ruminants to improve the performance as well as to reduce the greenhouse gas (Bhatta *et al*., 2007).

2.10 Strategies to Reduce Methane Production in Ruminant Animals

Reductions in CH_4 emissions from dairy cows can be achieved by reducing the conversion of feed to CH_4 in the rumen (i.e., CH_4 conversion rate). Various research groups around the world are exploring the potential of strategically using feed ingredients and supplemental feed additives as a means of reducing conversion rates (Beauchemin *et al*., 2008). In addition, non-dietary approaches are being examined including vaccination, biological controls (bacteriophage, bacteriocins), chemical inhibitors that directly target methanogens, and

promotion of acetogenic populations in the rumen to lower the supply of metabolic hydrogen to methanogens (McAllister and Newbold 2008).

2.10.1 Feeding fats and oilseeds

Adding fats to the diet of animals reduces CH_4 emissions by decreasing organic matter fermentation in the rumen, reducing the activity of methanogens and protozoal numbers, and for lipids rich in unsaturated fatty acids, through hydrogenation of fatty acids (Johnson and Johnson 1995). The effectiveness of adding lipids to the diet to reduce CH_4 emissions depends on many factors including level of supplementation, fat source, fatty acid profile, form in which the fat is administered (i.e., either as refined oil or as full-fat oilseeds) and the type of diet.However, level of added fat is by far the most important factor. (Beauchemin *et al*., 2008) Over a broad range of conditions, CH_4 (g/kg DMI) was reduced by 5.6% with each 1% addition of supplemental fat. In most cases, 2 to 3% fat can be added to dairy cow diets without negative effects. The total amount of fat in the diet (added fat plus fat in the basal diet) should not exceed 6 to 7% of the diet otherwise a depression in DMI may occur, negating the advantages of increased energy density of the diet.

Oils extracted from plant sources usually contain a favourable amount of medium- to long-chain fatty acids (Soliva *et al*., 2004;McGinn *et al*., 2004). Refined soy oil fed to beef bulls at 6% inclusion reduced methane production by 39% in terms of litres per day (l/d) (Jordan *et al*., 2006). Sunflower oil has also been combined with linseed oil at a ratio of 1:3 and fed to sheep on a pasturebased diet in a dose-response trial, but at 1.2–5% oil inclusion on a dry matter basis, there was no significant reduction in methanogenesis (Cosgroove *et al*., 2008). Linseed oil supplemented at a level of 5% of DM to lactating dairy cows resulted in a 55.8% reduction in grams of methane per day (Martin *et al*., 2008). Coconut oil is the most popular oil for methane abatement experiments and has been found to induce significant reductions in

methanogenesis, although the extent of the reduction varies from 13–73%, depending on the inclusion level, diet, and ruminant species used (Jordan *et al*., 2006).

2.10.2 Feeding high concentrate diets

Increasing the grain content of total mixed rations (TMR) lowers the proportion of feed energy converted to CH_4 by decreasing the acetate: propionate ratio in the rumen fluid. Furthermore, methanogens are susceptible to the low pH conditions in the rumen that result from feeding high grain diets. However, the potential of using concentrates to lower CH_4 emissions from the dairy sector is limited because the increased incidence of rumen acidosis jeopardizes cow health and reduces milk fat content.

2.10.3. Plant compounds.

The three main plant compounds effective at reducing methane emissions in vitro are condensed tannins, saponins, and essential oils. In vivo, the efficacy of these compounds varies in terms of methane abatement.

2.10.3.1 Condensed tannins

Condensed are thought to directly inhibit methanogens, as well as indirectly limit methanogenesis through a reduction in hydrogen availability (Tavendale *et al*., 2005). Condensed tannincontaining *Lespedeza cuneata* was fed to goats ad libitum and found to reduce methane 57% in terms of g/kg DMI, compared to goats fed a mixture of *Digitaria ischaemum* and *Festuca arundinacea*(Puchala*et al*., 2005). Sheep consuming 41 g of tanninc ontaining *Acacia mearnsii* per kg DM were found to have a 13% reduction in methanogenesis (Carulla *et al*., 2005). Tannin-containing *Callinada calothyrsus* and *Fleminga* macrophylla also reduced methane 24% in lambs (Beauchemin *et al*., 2007), but an extract of condensed tannin from *Schinopsis quebrachocolorado*(Beauchemin *et al*., 2007)

and tannincontaining sorghum silage (De Oliveira *et al*., 2007) fed to cattle did not suppress methanogenesis.

2.10.3.2 Saponins

Saponins have been shown in vitro to inhibit protozoa, as well as limit hydrogen availability for methanogensis (Guo *et al*., 2008). In a study by Holtshausen *et al*. (2009)cows were supplementedwith whole-plant *Yucca schidigera* powder at 10 g/kg DM or whole-plant *Quillaja saponaria* powder at 10 g/kg DM, both of which contain saponin. The authors stated that previous studies in vitro had found reductions in methane at higher inclusion levels (15 g/kg DM and greater), but these high levels were avoided in vivo in order to minimize effects ondigestibility. However, no effect of the plant supplementation was found *in vivo* and the authors concluded that the in vitro reductions in methane were likely due to reduced feed digestion and fermentation (Holtshausen *et al*.,2009). This makes *in vivo* supplementation difficult because higher feeding levels may be required to measure reductions in methane output, but these reductions would be at a cost to feed-digestibility.

2.10.3.3 Essential oils

Essential oils have antimicrobial activities that act in a similar way to monensin by inhibiting gram-positive bacteria (Burt *et al*., 2004; calsamilgia *et al*., 2007). In this way, essential oils can reduce the amount of available hydrogen for methanogenesis. Few *in vivo* studies have been conducted, but Beauchemin and McGinn (2006)reported no effect on methane output and a negative effect on feed digestibility, when heifers were fed 1 g/d of essential oil and spice extract.

2.10.4 Use of organic acids.

In vivo effects of organic acid supplementation on methane abatement are variable. Wood *et al*. (2009) supplemented 100 g/kg fumaric acid in the free or encapsulated form to growing lambs and found a 62% and 76% reduction in methane output, respectively. Fumaric acid was

also fed to growing beef cattle at 175 g/d, steers at 80 g/d, and wethers at 4–10 g/100 g (DM basis), but was not found to significantly reduce methane emissions, although suppression of DMI was found at higher inclusion levels (McGinn, *et al*., 2004;Molano, *et al*., 2008). Moreover, in another study by Foley *et al*., (2009).Heifers were supplemented with 3.75% and 7.5% malic acid on a DM basis and methane production was reducedby 3% and 9% as g/kg DMI were measured, respectively. Theauthors stated that the effect of organic acid supplementation on methane abatement appears to be influenced by diet, with greater abatement when high-concentrate diets are fed. This is due to a greater effect on the acetatetopropionate ratio in the rumen, in addition to its ability to act as a hydrogen sink (Foley *et al*.,2009).

2.10.5 Addition of yeast

Yeast cultures of *Saccharomyces cerevisiae* are widely used in ruminant diets to improve rumen function and milk production. Commercial products vary in the strain of yeast used and the number and viability of yeast cells present. Laboratory studies suggest that some live yeast strains can stimulate the use of hydrogen by acetogenic strains of ruminal bacteria, thereby enhancing the formation of acetate and decreasing the formation of CH_4 in the rumen. However, they conducted a study with growing beef cattle to evaluate two commercial yeast products,as commercial strains have not been selected for their effects on CH_4 (McGinn *et al*., 2004). One product caused a 3% decrease in CH_4 production (g/g DMI) while the other product increased CH_4 production (g/g DMI) by 8%.

2.10.6 Enzymes

Enzyme additives are concentrated fermentation products that contain fiber digesting enzymes (e.g., cellulases, hemicellulases). The focus to date has been on developing enzyme

additives that improve fiber digestion (Beauchemin *et al*., 2003). Enzymes that improve fiber degradation typically decrease the acetate: propionate ratio in rumen fluid as reported by Eun and Beauchemin (2007), which is thought to be the primary mechanism whereby enzymes decrease CH_4 production.However, McGinn *et al*. (2004) found no effect of enzyme on fiber digestibility and methane production in steers fed barley silage-based diet whereas Beauchemin *et al*. (1999) and Yang *et al*. (1999) reported no effect of fibrolytic enzymes on rumen fermentation.

2.10.7 Use of Ionophores

Ionophores such as monensin are antimicrobials typically used in dairy cattle diets to improve feed efficiency. Monensin decreases the proportion of acetate and increases the proportion of propionate in the rumen an effect that decreases CH_4 output. At times, monensin may also lower rumen protozoal numbers. This is important, as a direct relationship exists between rumen protozoal numbers and CH_4 formation in the rumen. Rumen protozoa are estimated to provide a habitat for up to 20% of ruminal methanogens while methanogens living on and within protozoa are thought to be responsible for about a third of the CH_4 emissions from ruminants. The effect of monensin on lowering CH_4 production appears to be dose dependent. In recent studies, providing a dose of 10-15 ppm had no effect on CH_4 production in dairy cows (Waghorn *et al*., 2008) while a dose of 15-20 ppm either had no effect on CH_4 production or reduced total CH_4 but not CH_4 per kilogram of DMI in dairy cows (VanVugt *et al*., 2005).

2.10.8 Defaunation

Defaunation, which is the elimination of protozoa from the rumen by dietary or chemical agents, has been shown to reduce ruminal CH_4 production by about 20 to 50% depending on the diet composition (Van Nevel and Demeyer, 1996). Whitelaw *et al*. (1984) observed that faunated cattle fed barley diets at restricted levels lost about 12% of GEI as CH_4 compared to

6–8% of GEI in ciliate-free animals. Protozoa in the rumen are associated with a high proportion of H_2 production, and are closely associated with methanogens by providing a habitat for up to 20% of rumen methanogens (Newbold *et al*., 1995).

The reduced ruminal methanogenesis observed with defaunation can be attributed to factors such as a shift of digestion from the rumen to the hind gut (Van Nevel and Demeyer, 1996) or the loss of methanogens associated with protozoa during defaunation (Hegarty, 2004). It has been shown that defaunation may depress fiber digestion, thus complete elimination of protozoa (rather than selective defaunation) is not recommended as a method for reducing CH_4 (Itabashi, 2001). On the other hand, protozoa have been reported to negatively affect ruminal protein metabolism through predation of bacteria, which reduces the flow of microbial protein leaving the rumen (Koenig *et al*., 2000). Therefore, the use of defaunation to mitigate CH_4 production from ruminants should be weighed against its possible impact on the efficiency of the whole ruminal system.

CHAPTER THREE

3.0. MARERIALS AND METHODS

3.1 Experimental Site

The experimentwas conducted at Teaching and Research Farm of the Department of Animal Science, Ahmadu Bello University Zaria, located on latitude 11° 11' N and longitude 07° 38' E. (Wikipedia, 2018). It is situated at an altitude of 686m above sea level and lies within the Northern Guinea Savannah zone. The mean relative humidity is 21 and 72% during the harmatan and rainy season respectively. Annual rainfall ranges from 1102mm to 1904mm per annum which last from late April or early May to mid-October. The mean temperature fluctuates from 31°C maximum during the late dry season to 18°C minimum during the wet season (Meteorological Unit, IAR/ABU, 2018).

3.2 Source of Bagasse and Treatment

Sugarcane bagasse was sourced from sugarcane juice producer in Makarfi Local Government Area of Kaduna state. The bagasse wassun dried for three days and ground into smaller particle sizes of approximately 5mm and then treated with urea at 5% (50g of urea was dissolved in one litre of water to treat one kg of bagasse). The treated bagasse was then packed in aPardue Improved Cowpea Storage (PICS) bags for two weeks, after which it was opened and aerated before inclusion in the TMR.

3.3 Source of Animalsand Management

The animals were purchased from Anchau cental market in Kubau Local Government Area of Kaduna state. Prior to the arrival of the rams, the pens were cleaned and disinfected, the rams were quarantined for 2 weeks; and treated with Ivomectin (Ivomec®) and antibiotics (Tetracycline L.A) at a dose of 1ml/10kg BW against internal and external parasites.

3.5 EXPERIMENT I: Effect of treated bagasse supplemented with various inclusion levels of yeast in TMR on performance of Yankasa Rams.

3.5.1Experimental Design and Diets

Twenty (20) Yankasa rams with an average live weight of 13±0.2kg were used for the experiment. The rams were allotted to four dietary treatments in a completely randomized design, to compare the effect of urea treated bagasse with different inclusion levels of yeast in TMR on the performance of Yankasa rams. The yeast was included at the rate of 0g/kg, 5g/kg, 6g/kg and 7g/kg of the diets. Other feed ingredients include maize offal, cotton seed cake, bone meal, salt and premix. Five rams were assigned per treatment. The trial lasted for 90 days.

3.5.2 Data Collection

Daily feed intake was taken throughout the experiment by weighing the feed offered eachday and the left over (orts) in the following day. Daily intake of the diets was estimated foreach animal by subtracting the left over from the quantity served to the animal. Weight of the individual animal was measured at the onset of the trial after balancing weight to obtain their initial weights and subsequently at 2 weeks' intervals in the morning throughout the feeding trial. Weight gain was determined bysubtracting the initial weight from the final weight within the periods. Feed conversionratio was also determined, by dividing feed intake by weight gain.

Table 3.1: Gross composition of experiment I Diets

	Levels of yeast (g/kg)			
Parameters (%)	0	5	6	7
Maize offal	36.2	36.2	36.2	36.2
Urea treated Bagasse	30	30	30	30
Cotton seed cake	25.5	25.5	25.5	25.5
Rice offal	5	5	5	5
Bone meal	2	2	2	2
Salt	1	1	1	1
Premix	0.27	0.27	0.27	0.27
Total	100	100	100	100
Calculated CP	14	14	14	14
M.E(Kcal/kg)	2267	2267	2267	2267

M.E=Metabolizable energy, CP=crude protein, CF= crude fibre
Note: The yeast supplementation is not part of the formulated diet

3.5.3Nutrient Digestibility Study

At the end of the feeding trial, three rams were randomly selected from each treatment group and housed in metabolic crates for easyand separate faecal and urine collection as described by Osuji *et al.*(1993). The rams were allowed 14 days for adjusting to the condition of the metabolic crates before commencement of the collection period which lasted for 7 days. The rams werefed experimental diets at 3% of their body weight daily. Daily faecal output was weighed and 10% of each day collection was sub sampled and oven dried at 60°C for DM determination which wasbulked for laboratory analysis. Daily urine output was collected in a plastic container containing 10mls 0.1N H_2SO_4 placed under the metabolic crates. At the end of the 7^{th}day collection period, 10% of the urine taken from each ram was bulked and sub sampled and stored in the refrigerator pending nitrogen determination.

3.5.4Rumen Indices

3.5.4.1Rumen Temperature and pH Measurement

Rumen samples were collected from each ram at the end of the digestibility study at 4hrs after feeding. About 20mls of the rumen fluid was collected from all the rams in each treatment using stomach tube. Immediately after collection, temperature of the rumen liquor was recorded using digital hand thermometer and also its pH was determined using henna digital hand pH meter (model 9404) immediately. The rumen fluid was then strained through double layers of cheesecloth and put into a plastic bottles containing equal quantity of 0.1N H_2SO_4 to trap rumen ammonia. The samples were frozen for further analysis.

3.5.4.2 Rumen Ammonia and Volatile Fatty Acids Determination

Rumen liquor was taken to National Animal Production Research Institute (NAPRI) and subjected to steam distillation into boric acid using simple micro-Kjeldahl distillation (AOAC, 2005)procedure for the determination of rumen ammonia concentration. Total volatile fatty acid was determined according to Abdulrazak and Fujihara (1999).

3.5.5Ruminal Methane Estimation

Calculation of ruminal methane (CH_4) production was based on nutrient intake and digestibility according to the following models:

1. Model I: Methane (g/d) = -1.7494+ (41.42 × NDFI) + (39.8686 × CPI) + (0.5197 × NFCI) (Kundu *et al*., 2014)
2. Model II: Methane (L/day) Y = -17.766+42.793 X-0.849 X^2(Shibata *et al*., 1993).
3. Model II: Methane (L/d) = 0.34 × BW (Kg) + 19.7 × DMI (Kg/d) + 12) (Ida *et al*., 2012).
4. Model IV: Methane (KJ/d) = 1.62 × DCP – 0.38 × DCFAT + 3.78 × DCF + 1.49 × DNFE + 11.42 (Jenstsc *et al*., 2007).

Where:

NDFI=Neutral detergent fibre intake

CPI= Crude protein intake

NFCI=Non fibrous carbohydrate intake which include%NDF, %CP, %EE and %Ash

X= DMI (kg/day)

DMI - Dry matter intake

DCP - Digestible crude protein

DCFAT - Digestible crude fat

DCF - Digestible crude fibre

DNFE - Digestible nitrogen -free extract

BW - Body weight

3.5.6Blood MetabolitesEvaluation

About 10mls Blood samples was collected from three (3) rams in each of the treatment at the end of the digestibility trial using Hypodermic Syringe through the jugular vein and stored in a plain bottle for determination of Serum Biochemical indices such as blood glucose, total protein, creatinine and blood urea nitrogen at Veterinary Teaching Hospital Zaria. Determination of the blood glucose levels was done by the Glucose Oxidase Principle (Beach and Turner, 1975), total protein was estimated by the method of Henry and Stobel, (1957), Creatinine was determined according to the method described by Lamb, (1991) and blood urea nitrogen was determined by the method of Tannins and Maylor, (1968).

3.5.7 Economic Analysis

The current market price of the various feed ingredients was used to compute the total cost of feed that was consumed during the feeding trial.Cost of feed per kilogram, feed cost per kilogram weight gain, total weight gain, and cost of live weight of rams were used to determine how profitable or otherwise it was to feedYankasa rams with urea treated bagasse supplemented with various inclusion levelsof yeast using the method described by Anigbogu (2003).

Cost of total feed consumed = Total feed intake x Cost per kg of feed.

Cost/kg weight gain = Cost per kg of feed x Efficiency of feed utilization

Cost of production = Cost of inputs (Cost of feed consumed + Cost of rams)

Gross profit = Price/kg ram x Final weight of ram.

Profit (Net income incurred) = Gross profit - Cost of production.

3.5.8Statistical Analysis

All data collected at the end ofexperiment I were analyse using GLM procedure of statistical Analysis (SAS, 2002). Significant differences in treatment means werecompared using Tukey test and contrast analysis.

The following model was used

$$Y_{ijk} = \mu + T_i + e_{ij}$$

Where

Y_{ijk} = Observation measured,

μ= Overall mean,

T_i=effect of inclusion levels of yeast (0, 5g, 6g and 7g)

e_{ij}= random error.

3.6EXPERIMENT II: Effect of inclusion level of enzyme in treated bagasse with yeast in TMR on performance of Yankasa rams

3.6.1 Experimental Design and Diets

Twenty-four (24) growing Yankasa rams with an average live weight of 18kg were used for the experiment. The rams were allotted to treatments in a 2×3 factorial arrangements in a completely randomized design, to compare the effect of urea treated bagasse without yeast and urea treated bagasse with yeast from the worst supplementation level (5g/kg) in experiment I with different levels of enzyme supplementation on the performance of Yankasa rams. A commercial cocktail enzyme (Fullzyme®) was used and included at the rate of 2, 4and 6g/kg. Other feed ingredients include maize offal, cotton seed cake, molasses, bone

meal, salt and mineral premix. Four rams were assigned per treatment. The trial lasted for 90 days.

Table 3.2: Gross composition of experiment II Diets

	WY			TY		
Parameters (%)	2	4	6	2	4	6
Maize offal	34.2	34.2	34.2	34.2	34.2	34.2
Rice offal	10	10	10	10	10	10
Cotton seed cake	17.5	17.5	17.5	17.5	17.5	17.5
Urea treated Bagasse	30	30	30	30	30	30
Molasses	5	5	5	5	5	5
Bone meal	2	2	2	2	2	2
Salt	1	1	1	1	1	1
Mineral Premix	0.27	0.27	0.27	0.27	0.27	0.27
Total	100	100	100	100	100	100
Calculated CP	12	12	12	12	12	12
Calculated CF	18.7	18.7	18.7	18.7	18.7	18.7
M.E Kcal/Kg	2299	2299	2299	2299	2299	2299

M.E=Metabolizable energy, CP=crude protein, CF= crude fibre, WY=Treated without yeast, TY=Treated with yeast
Note: The yeast and enzyme supplementation is not part of the formulated diet

3.6.2 Data Collection

Daily feed intake was taken throughout the experiment by weighing the feed offered eachday and the left over (orts) in the following day. Daily intake of the diets was estimated foreach animal by subtracting the left over from the quantity served to the animal. Weight of the individual animal was measured at the onset of the trial after balancing weight to obtain their initial weights and subsequently at 2 weeks' intervals in the morning throughout the feeding trial. Weight gain was determined bysubtracting the initial weight from the final weight within the periods. Feed conversionratio was also determined, by dividing feed intake by weight gain.

3.6.3 Nutrient Digestibility Study

At the end of the feeding trial, three rams were randomly selected from each treatment group and housed in metabolic crates for easyand separate faecal and urine collection as described by Osuji *et al.* (1993). The rams were allowed 14 days for adjusting to the condition of the metabolic crates before commencement of the collection period which lasted for 7 days. The rams were fed experimental diets at 3% of their body weight daily. Daily faecal output was weighed and 10% of each day collection was sub sampled and oven dried at 60°C for DM determination which was bulked for laboratory analysis. Daily urine output was collected in a plastic container containing 10mls 0.1N H_2SO_4 placed under the metabolic crates. At the end of the 7^{th}day collection period, 10% of the urine taken from each ram was bulked and sub sampled and stored in the refrigerator pending nitrogen determination.

3.6.4 Rumen Indices

3.6.4.1 Rumen Temperature and pH Measurement

Rumen samples was collected from each ram at the end of the digestibility study at 4hrs after feeding. About 20mls of the rumen fluid was collected from all the rams in each treatment using stomach tube. Immediately after collection, temperature of the rumen liquor was recorded using digital hand thermometer and also its pH was determined using henna digital hand pH meter (model 9404) immediately. The rumen fluid was then strain through double layers of cheesecloth and put into a plastic bottle containing equal quantity of 0.1N H_2SO_4 to trap rumen ammonia. The samples were frozen for further analysis.

3.6.4.2 Rumen Ammonia and Volatile Fatty Acids Determination

Rumen liquor was taken to National Animal Production Research Institute (NAPRI) and subjected to steam distillation into boric acid using simple micro-Kjeldahl distillation (AOAC, 2005)procedure for the determination of rumen ammonia concentration. Total volatile fatty acid was determined according to Abdulrazak and Fujihara (1999).

3.6.5 Ruminal Methane

Calculation of ruminal methane (CH_4) production was based on nutrient intake and digestibility according to the following models:

1. Model I: Methane (g/d) = -1.7494+ (41.42 × NDFI) + (39.8686 × CPI) + (0.5197 × NFCI) Kundu *et al*. (2014)
2. Model II: Methane (L/day) Y = -17.766+42.793 X-0.849 X^2 Shibata *et al*. (1993)

3. Model II: Methane (L/d) = 0.34 × BW (Kg) + 19.7 × DMI (Kg/d) + 12) Ida *et al*. (2012)
4. Model IV: Methane (KJ/d) = 1.62 × DCP – 0.38 × DCFAT + 3.78 × DCF + 1.49 × DNFE + 11.42 Jenstsc *et al*. (2007)

Where:

NDFI=Neutral detergent fibre intake

CPI= Crude protein intake

NFCI=Non fibrous carbohydrate intakewhich include %NDF, %CP, %EE and %Ash

X= DMI (kg/day)

DMI - Dry matter intake

DCP - Digestible crude protein

DCFAT - Digestible crude fat

DCF - Digestible crude fibre

DNFE - Digestible nitrogen free extract

BW - Body weight

3.6.6 Blood Metabolites Evaluation

About 10mls Blood samples were collected from three (3) rams in each of the treatment at the end of the digestibility trial using Hypodermic Syringe through the jugular vein and stored in a plain bottle for determination of Serum Biochemical indices such as blood glucose, total protein, creatinine and blood urea nitrogen at Veterinary Teaching Hospital Zaria. Determination of the blood glucose levels was done by the Glucose Oxidase Principle (Beach and Turner, 1975), total protein was estimated by the method of Henry and Stobel(1957), Creatinine was determined according to the method described by Lamb(1991) and blood urea nitrogen was determined by the method of Tannins and Maylor(1968).

3.6.7Economic Analysis

The current market price of the various feed ingredients wasused to compute the total cost of feed that was consumed during the feeding trial.Cost of feed per kilogram, feed cost per kilogram weight gain, total weight gain, and cost of live weight of rams wereused to determine how profitable or otherwise it was to feed Yankasa rams with urea treated bagasse supplemented with yeast and enzyme at various inclusion levels using the methoddescribed by Anigbogu (2003).

Cost of total feed consumed = Total feed intake x Cost per kg of feed.

Cost/kg weight gain = Cost per kg of feed x Efficiency of feed utilization

Cost of production = Cost of inputs (Cost of feed consumed + Cost of rams)

Gross profit = Price/kg ram x Final weight of ram.

Profit (Net income incurred) = Gross profit - Cost of production.

3.6.8Statistical Analysis

All data collected at the end of the experiment were analysedusing GLM procedure of statistical Analysis (SAS, 2002). Significant differences in treatment means werecompared using DMRT (Duncan 1955). The following model was used

$$Y_{ijk} = \mu + T_i + E_j + (T \times E)_{ij} + e_{ijk}$$

Where

Y_{ijk} = Observation measured,

μ= Overall mean,

T_i= Treated without or with yeast supplementation (0, 5g)

E_j=Inclusion levels of enzyme (2g, 4g and 6g)

$(T \times E)_{ij}$=Interaction between yeast and enzyme supplementation

e_{ijk}=Random error.

CHAPTER FOUR

4.0 RESULTS

4.1 EXPERIMENT I

4.1.1 Chemical composition of bagasse

The chemical composition of the urea treated and untreated bagasse are presented in Table 4.1. Urea treated bagasse had the highest values for ADF and NDF, (28.48% and 50.03% respectively) compared toUntreated bagasse with values of 21.56% and 42.71% respectively. There was a marked increase (74%) in crude protein content of untreated bagasse from 2.84% to 11.25% for treated bagasse andnumerically higher values were also obtained for dry matter and organic matter

4.1.2 Chemical composition of experiment I diets

Table 4.2 presents the chemical composition of the total mixed rations. It was observed that DM of the diets varied from 94.88% in the TMR without yeast supplementation to 94.38% in TMR with yeast supplementation. Organic matter follows the same trends. However crude protein content ranged from 13.00% in the TMR with (6g/kg) yeast inclusion level to 13.48% in the TMR with yeast supplementation (7g/kg). Treated bagasse supplemented with 5g/kgof Yeast had the highestNDF content (69.04%), followed by treatedsupplemented with 6g/kg of Yeast (68.94%),then treated without Yeastsupplementation (68.88%) and the least was treated with 7g/kg yeast supplementation (68.30%). Lignin content decreases with an increase in inclusion levels of yeast. Treated bagasse without yeast had the highest content 12.12%, followed by treated with 6g/kgof yeast (11.86%), then treated with 5 g/kg yeast (11.64%) and the least was treated with 7g/kg yeast supplementation (11.28%).

Table 4.1: Chemical composition of urea treated and untreated bagasse.

Parameters (%)	Treated bagasse	Untreated bagasse
Dry matter	93.81	92.23
Organic matter	90.95	89.80
Crude protein	11.25	2.84
Crude fibre	22.08	22.39
Ether extract	0.82	0.67
Ash	2.86	2.43
Nitrogen free extract	62.99	71.67
Acid detergent fibre	22.48	21.56
Neutral detergent fibre	50.03	42.71
Lignin	10.21	13.50

Table 4.2: Chemical composition of total mixed rations

Parameters (%)	Inclusion levels of yeast (g/kg)			
	0	5	6	7
Dry matter	94.88	94.91	94.52	94.38
Organic matter	89.12	88.78	88.64	89.49
Crude protein	13.23	13.75	13.0	13.48
Ash	5.76	6.13	5.88	4.89
Neutral detergent fibre	68.88	69.04	68.94	68.30
Acid detergent fibre	32.60	33.52	32.80	32.92
Acid detergent lignin	12.12	11.64	11.86	11.28

4.1.3: Effect of inclusion levels of yeast in urea treated bagasse based TMR on growth performance of Yankasa rams

Table 4.3a presents the effect of inclusion levels of yeast in urea treated bagasse based TMR on the performance of growing Yankasa rams. Significant ($P<0.05$) differences were observed in total weight gain and average daily gain. Rams fed 7g inclusion level of yeast had higher weigh gain (4.54kg) and ADG (50.44g) than those on control diets (2.40kg) and (37.76g) respectively. Feed conversion ratio was decreased by 20% in rams fed 7g inclusion level than the control diet.Rams fed 7g/kg yeast had lower feed conversion ratio (10.44), followed by rams fed 6g/kg inclusion level of yeast (11.56), then rams fed 5g/kg inclusion level of yeast and the highest was recorded in the control diet without yeast (13.35). The result of pairwise comparism of the treatments using contrast is given in Table 4.3b. Significant ($P<0.05$) differences were observed in total weight gain, ADG and FCR between rams fed control diet and those fed with yeast supplementation. Also, the comparism between rams fed 5g inclusion level of yeast and those fed 6 plus 7g inclusion level of yeast was significant. However, there were no differences in weight gain and ADG between those fed control diet and 5g inclusion levels of yeast.

Table 4.3a: Effect of inclusion levels of yeast in urea treated bagasse based TMR on performance of Yankasa rams

Parameters	Inclusion levels of yeast (g/kg)				SEM
	0	5	6	7	
Initial weight (kg)	14.10	14.60	14.90	14.76	0.506
Final weight (kg)	17.50	18.20	19.00	19.30	0.690
Total weight gain (kg)	3.40^{c}	3.60^{bc}	4.10^{ab}	4.54^{a}	0.350
ADG (g/d)	37.76^{d}	40.00^{c}	45.56^{b}	50.44^{a}	0.003
Feed intake (g/d)	488.00^{b}	493.00^{ab}	511.00^{ab}	524.00^{a}	17.26
FCR	13.35^{b}	12.40^{b}	11.56^{ab}	10.44^{a}	0.90

[a,b,c,] Means with different superscript across treatment differ (P<0.05) significantly, SEM=Standard Error of mean, ADG=Average daily gain, FCR=Feed conversion Ratio.

Table 4.3b: Contrast analysis of the different treatment combinations on performance of Yankasa rams

		P values		
Contrast	AIM	TWG	ADG	FCR
0 vs 5g	Control vs low level	0.676	0.676	0.453
0 vs 6g	Control vs medium	0.156	0.156	0.169
0 vs 5 and 6g	Control vs low and medium	0.285	0.285	0.220
0 vs 5 and 7g	Control vs low and high	0.120	0.120	0.092
0 vs 5, 6 and 7g	Control vs all levels	0.038	0.038	0.044
5 vs 6 and 7g	Low vs medium and high	0.026	0.026	0.032

TWG=Total weight gain, ADG=Average daily gain, FCR=Feed conversion ration

4.1.4: Effect of inclusion levels of yeast in bagasse based TMR on Nutrient Digestibility by Yankasa rams

The effect of inclusion levels of yeastin bagasse based TMR on nutrient digestibility of growing Yankasa rams is presented in Table 4.4a. There were significant differences ($P<0.05$) in digestibility coefficients of DM, OM, CP, NDF, ADF and ADL among the treatment groups. DM digestibility increases with an increase in the inclusion levels of yeast.Grower rams fed TMR containing 7g inclusion level of yeast had highest value (59.64%), followed by rams fed 6g/kg inclusion level of yeast (58.61%), then rams fed 5g/kg inclusion level of yeast (53.19%) and the least was obtained in rams fed the control diet without yeast (53.08%). CP, NDF and ADF digestibility's followed similar trend. Rams fed 7g inclusion level of yeast had highest values (74.19%, 74.41%, and 75.36%), followed by rams TMR containing 6g/kg inclusion level of yeast (73.68%, 71.05%, 71.92%), then rams fed TMR containing 5g/kg inclusion level of yeast (67.80%,70.18% and 67.88%) and the least was obtained in grower rams fed TMR without yeast (67.33%, 67.27% and 67.38%) for CP, NDF and ADF digestibility's respectively. Results of the pairwise comparison is presented in Table 4.4b. The results showed significant ($P<0.05$) differences in NDF and ADL between rams on control diet and 5g inclusion levels of yeast. Rams fed 6g inclusion level of yeast, all other treatments also showed significant ($P<0.05$) difference in CP, NDF, ADF and ADL compared to control diet.

Table 4.4a: Effect of inclusion levels of yeast in bagasse based TMR on nutrient digestibility by Yankasa rams

Parameters (%)	Inclusion levels of yeast (g/kg)				SEM
	0	5	6	7	
Dry matter	53.08^{cd}	53.19^{c}	58.61^{ab}	59.64^{a}	2.02
Organic matter	52.27^{c}	52.09^{cd}	58.85^{ab}	59.23^{a}	2.1
Crude protein	67.33^{cd}	67.80^{c}	73.68^{ab}	74.19^{a}	1.47
Neutral detergent fibre	67.27^{cd}	70.18^{bc}	71.05^{b}	74.41^{a}	1.60
Acid detergent fibre	67.38^{cd}	67.88^{bc}	71.92^{ab}	75.36^{a}	2.58
Acid detergent lignin	57.51^{bc}	62.56^{b}	62.74^{ab}	68.21^{a}	3.54

^{a,b,c,d,} Means with different superscript across treatment differ (P<0.05) significantly, SEM=Standard Error of mean

Table 4.4b: Contrast analysis of the different treatment combinations on nutrients digestibility by Yankasa rams

		P values					
Contrast	AIM	DMD	OMD	CPD	NDFD	ADFD	ADLD
0 vs 5g	Control vs low level	0.982	0.970	0.892	0.034	0.254	0.044
0 vs 6g	Control vs medium	0.272	0.177	0.028	0.031	0.043	0.033
0 vs 5 and 6g	Control vs low and medium	0.522	0.427	0.275	0.296	0.452	0.664
0 vs 5 and 7g	Control vs low and high	0.004	0.043	0.024	0.034	0.038	0.022
0 vs 5, 6 and 7g	Control vs all levels	0.026	0.032	0.007	0.013	0.009	0.032
5 vs 6 and 7g	Low vs medium and high	0.009	0.012	0.045	0.018	0.027	0.021

DMD=Drymatter digestibility, OMD=Organic matter digestibility, CPD=Crude protein digestibility,NDFD=Neutral detergent fibre digestibility, ADFD=Acid detergent fibre digestibility, ADLD=Acid detergent lignin digestibility

4.1.5:Effect of inclusion levels of yeast in urea treated bagasse based TMR on nitrogen balance by Yankasa rams

The result of inclusion level effect of yeast in urea treated bagasse based TMR on Nitrogen balance of growing Yankasa Rams is presented in Table 4.5a. The result shows significant ($P<0.05$) differences in Nitrogen intake and faecal nitrogen among the treatment groups. Nitrogen intake of grower rams on diet containing 7g/kg inclusion level of yeast had higher nitrogen intake (16.99g/d), followed by rams fed TMR with 6g/kg inclusion level of yeast (16.14g/d), then those fed diets containing 5g/kg inclusion level of yeast (13.88g/d) and the least was obtained in rams fed TMR without yeast supplementation (13.84g/d). Results for nitrogen absorbed, nitrogen retained and nitrogen retained as percentage intake were also significant ($P<0.05$) among treatment groups. However, grower rams fed diet containing 7g/kg inclusion level of yeast had higher nitrogen absorbed (12.86g/d), compared to rams fed TMR without yeast supplementation (9.33g/d). Nitrogen retained and nitrogen retained as percentage of intake were also higher in rams fed TMR containing 6g/kg inclusion level of yeast (8.8g/d and 54.52%), followed by rams fed TMR containing 7g/kg inclusion level of yeast (8.71g/kg and 51.26%), then rams on diets with 5g/kg inclusion level of yeast (5.83g/d and 42.00%) and the least were recorded in rams fed TMR without yeast supplementation (5.67g/d and 40.96%) for nitrogen retained and nitrogen retained as percentage of intake respectively. Table 4.5b shows the result of the pairwise comparism between treatment groups. Significant ($P<0.05$) differences were observed in nitrogen absorbed, nitrogen retained and nitrogen as percentage intake between rams control diet and other treatments and also between rams fed 5g and those fed 6 and 7g inclusion level of yeast.

Table 4.5a:Effect of inclusion levels of yeast in urea treated bagasse based TMR on nitrogen balance by Yankasa rams

Parameters	Inclusion Levels of yeast (g/kg)				SEM
	0	5	6	7	
Nitrogen Intake (g/d)	13.84^{bc}	13.88^{bc}	16.14^{b}	16.99^{a}	0.69
Urinary Nitrogen (g/d)	3.66	3.65	3.69	4.15	0.50
Faecal Nitrogen (g/d)	4.51^{a}	4.40^{a}	3.65^{b}	4.13^{ab}	0.15
Total Nitrogen output (g/d)	8.17	8.05	7.34	8.28	0.50
Nitrogen Absorbed (g/d)	9.33^{c}	9.48^{c}	12.49^{ab}	12.86^{a}	1.26
Nitrogen Retained (g/d)	5.67^{c}	5.83^{c}	8.80^{a}	8.71^{ab}	0.80
Nitrogen Retained as % intake	40.96^{b}	42.00^{b}	54.52^{a}	51.26^{ab}	6.17

^{a,b,c,} Means with different superscript across treatment differ (P<0.05) significantly, SEM=Standard Error of mean

Table 4.5b: Contrast analysis of the different treatment combinations on nitrogen balance by Yankasa rams

		P values				
Contrast	AIM	NI	NO	NA	NR	NR%
0 vs 5g	Control vs low level	0.973	0.872	0.930	0.903	0.984
0 vs 6g	Control vs medium	0.092	0.529	0.333	0.061	0.622
0 vs 5 and 6g	Control vs low and medium	0.290	0.783	0.535	0.216	0.782
0 vs 5 and 7g	Control vs low and high	0.928	0.780	0.720	0.593	0.713
0 vs 5, 6 and 7g	Control vs all levels	0.418	0.072	0.013	0.033	0.015
5 vs 6 and 7g	Low vs medium and high	0.285	0.925	0.044	0.012	0.018

NI=Nitrogen intake, NO=Nitrogen output, NA=Nitrogen absorbed, NR=Nitrogen retained, NR%=Nitrogen retained as percentage intake.

4.1.6: Effect of inclusion levels of yeast in urea treated bagasse based TMR on rumen indices of Yankasa rams

Table 4.6a shows the effect of inclusion levels of yeast in urea treated bagasse based TMR on rumen indices. It was observed that pH and TVFA differed significantly ($P<0.05$) among treatment groups. Rumen ammonia vales were similar ($P<0.05$) among treatment groups. However, rumen ammonia nitrogen increased with increasing levels of yeast while TVFA increased with an increase in inclusion level by 29%. Rams fed TMR containing 7g/kg inclusion level of yeast had the highest TVFA (65.33mmol/L), followed by rams fed TMR containing 6g/kg inclusion level (56.00mmol/L), followed by rams fed diets with 5g/kg inclusion level (47.33mmol/L) and least for rams fed TMR without yeast supplementation (46.33mmol/L). Results of the pairwise comparism is given in Table 4.6b. All parameters measures were similar between all comparism except for TVFA which was significant ($P<0.05$) between rams fed control diet and all other groups and also between rams fed 5g inclusion level of yeast and those fed 6g and 7g inclusion level of yeast.

Table 4.6a: Effect of inclusion levels of yeast in urea treated bagasse based TMR on rumen indices of Yankasa rams

Parameter	Inclusion levels of yeast (g/kg)				SEM
	0	5	6	7	
pH	6.1^{ab}	6.2^{a}	6.2^{a}	6.3^{a}	0.05
Temperature (°c)	30.66^{b}	31.66^{a}	31.0^{ab}	30.50^{bc}	0.37
NH_3N-N (mg/100ml)	20.16	20.18	20.18	20.19	0.23
TVFA (mmol/L)	46.33^{bc}	47.33^{b}	56.0^{ab}	65.33^{a}	5.70

[a,b,c,] Means with different superscript across treatment differ (P<0.05) significantly,NH_3N-N= Rumen ammonia nitrogen, TVFA=Total volatile fatty acids, SEM=Standard Error of mean

Table 4.6b: Contrast analysis of the different treatment combinations on rumen indices of Yankasa rams

		P values	
Contrast	AIM	NH_3-N	TVFA
0 vs 5g	Control vs low level	0.439	0.273
0 vs 6g	Control vs medium	0.357	0.905
0 vs 5 and 6g	Control vs low and medium	0.332	0.473
0 vs 5 and 7g	Control vs low and high	0.257	0.081
0 vs 5, 6 and 7g	Control vs all levels	0.243	0.009
5 vs 6 and 7g	Low vs medium and high	0.716	0.036

NH_3N-N= Rumen ammonia nitrogen, TVFA=Total volatile fatty acids

4.1.7: Effect of inclusion levels of yeast in urea treated bagasse based TMR on blood serum indices of Yankasa rams

The effect of inclusion levels of yeast in bagasse based TMR on blood serum indices in presented in table 4.7a. The results indicated that all parameters measured were similar (P>0.05) except for blood glucose level which differed significantly (P<0.05). Blood glucose level increases with an increased in the inclusion level of yeast by 19% in rams fed TMR with 7g inclusion level of yeast. Higher blood glucose level was recorded in rams fed TMR with 7g/kg inclusion level of yeast (74.00mg/dl), thenrams fed TMR with 6g/kg inclusion level of yeast (66.83mg/dl), followed by rams fed on 5g/kg inclusion level of yeast (61.50mg/dl) and the least was recorded in rams fed TMR without yeast supplementation (60.16mg/dl).

The pairwise comparism presented in Table 4.1b showed significant (P<0.05) difference in total protein across all comparism. Blood glucose was significant (P<0.05) between rams fed control diet and those on other treatment and also rams fed 5g inclusion level of yeast and those fed 6 and 7g inclusion level of yeast.

4.1.8: Effect of inclusion levels of yeast in urea treated bagasse based TMR on methane production by Yankasa rams

The effect of inclusion levels of yeast in bagasse based TMR on methane production is presented in Figure 1. The quantity of methane estimated did not varies (P>0.05) with respect to model I, and Model II. However, rams fed TMR with 7g inclusion level had the least level of methane production (182.52 and 178.38 respectively) while rams fed TMR with 0g inclusion level had the highest level of production (210.9 and 202.98). Model III and Model IV showed significant (P<0.05) difference in the level of methane produced by Yankasa rams fed TMR containing various inclusion level of yeast. Rams fed TMR with 5g inclusion level

had the highest level of production, (133.97), which is similar with rams fed TMR with 0g inclusion level (123.25) and statistically different and the lowest for rams 7g inclusion level (109.99).

Table 4.7a: Effect of inclusion levels of yeast in urea treated bagasse based TMR on blood serum indices of Yankasa rams

	Inclusion levels of yeast (g/kg)					
Parameters	0	5	6	7	SEM	Normal range
Total protein (g/dl)	6.13	6.23	6.53	6.8	0.60	6-7.9g/dl
Blood urea N (mg/dl)	13.66	13.33	14.0	15.0	1.59	10-30mg/dl
Blood glucose (mg/dl)	60.16^{c}	61.50^{bc}	66.83^{b}	74.0^{a}	2.93	50-80mg/dl
Creatinine (mg/dl)	1.8	1.8	1.76	1.63	0.09	1-2mg/dl

^{a,b,c,} Means with different superscript across treatment differ ($P<0.05$) significantly, SEM=Standard Error of mean

Table 4.7b: Contrast analysis of the different treatment combinations on blood serum indices of Yankasa rams

		P values			
Contrast	AIM	TP	BUN	BG	CREATININE
0 vs 5g	Control vs low level	0.289	0.882	0.752	0.677
0 vs 6g	Control vs medium	0.002	0.767	0.145	0.066
0 vs 5 and 6g	Control vs low and medium	0.013	0.797	0.293	0.176
0 vs 5 and 7g	Control vs low and high	0.001	0.863	0.068	0.809
0 vs 5, 6 and 7g	Control vs all levels	0.0009	1.000	0.046	0.323
5 vs 6 and 7g	Low vs medium and high	0.0007	0.797	0.039	0.477

TP=Total protein, BUN=Blood urea nitrogen, BG=Blood glucose

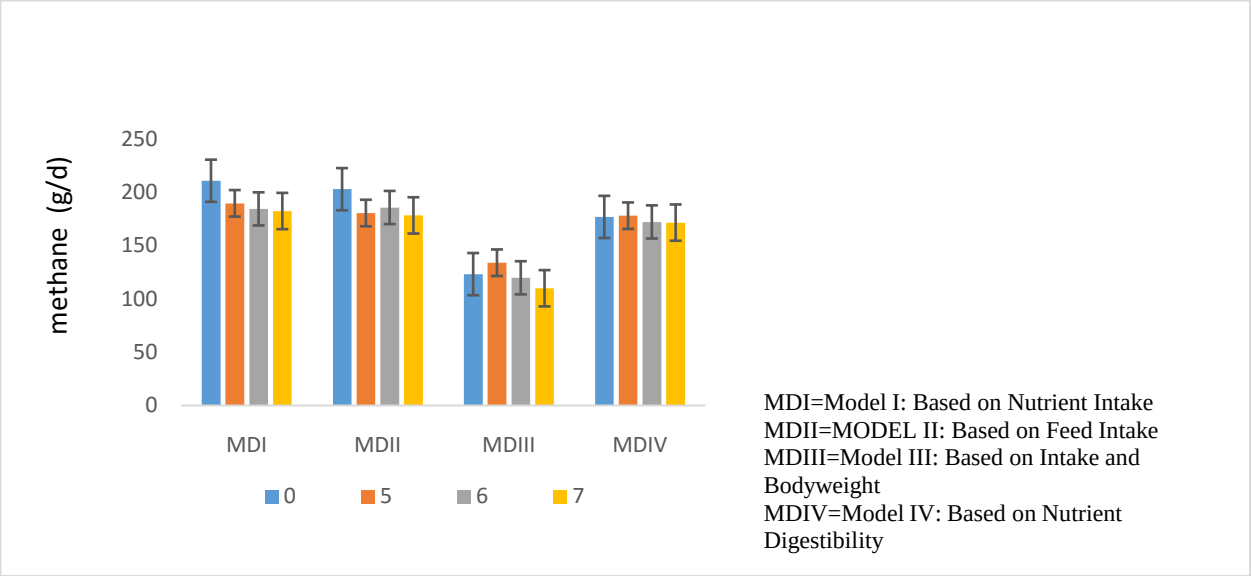


FIGURE 1: Effect of inclusion levels of Yeast on methane production by Yankasa rams

4.1.9 Effect of inclusion levels of yeast in urea treated bagasse based TMR on economic benefits

The results of the effect of inclusion levels of yeast inurea treated bagasse based TMR on economic returns is presented in Table 4.8. A significant ($P<0.05$) difference was observed in total weight gain, average daily gain and total feed intake across all treatments. Higher weight gains were recorded in rams fed 7g/kg inclusion level (5.54kg) than rams fed TMR without yeast inclusion level (3.40kg). However,cost/kg gain was reduced with an increase in the inclusion levels of yeast. Rams fed TMR with 7g/kg inclusion level of yeast had least cost/kg gain (₦236.66) which is better compared to ₦251.10, ₦273.5 and ₦285.53 recorded in rams fed treated bagasse with 6g/kg, 5g/kg and without yeast supplementation respectively. Moreover, income incurred over cost increases with an increase in the inclusion levels of yeast. Rams fed TMR with 7g/kg inclusion level had higher income returns (₦2329.76) compared to rams fed TMR without yeast supplementation (₦1579.37).

Table 4.8: Effect of inclusion levels of yeast in urea treated bagasse based TMR on economic benefit

Parameters	Inclusion levels of yeast (g/kg)				SEM
	0	5	6	7	
Total weight gain (kg)	3.40^{c}	3.60^{bc}	4.10^{ab}	4.54^{a}	0.35
ADG(g)	37.76^{b}	40.00^{b}	45.56^{ab}	50.44^{a}	3.99
Total feed intake (kg)	43.92^{b}	44.37^{ab}	45.99^{ab}	47.16^{a}	1.5
Total cost of feed (₦)	970.63	985.01	1030.17	1075.24	-
Cost/kg gain (₦)	285.53	273.50	251.10	236.66	-
Value of gain (₦)	2550	2700	3075	3405	-
Income over cost (₦)	1579.37	1714.99	2044.83	2329.76	-

^{a,b,cd,} Means with different superscript across treatment differ (P<0.05) significantly, SEM=Standard Error of mean, ADG=Average daily gain

4.2 EXPERIMENT II

4.2.1 Chemical composition of experiment II diets

Table 4.9 presents the chemical composition of the total mixed ration. It was observed that DM of the diets varied from 92.23% in the TMR without yeast and 6g/kg enzyme supplementation to 93.67% in TMR with yeast and 4g/kg enzyme supplementation. Organic matter follows the same trends. However crude protein content ranged from 13.75% in the TMR without yeast and 4g/kg enzyme supplementationto 14.58% in the TMR with yeast and 6g/kg enzyme supplementation. Treated bagasse without Yeast and 6g/kg enzyme supplementation had the highest ADF content (34.81%), followed by treated bagasse withoutyeast and 2g/kg enzyme (33.61%), then treated without yeast and 4g/kg enzyme (33.23%) and the least was recorded in TMR containing urea treated bagasse with yeast and 6g/kg enzyme supplementation (32.81%). Lignin content in diet containing treated bagasse without yeast and 4g/kg enzyme had the highest content (12.21%), followed by treated bagasse without yeast and 6g/kg enzyme 11.68%, then TMR containing treated bagasse with yeast and 6g/kg enzyme (11.59%) and the least was recorded in TMR containing treated bagasse with yeast and 4g/kg enzyme supplementation (11.34%).

Table 4.9: Chemical composition of experiment II diets

Parameter	Without yeast			With yeast		
	2	**4**	**6**	**2**	**4**	**6**
Dry matter	93.28	92.41	92.23	93.51	93.67	92.45
Organic matter	88.64	87.78	87.56	88.62	87.21	88.25
Crude protein	14.13	13.75	14.50	14.38	14.21	14.58
Neutral detergent fibre	67.38	66.04	65.94	68.32	67.94	66.30
Acid detergent fibre	33.61	33.23	34.81	33.43	33.36	32.82
Acid detergent lignin	11.45	12.21	11.68	11.45	11.34	11.59

4.2.2 Effect of yeast supplementation in urea treated bagasse based TMR on performance of Yankasa rams

Table 4.10shows the effect of yeast supplementation in bagasse based TMR on performance of growing Yankasa rams. A significant (P<0.05) difference was observed between rams fed treated bagasse without yeast and rams fed treated bagasse with yeast in total weight gain and average daily gain respectively. Rams fed treated bagasse with yeast had 15% higher total weight gain (4.59kg) and average daily gain(51.01g/d) than those without yeast supplementation (3.9kg and 43.33g/d) for weight gain and average daily gain respectively. Feed conversion ratio (FCR) of rams fed treated bagasse with yeast supplementation was lower (11.11) than those fed TMR without yeast supplementation (12.34) by 11%.

4.2.3 Effect of inclusion levels of enzyme in urea treated bagasse based TMR on performance of Yankasa rams

The effect of inclusion levels of enzyme in bagasse based TMR is presented in Table 4.11. It was observed that there was no significant (P>0.05) difference among treatment groups. However, feed intake, weight gain and average daily gain were higher (551.88g, 4.32kg and 48.05g/d) in rams fed TMR with 2g/kg enzyme supplementation, followed by rams fed TMR with 6g/kg inclusion level of enzyme (541.0g, 4.23kg and 47.08g/d)and the least were recorded inrams on TMR containing 4g inclusion level of enzyme (512.0g, 4.17kg and 46.38g/d) for feed intake, total weight gain and average daily gain respectively. FCR was decreased by 3.1% in rams fed TMR containing 2g inclusion level of enzyme (11.48) compared to other groups (11.85).

Table 4.10: Main effect of yeast supplementation in urea treated bagasse based TMR on performance of Yankasa rams

Parameter	WY	TY	SEM
Initial weight (kg)	18.41	17.95	0.65
Final weight (kg)	22.31	22.55	0.66
Total weight gain (kg)	3.9[b]	4.59[a]	0.22
ADG(g/d)	43.33[b]	51.01[a]	0.25
Feed intake (g/d)	514.00[b]	556.25[a]	18.38
FCR	12.34	11.11	0.83

[a,b,c,] Means with different superscript across treatment differ (P<0.05) significantly, SEM=Standard Error of mean, WY=Treated without yeast, TY=Treated with yeast

Table 4.11: Main effect of inclusion levels of enzyme in urea treated bagasse based TMR on performance of Yankasa rams

Parameter	2	4	6	SEM
Initial weight (kg)	18.5	17.95	18.18	0.80
Final weight (kg)	22.85	22.05	22.42	0.82
Total weight gain (kg)	4.32	4.17	4.23	0.27
ADG(g/d)	48.05	46.38	47.08	3.09
Feed intake (g/d)	551.88	512.0	541.0	22.5
FCR	11.48	11.85	11.85	1.02

[a,b,c,] Means with different superscript across treatment differ (P<0.05) significantly, SEM=Standard Error of mean

4.2.4 Interaction effect of yeast and inclusion levels of enzyme in urea treated bagasse based TMR on performance of Yankasa rams

The result of the interaction effect of yeast and inclusion levels of enzyme in urea treated bagasse based TMR on performance of Yankasa rams is presented in Table 4.12.Yeast and enzyme addition significantly ($P<0.05$) influenced growth performance. Weight gain and average daily gain of rams fed TMR containing yeast and 2g inclusion level of enzyme were significantly ($P<0.05$) higher (4.65kg and 51.66g/d) respectively with 17% than those rams fed TMR without yeast and 6g enzyme inclusion level (3.82kg and 42.50g/d) for weight gain and average daily gain respectively. Feed intake followed similar pattern. However, feed intake was increased by 10% in rams fed TMR with yeast and 6g inclusion level of enzyme (576.25g/d) compared to those fed TMR without yeast and 6g inclusion level of enzyme (519.5g)/d while FCR increases with an increase in the inclusion level of enzyme with or without yeast. Rams fed TMR without yeast and 4g/kg inclusion level of enzyme had highest FCR (12.81), followed by those rams fed TMR containing treated bagasse without yeast and 6g/kg inclusion level of enzyme (12.76) while the least was recorded in rams fed TMR containing treated bagasse with yeast and 4g/kg inclusion level of enzyme (10.90).

Table 4.12: Interaction effect of yeast and inclusion levels of enzyme in urea treated bagasse based TMR on performance of Yankasa rams

	WY			TY			
Parameter	**2**	**4**	**6**	**2**	**4**	**6**	**SEM**
Initial weight (kg)	18.62	18.12	18.5	17.87	17.62	18.37	1.13
Final weight (kg)	22.750	21.87	22.32	22.52	22.22	22.90	1.15
Total weight gain (kg)	4.12^{ab}	3.75^{b}	3.82^{ab}	4.65^{a}	4.60^{ab}	4.52^{ab}	0.39
ADG (g/d)	45.83^{ab}	46.66^{ab}	42.50^{b}	51.66^{a}	51.11^{a}	50.27^{a}	4.38
Feed intake (g/d)	527.5^{bc}	495.00^{c}	519.50^{ab}	562.50^{ab}	530.00^{ab}	576.25^{a}	31.84
FCR	11.46	12.81	12.76	10.94	10.90	11.50	1.14

^{a,b,c,} Means with different superscript across treatment differ (P<0.05) significantly, SEM=Standard Error of meanWY=Treated without yeast, TY=Treated with yeast ADG=Average daily gain, FCR=Feed conversion ratio

4.2.5 Effect of yeast supplementation in urea treated bagasse based TMR on nutrient digestibility by Yankasa rams

Table 4.13presents the effect of yeast supplementation in bagasse based TMR on nutrient digestibility by growing Yankasa rams. A significant (P<0.05) difference was observed in crude protein digestibility. Rams fed TMR with yeast supplementation had higher (74.17%) CP digestibility coefficient compared to those fed TMR without yeast (70.83%). However, other nutrient digestibility values were similar (P>0.05), even though digestibility coefficients were relatively increased in rams fed TMR with yeast by 2.3, 2.1 and 3.4% for NDF, ADF and ADL respectively, compared those fed TMR without yeast.

4.2.6 Effect of inclusion levels of enzyme in urea treated bagasse based TMR on nutrient digestibility by Yankasa rams

Result of the effect of inclusion levels of enzyme in bagasse based TMR on nutrient digestibility is presented in Table 4.14. Significant (P<0.05) differences were observed in all nutrients digestibility coefficients except for CP which were similar. Dry matter digestibility of rams fed TMR containing 4g inclusion level of enzyme was higher (67.73%) by 11.4% compared to those fed TMR containing 6g inclusion level of enzyme (54.44). OM digestibility followed similar pattern.Rams fed 6g/kg inclusion level of enzyme had highest NDF digestibility (76.39%), followed by rams fed TMR with 2g/kg enzyme supplementation (75.57%) and the least was recorded in rams fed TMR with 4g/kg inclusion level of enzyme (70.68%). ADL digestibility was increased by 19% in rams fed TMR with 2g inclusion level of enzyme (71.82%), followed by rams TMR with 4g/kg inclusion level of enzyme (69.19%), and the least was recoded in rams fed TMR with 6g/kg inclusion level (58.33%).

Table 4.13: Main effect of yeast supplementation in urea treated bagasse based TMR on nutrient digestibility by Yankasa rams

Parameter(%)	WY	TY	SEM
Dry matter	60.08	62.38	2.10
Organic matter	59.38	61.92	2.23
Crude protein	70.83[b]	74.17[a]	1.07
Neutral detergent fibre	73.34	75.07	1.36
Acid detergent fibre	73.01	74.60	1.36
Acid detergent lignin	65.31	67.59	2.52

[a,b,] Means with different superscript across treatment differ (P<0.05) significantly, SEM=Standard Error of mean,WY=Treated without yeast, TY=Treated with yeast

Table 4.14: Main effect of inclusion level of enzyme in urea treated bagasse based TMR on nutrient digestibility by Yankasa rams

Parameter (%)	2	4	6	SEM
Dry matter	63.51[a]	63.73[a]	56.44[b]	2.58
Organic matter	62.04[a]	62.05[a]	54.20[b]	2.73
Crude protein	72.07	74.19	71.24	2.08
Neutral detergent fibre	75.57[ab]	70.68[b]	76.39[a]	1.67
Acid detergent fibre	74.39[ab]	70.16[b]	76.86[a]	1.67
Acid detergent lignin	71.82[a]	69.19[a]	58.33[b]	3.09

[a,b,] Means with different superscript across treatment differ (P<0.05) significantly, SEM=Standard Error of mean

4.2.7 Interaction effect of yeast and inclusion levels of enzyme in urea treated bagasse based TMR on nutrient digestibility by Yankasa rams

Table 4.15shows the interaction effect of yeast and inclusion levels of enzyme in bagasse based TMR on nutrient digestibility. The result indicated that there was a significant ($P<0.05$) difference across all the parameters measured. Dry matter digestibility was significantly ($P<0.05$) increased by 16.5% in rams fed TMR with yeast and 4g inclusion level of enzyme (68.87%) compared to those fed TMR with yeast and 6g inclusion level of enzyme (57.54%). NDF and ADL digestibility coefficients of rams fed TMR with yeast decreases with increase in inclusion level of enzyme in TMR. Rams fed TMR with yeast and 2g/kg inclusion level of enzyme had the highest digestibility coefficients (78.11% and 73.14%), followed by rams fed TMR with yeast and 4g/kg inclusion level of enzyme (77.75% and 72.89%) while rams fed TMR with yeast and 6g/kg inclusion level of enzyme had the least digestibility coefficients (69.36% and 56.73%) for NDF and ADL respectively. A decrease of 12% and 28% was recorded in rams fed TMR with yeast and 6g inclusion level of enzyme for ADF and ADL digestibility coefficient's respectively, compared to those fed TMR with yeast and 2g inclusion level of enzyme.

Table 4.15: Interaction effect of yeast and inclusion levels of enzyme in urea treated bagasse based TMR on nutrient digestibility by Yankasa rams

	WY			TY			
Parameter(%)	**2**	**4**	**6**	**2**	**4**	**6**	**SEM**
Dry matter	62.73^{a}	55.35^{c}	62.15^{a}	64.74^{ab}	68.87^{a}	57.54^{bc}	3.65
Organic matter	61.12^{a}	51.17^{c}	58.52^{bc}	62.98^{ab}	65.56^{a}	57.23^{bc}	3.87
Crude protein	66.11^{b}	73.32^{a}	73.95^{a}	76.37^{a}	71.09^{ab}	75.05^{a}	2.94
Neutral detergent fibre	74.67^{ab}	71.99^{bc}	74.38^{ab}	78.11^{a}	77.75^{a}	69.36^{c}	2.36
Acid detergent fibre	74.73^{bc}	73.62^{bc}	70.70^{c}	79.00^{a}	78.09^{ab}	66.70^{c}	2.36
Acid detergent lignin	70.49^{a}	59.94^{bc}	65.50^{ab}	73.14^{a}	72.89^{a}	56.73^{c}	4.37

^{a,b,c,} Means with different superscript across treatment differ (P<0.05) significantly, SEM=Standard Error of mean,WY=Treated without yeast, TY=Treated with yeast

4.2.8 Effect of yeast supplementation in urea treated bagasse based TMR on nitrogen balance by Yankasa rams

The result of nitrogen balance by Yankasa rams fed urea treated bagasse based TMR with yeast supplementation is shown in table 4.16. Nitrogen intake, nitrogen absorbed, nitrogen retained and percentage N retention were similar (P>0.05) between groups. Rams fed TMR without yeast had higher values (16.98, 14.98 and 9.33g/d) compared to lower values (15.32, 13.47 and 9.03g/d) recorded in rams fed TMR with yeast for Nitrogen intake, nitrogen absorbed and nitrogen retained respectively. However, a significant (P<0.05) difference was observed in urinary nitrogen, faecal nitrogen and total nitrogen output.Rams fed TMR without yeast had higher values (5.05, 2.00 and 7.06g/d) compared to lower values (4.44, 1,85 and 6.29g/d) recorded in rams fed TMR with yeast supplementation for Urinary nitrogen, faecal nitrogen and total output respectively.

4.2.9: Effect of inclusion level of enzyme in urea treated bagasse based TMR on nitrogen balance by Yankasa rams

Table 4.17presents the effect of inclusion levels of enzyme in bagasse based TMR on nitrogen balance. A significant (P<0.05) difference was observed in urinary nitrogen, faecal nitrogen, and nitrogen output. Significantly (P<0.05) higher urinary nitrogen were excreted by rams fed TMR with 2g inclusion level of enzyme, followed by rams fed 4g/kg inclusion level of enzyme (4.82g/d) and least urinary nitrogen was excreted by rams fed 6g/kg inclusion level of enzyme (4.28g/d). Nitrogen absorbed, nitrogen retained and nitrogen retained as percentage intake were similar (P>0.05) among treatment groups. However, nitrogen absorbed, nitrogen retained and nitrogen retained as percentage intake increases with an increase in the inclusion level of enzyme.

Table 4.16: Main effect of yeast supplementation in urea treated bagasse based TMR on nitrogen balance in Yankasa rams

Parameter	WY	TY	SEM
Nitrogen intake (g/d)	16.98	15.32	0.84
Urinary nitrogen (g/d)	5.05[a]	4.44[b]	0.27
Faecal Nitrogen (g/d)	2.00[a]	1.85[b]	0.02
Total Nitrogen (g/d)	7.05[a]	6.29[b]	0.27
Nitrogen Absorbed (g/d)	14.98	13.47	0.85
Nitrogen Retained (g/d)	9.33	9.03	0.88
Nitrogen Retained as % intake	58.48	58.94	2.76

[a,b,] Means with different superscript across treatment differ (P<0.05) significantly, SEM=Standard Error of mean,WY=Treated without yeast, TY=Treated with yeast

Table 4.17: Main effect of inclusion level of enzyme in bagasse based TMR on nitrogen balance in Yankasa rams

Parameter	Inclusion levels of enzyme			SEM
	2	4	6	
Nitrogen intake (g/d)	16.14	15.92	16.83	1.02
Urinary nitrogen (g/d)	5.14[a]	4.82[ab]	4.28[b]	0.33
Faecal Nitrogen (g/d)	1.98[b]	1.69[c]	2.11[a]	0.02
Total Nitrogen (g/d)	7.12[a]	6.51[b]	6.39[b]	0.33
Nitrogen Absorbed (g/d)	14.16	14.23	14.72	1.04
Nitrogen Retained (g/d)	9.02	9.41	19.44	1.08
Nitrogen Retained as % intake	55.88	59.10	62.03	3.38

[a,b,,]Means with different superscript across treatment differ (P<0.05) significantly, SEM=Standard Error of mean

4.2.10: Interaction effect of yeast and inclusion levels of enzyme in urea treated bagasse based TMR on nitrogen balance by Yankasa rams

The interaction effect of yeast and inclusion levels of enzyme in bagasse based TMR on nitrogen balance is presented in table 4.18.A significant (P<0.05) difference was observed in all parameters measured. The results indicated that rams fed TMR without yeast and 6g/kg enzyme inclusion level had the highest nitrogen intake (19.30g/d), followed by rams fed TMR with yeast and 4g/kg inclusion level of enzyme (17.80g/d), followed by rams fed TMR without yeast and 4g/kg inclusion level of enzyme, then least were recorded in rams fed TMR with and without yeast and 2 g/kg inclusion level of enzyme (14.72g/d and 14.32g/d) respectively. Ramsfed TMR without yeast and 2g inclusion level had the highest total nitrogen output (7.63g/d), which were significantly (P<0.05) higher compared to those rams fedTMR with yeast and 6g/kg inclusion level of enzyme (5.24g/d). However, rams fed TMR with yeast and 6g/kg inclusion level of enzyme had the highest nitrogen balance (11.78g/d) compared to those fed TMR without yeast and 2g/kg inclusion level of enzyme (6.8g/d). Moreover, rams fed TMR without yeast and 4g inclusion level of enzyme had significantly (P<0.05) higher percentage nitrogen retention (65.15%) which were similar with rams fed TMR without yeast and 6g inclusion level of enzyme (61.03%)and ramsfed TMR with yeast and 2g/kg (52.24%) and 6g/kg inclusion levels of enzyme (63.53%) but statistically differ from rams fed TMR without yeast and 2g inclusion level where the lowest percentage retention was recorded (47.12%).

Table 4.18: Interaction effect of yeast and inclusion levels of enzyme in bagasse based TMR on nitrogen balance in Yankasa rams

	WY			TY			
Parameter	**2**	**4**	**6**	**2**	**4**	**6**	**SEM**
Nitrogen intake (g/d)	14.43^{b}	17.22^{a}	19.30^{a}	14.72^{a}	17.80^{b}	14.37^{b}	1.45
Urinary nitrogen (g/d)	5.67^{a}	4.19^{c}	5.30^{ab}	5.46^{a}	4.61^{b}	3.25^{d}	0.47
Faecal Nitrogen (g/d)	1.96^{b}	1.81^{c}	2.22^{a}	1.57^{d}	1.99^{b}	1.99^{b}	0.03
Total Nitrogen (g/d)	7.63^{a}	6.00^{c}	7.52^{ab}	7.03^{ab}	6.60^{b}	5.25^{c}	0.47
Nitrogen Absorbed (g/d)	12.47^{b}	15.41^{a}	17.08^{a}	13.15^{b}	15.81^{ab}	12.38^{c}	1.47
Nitrogen Retained (g/d)	6.80^{b}	11.22^{a}	11.78^{a}	7.69^{b}	11.20^{a}	9.13^{ab}	1.53
Nitrogen Retained as % intake	47.12^{b}	65.15^{a}	61.03^{a}	52.24^{ab}	62.92^{ab}	63.53^{a}	4.79

^{a,b,c,d,} Means with different superscript across treatment differ ($P<0.05$) significantly, SEM=Standard Error of mean,WY=Treated without yeast, TY=Treated with yeast

4.2.11: Effect of yeast supplementation in bagasse based TMR on rumen indices of Yankasa rams

The result of rumen indicesof Yankasa rams fed bagasse based TMR with yeast supplement is shown in Table 4.19.The result shows that rumen ammonia nitrogen was significantly (P>0.05) increased by 15% with yeast supplementation.Rumen ammonia nitrogen increased from 28.00mg/100ml in rams fed TMR without yeast to 33.00mg/100ml in rams fed TMR with yeast supplementation. Total volatile fatty acid was also significantly (P<0.05) affected with yeast supplementation.Rams fed TMR with yeast supplementation had higher TVFA (52.00mmol/L) compared to rams fed TMR without yeast supplementation (45.00mmol/L).

4.2.12: Effect of inclusion level of enzyme in bagasse based TMR on rumen indices of Yankasa rams

Results of the effect of inclusion levels of enzyme in bagasse based TMR on mean rumen fluid variables in Yankasa rams is presented in Table 4.20. The pH was not affected with increasing level of enzyme. However, NH_3-N significantly (P<0.05) decreases with increasing level of enzyme. Rams fed 2g/kg inclusion level of enzyme had higher NH_3-N (33.00mg/100ml) while rams fed 4g/kg inclusion level had the least concentration (28.00mg/100ml).The effect of inclusion level of enzyme on mean TVFA is also presented on Table 4.18.TVFA concentration increased significantly (P<0.05). The mean values for TVFA across treatments showed that 4g inclusion level had the least (43.50mmol/L) TVFA concentration, which was comparable to TVFA concentration in rams fed TMR containing 2g inclusion level (46.33mmol/L) but were significantly (P<0.05) different from rams fed TMR containing 6g inclusion level of enzyme (55.66mmol/L).

Table 4.19: Main effect of yeast supplementation in urea treated bagasse based TMR on rumen indices of Yankasa rams

Parameter	WY	TY	SEM
pH	6.06[b]	6.25[a]	0.05
Temperature (°C)	31.88	32.0	0.31
NH_3N-N(mg/100ml)	28.00[b]	33.00[a]	0.02
TVFA(mmol/L)	45.00[b]	52.00[a]	2.48

[a,b,] Means with different superscript across treatment differ (P<0.05) significantly, SEM=Standard Error of mean,WY=Treated without yeast TY=Treated with yeast,NH_3N-N=Rumen ammonia nitrogen, TVFA=Total volatile fatty acids

Table 4.20: Main effect of inclusion level of enzyme in urea treated bagasse based TMR on rumen indices of Yankasa rams

Parameters	2	4	6	SEM
pH	6.15	6.18	6.15	0.06
Temperature (°C)	31.5	32.16	32.16	0.38
NH_3N-N (mg/100ml)	33.00[a]	28.00[b]	31.00[ab]	0.02
TVFA (mmol/L)	55.66[a]	43.5[b]	46.33[b]	3.04

[a,b,] Means with different superscript across treatment differ (P<0.05) significantly, SEM=Standard Error of mean NH_3N-N=Rumen ammonia nitrogen, TVFA=Total volatile fatty acids

4.2.13: Interaction effect of yeast and inclusion levels of enzyme in urea treated bagasse based TMR on rumen indices of Yankasa rams

Results of the interaction effect of yeast and inclusion levels of enzyme in bagasse based TMR on mean rumen fluid variables in Yankasa rams is presented in Table 4.21.The pH significantly ($P<0.05$) differed among treatment groups. Rams fed TMR without yeast and 2g/kg inclusion level of enzyme had the least pH (6.00) which differs with rams fed TMR with yeast and 4g/kg inclusion level of enzyme (6.3). NH_3-N decreases significantly ($P<0.05$) with an increase in the inclusion level of enzyme with or without yeast supplementation. Rams fed TMR with yeast and 2g/kg inclusion level of enzyme had the highest NH_3-N (35.00mg/100ml) which is comparable with values recorded in rams fed TMR without yeast and 2g/kg inclusion level (32.00mg/100ml) but differs with values recorded in rams fed TMR without yeast and 4g/kg inclusion level of enzyme (22.00mg/100ml).

The interaction effect of yeast and inclusion level of enzyme on mean TVFA is also presented on Table 4.19. The mean values for TVFA across treatments showed that TVFA concentration was significantly ($P<0.05$) decreased with increasing level of enzyme with or without yeast supplementation. Higher TVFA concentrations were recorded in rams fed TMR with yeast and 2g inclusion level of enzyme (59.33mmol/L), followed by rams fed TMR with yeast and 4g inclusion level of enzyme (52.00mmol/L) while least values were recorded in rams fed TMR with yeast and 6g/kg inclusion level of enzyme (51.66mmol/L).

Table 4.21: Interaction effect of yeast and inclusion levels of enzyme in bagasse based TMR on rumen indices of Yankasa rams

	WY			TY			
Parameter	**2**	**4**	**6**	**2**	**4**	**6**	**SEM**
pH	6.0^{b}	6.13^{ab}	6.06^{ab}	6.23^{a}	6.3^{a}	6.23^{a}	0.09
Temperature (°C)	31.33	32.0	32.33	31.66	32.33	32.0	0.54
NH_3N-N (mg/100ml)	32.00^{a}	22.00^{b}	29.00^{a}	35.00^{a}	34.00^{a}	33.00^{a}	0.03
TVFA (mmol/L)	52.33^{a}	40.33^{b}	35.33^{b}	59.33^{a}	52.00^{a}	51.66^{a}	4.30

^{a,b,} Means with different superscript across treatment differ ($P<0.05$) significantly, SEM=Standard Error of mean,WY=Treated without yeast TY=Treated with yeast NH_3N-N=Rumen ammonia nitrogen, TVFA=Total volatile fatty acids

4.2.14: Effect of yeast supplementation in urea treated bagasse based TMR on blood serum indices of Yankasa rams

Table 4.22 shows the effect of yeast supplementation in urea treated bagasse based TMR on blood serum profiles of Yankasa rams. The result indicated a significant (P<0.05) difference in all the parameters measured. Total protein had significantly (P<0.05)higher value (6.65g/dl) in rams fed TMR with yeast while a lower value (6.43mg/dl) was recorded in rams fed TMR without yeast. Blood urea nitrogen and total glucose follows similar trend. Rams fed TMR with yeast had higher values (19.6mg/dl and 69.18mg/dl) compared to rams fed TMR without yeast with mean values (18.24mg/dl and 66.83mg/dl) for blood urea nitrogen and total glucose respectively. Moreover, creatinine was significantly (P<0.05) higher in rams fed TMR without yeast (1.77mg/dl) while rams fed TMR with yeast inclusion had the least value (1.58mg/dl).

4.2.15: Effect of inclusion level of enzyme in urea treated bagasse based TMR on blood serum of Yankasa rams

The effect of inclusion levels of enzyme in urea treated bagasse based TMR on blood serum is presented in Table 4.23. It was noted that there was a significant (P<0.05) difference in total protein. Rams fed TMR with 6g/kg inclusion levels of enzyme had the highest value (6.71g/dl) which is similar to (6.58g/dl) recorded in rams fed TMR with 4g/kg inclusion level of enzyme and both are statistically different from (6.33g/dl) obtained in rams fed TMR with 2g/kg inclusion levels of enzyme. However, blood urea nitrogen, total glucose and creatinine were similar (P>0.05) among treatment groups. Blood urea nitrogen ranged from 18.51mg/dl in rams fed TMR with 4g/kg inclusion levels of enzyme to 19.7mg/dl in rams fed TMR with 6g/kg inclusion level of enzyme. Total glucose fells within the range of 66.3mg/dl to 68.9mg/dl. while mean creatinine value obtained range from 1.61mg/dl in rams fed TMR

with 6g/kg inclusion levels of enzyme to 1.77mg/dl in rams fed TMR with 2g/kg inclusion level of enzyme.

Table 4.22: Main effect of yeast supplementation in bagasse based TMR on blood serum indices of Yankasa rams

Parameter	WY	TY	SEM	Normal range
Total protein (g/dl)	6.43[b]	6.65[a]	0.10	6-7.9g/dl
Blood urea N (mg/dl)	18.24[b]	19.6[a]	0.51	10-30mg/dl
Blood glucose (mg/dl)	66.83[b]	69.18[a]	1.17	50-80mg/dl
Creatinine (mg/dl)	1.73[a]	1.58[b]	0.07	1-2mg/dl

[a,b,] Means with different superscript across treatment differ (P<0.05) significantly, SEM=Standard Error of meanWY=Treated without yeast, TY=Treated with yeast

Table 4.23: Main effect of inclusion level of enzyme in bagasse based TMR on blood serum indices of Yankasa rams

Parameters	2	4	6	SEM	Normal range
Total protein (g/dl)	6.33[b]	6.58[a]	6.71[a]	0.12	6-7.9g/dl
Blood urea N (mg/dl)	18.55	18.51	19.7	0.63	10-30mg/dl
Blood glucose (mg/dl)	66.3	68.82	68.9	1.43	50-80mg/dl
Creatinine (mg/dl)	1.71	1.65	1.61	0.09	1-2mg/dl

[a,b,] Means with different superscript across treatment differ (P<0.05) significantly, SEM=Standard Error of mean

4.2.16: Interaction effect of yeast and inclusion levels of enzyme in urea treated bagasse based TMR on blood serum indices of Yankasa rams

The interaction effect of yeast and inclusion level of enzyme on blood serum indices of Yankasa rams fed bagasse based TMR is illustrated in Table 4.24. The result shows that the parameters measured differed significantly ($P<0.05$) except for creatinine which were similar. Total protein increased with increase in inclusion levels of enzyme. Total protein ranged from 6.23g/dl in rams fed TMR with no yeast and 2g/kg inclusion level to 6.76g/dl in rams fed TMR without yeast and 6g/kg inclusion level of enzyme. The result also showed increase in the BUN concentration, as the inclusion level of enzyme increases from 2g/kg to 6g/kg in TMR with no yeast.Rams fed TMR with yeast and 2, 4 and 6g/kg inclusion level of enzyme, had comparable BUN (19.83, 19.33 and 19.73mg/dl) concentration respectively, but were significantly ($P<0.05$) higher than the values recorded in rams fed TMR without yeast and 2 and 4g/kg inclusion level of enzyme (17.26 and 17.7mg/dl respectively).

The interaction effect of yeast and inclusion level of enzyme on mean creatinine is also presented on Table 4.23. mean creatinineconcentration were similar ($P>0.05$) among treatment groups which showed a decreased in concentration with increasing level of enzyme in rams fed TMR with and without yeast supplementation.

Table 4.24: Interaction effect of yeast and inclusion levels of enzyme in urea treated bagasse based TMR on blood serum indices of Yankasa rams

	WY			TY			
Parameter	**2**	**4**	**6**	**2**	**4**	**6**	**SEM**
Total protein (g/dl)	6.23^{c}	6.30^{c}	6.76^{a}	6.43^{bc}	6.86^{a}	6.66^{ab}	0.17
Blood urea N (mg/dl)	17.26^{b}	17.7^{b}	19.76^{a}	19.83^{a}	19.33^{ab}	19.63^{a}	0.90
Blood glucose (mg/dl)	63.83^{b}	68.63^{a}	68.03^{a}	68.76^{a}	69.03^{a}	69.76^{a}	2.03
Creatinine (mg/dl)	1.76	1.73	1.70	1.66	1.56	1.53	0.13

^{a,b,c,} Means with different superscript across treatment differ (P<0.05) significantly, SEM=Standard Error of meanWY=Treated without yeast, TY=Treated with yeast

4.2.17Effect of yeast supplementation in urea treated bagasse based TMR on methane production by Yankasa rams

Figure 2 shows the effect of yeast supplementation in bagasse based TMR on methane production. A reduction in level of methane production was observed with yeast supplementation across all models tested. Rams fed TMR with yeast had lower (207.24, 201.47, 185.7 and 133.89) quantity of methane compared to rams fed TMR with no yeast supplementation with higher values (225.94, 212.4, 182.08 and 141.23) for MDI, MDII, MDIII and MDIV respectively.

4.2.18Effect of inclusion level of enzyme in urea treated bagasse based TMR on Methane production by Yankasa rams

The effect of inclusion levels of enzyme in bagasse based TMR on methane production is presented in figure 3. A non-significant ($P>0.05$) difference was observed across all the models tested. Fitting into model I, rams fed TMR with 2g inclusion level of enzyme had the least (203.69) quantity while rams fed TMR with 4g inclusion level had the highest (227.14). Similar pattern was obtained when fitted into model II. A quadratic response was observed when fitted into Model III and Model IV. Rams fed TMR with 4g inclusion level had the highest quantity (184.85) followed by rams fed TMR with rams fed TMR with 6g inclusion level (184.52) while the least was recorded in rams fed TMR with 2g inclusion level.

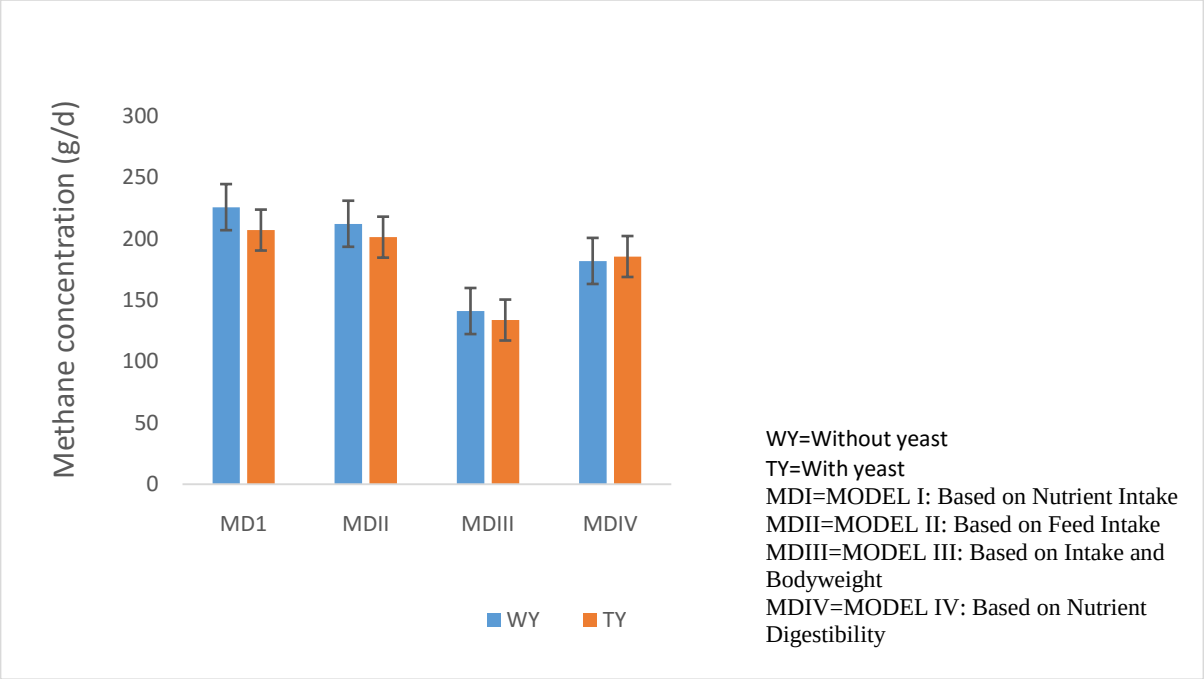


FIGURE 2: Main effect of yeast supplementation in urea treated bagasse based TMR on methane production by Yankasa rams

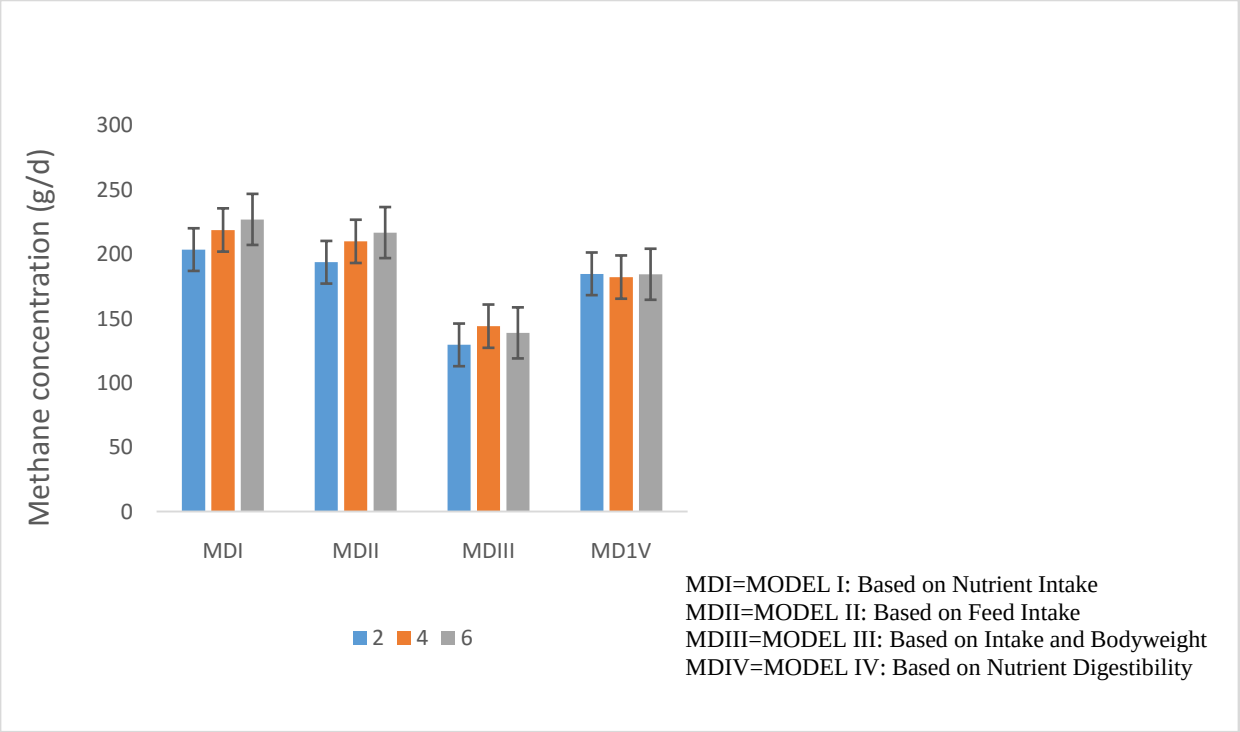


FIGURE 3: Main effect of inclusion levels of enzyme in urea treated bagasse based TMR on methane production by Yankasa rams

4.2.19Interaction effect of yeast and inclusion levels of enzyme in urea treated bagasse based TMR on methane production by Yankasa rams

The results obtained from the models tested in quantifying the level of methane produced by Yankasa ram's bagasse based TMR with or without yeast and varying inclusion levels of enzyme are presented in figure 4. Anon-significant (P>0.05) difference was recorded across all models tested. For Model I, rams fed TMR with no yeast and 4g inclusion level of enzyme had the highest (235.65) followed by those fed TMR with no yeast and 6g inclusion level (231.96). rams fed TMR with yeast and 4g inclusion level of enzyme had moderate quantity (218.62.) while the least quantity of (197.2) was recorded for rams fed TMR with yeast and 2g inclusion level. Models II, III and IV followed similar pattern with highest quantity recorded in rams fed TMR with no yeast and 2g inclusion level while the lowest was obtained in rams fed TMR with yeast and 2g inclusion level.

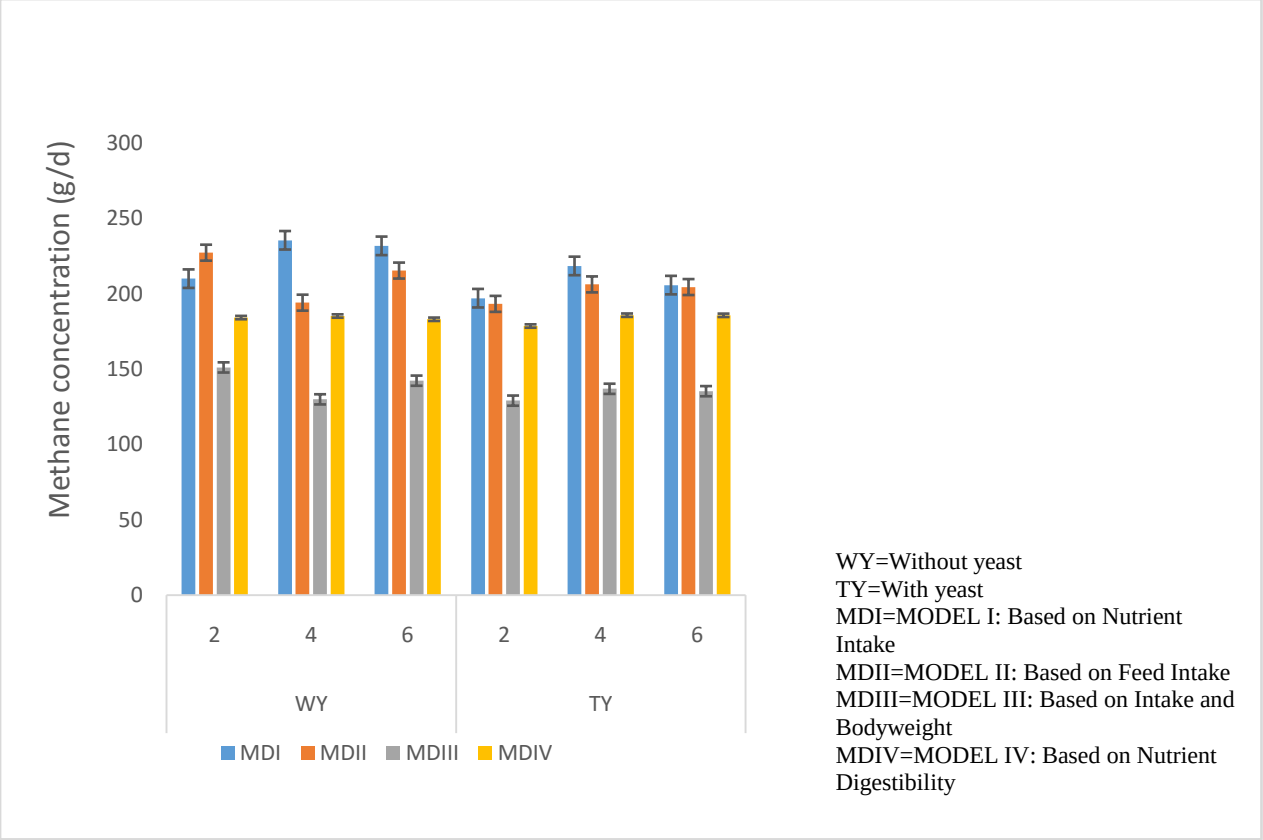


FIGURE 4: Interaction effect of yeast and inclusion levels of enzyme in urea treated bagasse based TMR on methane production by Yankasa rams

4.2.20 Effect of yeast supplementation in urea treated bagasse based TMR on cost benefit

Table 4.25 presents the effect of yeast supplementation in urea treated bagasse based TMR on cost benefit by Yankasa rams. A significant (P<0.05) difference was observed in total weight gain and average daily gain. Rams fed TMR with yeast supplementation had a 9.4% increase in total cost of feed consumed compared to those fed TMR without yeast. However, cost/kg gain was decreased by 7% in rams fed TMR with yeast supplementation. Rams fed treated bagasse with yeast supplementation had lower cos/kg gain (₦433.85) compared to rams fed TMR without yeast supplementation(₦462.15). Value of gain and income incurred over cost were increased with yeast supplementation. Rams fed TMR with yeast had higher value of gain (₦3442.5) and income incurred over cost (₦1451.1) while rams fed TMR without yeast had lower value of gain (₦2925.0) and income incurred over cost of production (₦1122.6).

4.2.21 Effect of inclusion levels of enzyme in urea treated bagasse based TMR on cost benefit

Table 4.26 showed the cost benefit of inclusion levels of enzyme in bagasse based TMR. The result showed that total cost of feeding rams indicated a non-linear response as the inclusion level of enzyme increased from 2g/kg to 6g/kg in the diet. Rams fed TMR with 6g/kg inclusion level of enzyme had the highest cost of feed (₦1974.8), followed by rams fed TMR with 2g/kg inclusion level of enzyme (₦1928.4) and the least was recorded in rams fed TMR with 4g/kg inclusion level of enzyme (₦1787.4). The result further pointed out that the cost of feed per kg gain was least in rams fed diet containing 4g/kg of enzyme (₦428.63) than those fed diet containing 6g/kg inclusion level of enzyme (₦466.85). However, value of gain was higher in rams fed diet containing 2g/kg inclusion level of enzyme (₦3240.0) compared to rams fed TMR with 4g/kg inclusion level of enzyme (₦3127.5) while income incurred over cost was higher in rams 4g/kg inclusion level of enzyme (₦1340.0) compared to 6g/kg inclusion level of enzyme (₦1197.7)

Table 4.25: Main effect of yeast supplementation in urea treated bagasse based TMR on cost benefit

Parameter	WY	TY	SEM
Total weight gain (kg)	3.9[b]	4.59[a]	0.22
Average daily gain (g)	43.33[b]	51.01[a]	0.25
Total feed intake (kg)	53.85	50.55	2.89
Total cost of feed (₦)	1802.4	1991.4	99.09
Cost/kg gain (₦)	462.15	433.85	26.83
Value of gain (₦)	2925.0	3442.5	171.89
Income over cost (₦)	1122.6	1451.1	163.02

Table 4.26: Main effect of inclusion level of enzyme in urea treated bagasse based TMR on cost benefit

Parameters	2	4	6	SEM
Total weight gain (kg)	4.32	4.17	4.23	0.28
Average daily gain (g)	48.05	46.38	47.08	3.09
Total feed intake (kg)	54.97	49.05	52.57	3.54
Total cost of feed (₦)	1928.4	1787.4	1974.8	121.3
Cost/kg gain (₦)	446.38	428.63	466.85	32.86
Value of gain (₦)	3240.0	3127.50	3172.5	210.5
Income over cost (₦)	1311.6	1340	1197.7	199.6

4.2.22 Interaction effect of yeast and inclusion levels of enzyme in urea treated bagasse based TMR on cost benefit

The interaction effect of yeast and inclusion levels of enzyme in bagasse based TMR on cost benefit is presented in Table 4.27. The result indicated that there was a significant ($P<0.05$) difference total weight gain and average daily gain. Total feed intake was increased by 16% in rams fed TMR without yeast and 2g inclusion level of enzyme compared to those fed TMR with yeast and 6g inclusion level of enzyme. Rams fed TMR without yeast and 6g/kg inclusion level of enzyme had highest cost/kg gain (₦ 491.88) while rams fed TMR with yeast and 4g/kg inclusion level had the least cost/kg gain (₦ 418.82). The value of gain decreases with increase in inclusion level of enzyme in TMR with yeast. However, income incurred over cost was increased by 35% in rams TMR with yeast and 4g/kg inclusion level of enzyme. Rams fed TMRwith yeast and 4g/kg inclusion level of enzyme had higher income (₦1523.4) followed by rams fed TMR with yeast and 2g/kg inclusion level (₦1510.70), followed by rams fed TMR with yeast and 6g/kg inclusion level of enzyme (₦1319.4), while least income incurred (₦1210.2, ₦1164.3 and ₦986.0) was recorded in rams fed TMR without yeast and 2, 4 and 6g/kg respectively.

Table 4.27: Interaction effect of yeast and inclusion levels of enzyme in urea treated bagasse based TMR on cost benefit

	WY			TY			
Parameter	**2**	**4**	**6**	**2**	**4**	**6**	**SEM**
TWG (kg)	4.12^{ab}	3.75^{b}	3.82^{ab}	4.65^{a}	4.60^{ab}	4.52^{ab}	0.39
ADG (g)	45.83^{ab}	46.66^{ab}	42.50^{b}	51.66^{a}	51.11^{a}	50.27^{a}	4.38
TFI (kg)	58.20	49.20	54.15	51.75	48.90	51.00	5.00
TCF (₦)	1879.80	1648.20	1879.00	1976.80	1926.60	2070.60	171.60
Cost/kg gain (₦)	456.26	439.52	491.88	425.11	418.82	458.09	46.48
Value of gain (₦)	3090.00	2812.50	2865.00	3487.50	3450.00	3390.00	297.70
Net Income(₦)	1210.20	1164.3	986.00	1510.70	1523.4	1319.4	282.30

TWG=Total weight gain, ADG=Average daily gain, TFI=Total feed intake, TFC=Total cost of feed
SEM=Standard Error of Mean

CHAPTER FIVE

5.0 DISCUSSIONS

5.1 EXPERIMENT I

5.1.1 Chemical composition of bagasse

The chemical composition of both untreated and urea treated bagasse obtained in this study indicated that urea treatment increased the CP of the bagasse up to 74% from 2.84% in the untreated to 11.25% after treatment. This result obtained is lower but similar to the results obtained by Mijinyawa (2016) who reported an increase in CP from 2.69% in the untreated bagasse to 12.31% in urea treated bagasse. Moreover, Ngele (2008), also reported an increase in CP from 4.4% in untreated rice straw to 12.4% in urea treated rice straw. In the same vein, Abdu *et al.* (2012) treated maize Stover with urea and reported an increase in CP from 8.75% in the untreated to 14.38% after urea treatment. Urea is one of the commonest chemical used to improve the nutritive value of crop residues, it is cheap and has practical application to small holder farmers (Ehoche, 2002).

5.1.2: Effect of inclusion levels of yeast in urea treated bagasse based TMR on performance of Yankasa rams

Feed intake obtained in this study was affected by inclusion levels of yeast in diets of Yankasa rams, it increases with an increase in the inclusion level of yeast. This was in conformity with the report of Khadem *et al*. (2007) that addition of *Saccharomyces cerevisiae* (SC) at levels 2.5, 5 and 7.5g in a TMR increases the amount of feed consumed. Also, Robinson (2002) established similar result, although small improvements in dry matter intake. This increase in feed intake may be associated with the addition of yeast which stimulated the rate of degradation of solid feeds in the rumen within the first 6 to 8 hrs after the meal(Pedro*et al*., 2015).Therefore, the animals can ingest more dry matter to fill their digestive compartment at the same level and this physical regulation could be involved to explain the higher feed intake in rams fed TMR with increased inclusion level of yeast.

Average daily gain observed in this study (37.76-45.56g/d) was lower than the values of 68.43-95.11g/day reported by Bello (2017) who fed different treated groundnut shell to Yankasa rams, 63.61-68.88g/d reported by Hanwa (2016) who also fed different groundnut haulms to Yankasa rams and 80.26-88.57g/d for sheep fed groundnut hay based blocks supplemented with *Saccharomyces cerevisiae*(Garg *et al*., 2009). However, it was higher than the values of 28 to 47g/d reported by Lamidi *et al.* (1998) for Yankasa sheep fed graded levels of *Ficus thonnigii* leaves as replacement for fresh *Hyparrhenia rufa,* 24.27-37.78g/d reported by Yashim (2014) who fed inclusion levels of *Ficus sycomorus* leaf meal in concentrate diet to Yankasa rams offered*Digitaria smutsii* hay as basal diet. Rams fed 7g inclusion level of yeast had the higher average daily gain compared to those in other treatment, this variation may be attributed to the rich source of B-complex, protein and minerals in the yeast (Kowalik, *et al.*,2011). Also, this result is in agreement with Fadel Elseed and Abusamra (2007) who reported that Nubian goat kids had lower average daily gain than those supplemented with 2.5 and 5g/d inclusion level of yeast. The differences observed with previous findings may be associated to the differences in the strain of yeast and level of inclusion in the diets.

5.1.3: Effect of inclusion levels of yeast in urea treated bagasse based TMR on nutrient digestibility by Yankasa rams

A significant difference in apparent digestibility coefficients of DM, OM, ADF, NDF and ADL across the inclusion levels was observed in this study. This may however be attributed to the addition of yeast since Kamel *et al*. (2000) reported similar findings that addition of yeast in the diet of sheep resulted in the stimulation and proliferation of rumen micro-organism which in turn enhanced of cell wall digestion. Also,yeast offers several important nutritional benefits such as naturally high levels of protein, a wide array of amino acids, a high concentration of the B vitamins and several minerals necessary for maintaining healthy

animals (Habeeb*et al*., 2017).It has also been reported that yeast produces enzymes which assist animal digestion as well as nutrients which stimulate digestive bacteria found in the gut. and yeast also improved digestion by providing the digestive enzymes amylase for starch digestion, protease for protein digestion, lipase for fat digestion and cellulase for butterfat synthesis (Kowalik*et al*., 2011).This is in line with the work of Gafaar *et al*. (2009) who observed that yeast supplementation increased digestibility of DM, OM, CP, NDF and ADF of tomato pomace where the gross digestibility derived from the supplementation was superior for 4g yeast inclusion compared to the control group. Moreover, Fadel Elseed and Abusamra (2007) observed that yeast supplementation increased OMD and NDFD by Nubian goat kids fed sorghum hay supplemented with 2.5 and 5g of *saccharomyces cerevisiae.*

5.1.4:Effect of inclusion levels of yeast in urea treated bagasse based TMR on nitrogen balance by Yankasa rams

Rams fed TMR with 7g inclusion level of yeast had higher nitrogen intake, nitrogen absorbed, nitrogen retained and percent retention compared to rams fed TMR with no yeast inclusion level.Nitrogen balance was positive for rams on all the treatments. This indicates that all the nitrogen absorbed was well tolerated and utilized, however, the lower level of nitrogen retained on diets containing no yeast and 5g inclusion level of yeast may be due to the presence of urea being hydrolysed into ammonia more rapidly than the ammonia could be fixed into microbial protein. This could account for the greater urinary N loss and the higher blood urea nitrogen in Rams fed TMR with no yeast and 5ginclusion levels of yeast.

Nitrogen retention is a major indicator used to assess the protein nutrition status of ruminant livestock (Abdu *et al*., 2012). Increase in nitrogen absorbed and retained as percentage intake in rams fed TMR containing both 7g and 6g inclusion levels was in agreement with the report

of Sawar*et al*. (2005)that nitrogen retention depends on good digestibility of nutrients and / or utilization. In some cases, this effect is sufficient to maintain an adequate N balance.

5.1.5:Effect of inclusion levels of yeast in urea treated bagasse based TMR on rumen indices of Yankasa rams

The pH values obtained in this study increases with an increase in yeast supplementation. This is however in line with the report of Callaway and Martin (1997), who reported higher pH, increase number of cellulolytic and lactate utilizing bacteria in the rumen as the observed benefits of supplementing yeast. Ruminal pH is an important factor that measure the acidity and alkalinity of rumen content in ruminants and for optimum rumen microbial fermentation. Therefore, the pH values recorded in this study is in agreement with the findings of Osinowo *et al*. (1994) who reported that for optimum rumen microbial fermentation, the pH should range between 6.00-7.00.

Ammonia Nitrogen(NH_3–N) needs to be adequate for proper forage digestion, the NH_3-N concentration in the rumen fluid obtained in this study were comparable with the findings of Yusuf *et al*. (2013). The author reported that ruminal NH_3–N concentration above 20mg/100ml is required for sufficient voluntary intake of low-quality roughage. Moreover, the results were also in consonance with the reported values of 20.08-36mg/100ml (Yashim 2014) when the author fed different inclusion levels of *Ficus sycomorus* leaf meal to Yankasa rams.

The linear increase in the TVFA concentration in the present study may probably be due to increase in the concentration of ammonia in the rumen. Galip (2006) reported that when *saccharomyces cerevisiae* was added to the forage enriched ration, TVFA tends to significantly ($P<0.05$) increased from 91.26 to 103.34mmol/l in the control and 2.5g yeast inclusion respectively. However, the values obtained in this study were higher than the values

of 14.0-14.60Mmol/L reported by Bello (2017) in Yankasa rams offered treated groundnut shell. The increase in total volatile fatty acid noticed across the treatment means is an indication that the microbes in the rumen of the rams had enough time to act on the feed thereby producing TVFAs. The increase in TVFA may also be attributed to the increase in cellulose digestion due to addition of yeast as it is the building block for protein, fat and vitamins synthesis necessary to allow for the increase in weight gain and feed efficiency (Habeeb, 2017).

5.1.6: Effect of inclusion levels of yeast in urea treated bagasse based TMR on blood serum indices of Yankasa rams

Total protein, blood urea nitrogen and creatinine measured were similar across treatment groups but total glucose differed significantly ($P<0.05$) with increase in inclusion levels of yeast. The result obtained in the present study is in agreement with the findings of Milewski and Sobiech (2009). The authors reported that dietary supplementation of dried yeast caused an increase in the concentrations of blood glucose. These results are consistent with the findings of Lesmeister *et al*. (2004).The authors showed that addition of *Saccharomyces cerevisiae* significantly increased the production of propionic acid, the main substrate for glucose synthesis in ruminants. The higher blood glucose concentrations in ewes fed supplemental dried yeast could be related to the elevated concentrations of mannan oligosaccharide which are precursor of VFA and stimulate an increase in energy metabolism parameters. However, the values of total glucose, blood urea nitrogen, blood glucose and creatinine reported in this study were within the normal range of (6-7.9g/dl, 10-30mg/dl, 50-80mg/dl, and 1-2mg/dl respectively) (Margi 1995). However, the values are lower to the values of 14.0-21.4g/dl reported by Aliyu *et al*. (2012) when the author fed urea and poultry treated kyasuwa to Yankasa rams.

5.1.7: Effect of inclusion levels of yeast in urea treated bagasse based TMR on methane production by Yankasa rams

The reduction in the level of methane produced by Yankasa rams as yeast increased could be associated with the increase in the yeast content in the TMR which resulted in changes in the microbial ecosystem. The *S. cerevisiae* might have stimulated the growth of acetogenic bacteria capable of using metabolic hydrogen (H_2) in the rumen, thus diverting H_2 from methanogenesis. It has been reported that, addition of yeast in diets of ruminants reduces the level of methane production through reducing protozoa numbers or by increasing butyrate or propionate production and or by promoting acetogenesis (Newbold *et al*., 1998). The result obtained in the present study agrees with the work of Mwenya *et al*. (2004) who reported that sheep fed 70:30 forage: concentrate diet produced 10 percent less methane when received daily 4 g of a yeast culture (*Trichosporom sericeum* containing 1.2–2.3× 10^7 CFU/g). Contrastingly, Lila *et al*. (2004) reported no effect of twin-strains of *S. cerevisiae* (0.33– 1.32 g / L – 5 x 10^9 live cells /g) on in vitro methane output when co-incubated with sudan grass hay and concentrate (1.5: 1) and McGinn *et al*. (2004) also concluded that *S. cerevisiae* (4.0 g /day and 1.0 g /day) had no effect on methane emission in cattle offered barley silage.These variations can be partly explained by the differences in experimental conditions viz., yeast strains, formats - live culture or freeze-dried preparation, dose, animal species, physiological state of animals and diets (Patra, 2012).

5.1.8 Effect of inclusion levels of yeast in urea treated bagasse based TMR on economic benefits

Increasing the inclusion levels of yeast in bagasse based TMR significantly improved total weight gain which invariably increased the value of gain and income incurred over cost of production. The increase in net income can be associated to the higher weight gains by rams fed 7g/kg inclusion level of yeast which resulted in an increased value of gain as such higher net benefit. This finding is consistent with the report of Ahiwe *et al*. (2015) when the author fed diets containing royal yeast additive to broilers at 5g/kg and reported an improved performance with higher economic gains. Moreover, results obtained in this study is in harmony with the report of Gafaar *et al*. (2009) and Mijinyawa *et al*. (2016) when the authors fed concentrate (40): roughage (60) mixture containing 15g/head/day baker's yeast supplementation and treated or untreated sugarcane bagasse with or without enzyme supplementation and reported an increased milk yield, feed conversion and economic efficiency and higher net benefit respectively for lactating buffaloes and Red Sokoto bucks.

5.2 EXPERIMENT II

5.2.1: Effect of yeast supplementation in urea treated bagasse based TMR onperformance of Yankasa rams

The significant difference observed in the present study in feed intake, total weight gain and average daily gain implies that yeast supplementation at 5g/kg inclusion level had effect on the performance of Yankasa rams than the unsupplemented group of rams. This may be

attributed to the rich source of B complex; protein and minerals present in the yeast. Garg *et al*. (2009), reported similar result with an increase in DMI from 72.13 to 74.33k/kg$W^{0.75}$ for sheep fed un-supplemented ground nut hay-based block and those fed same diet supplemented with yeast respectively. Moreover, ADG was also reported to be significantly higher (88.75g) as compared to un-supplemented group (80.26g). This finding is in contrast to the report of Macedo *et al*. (2006) who reported a non-significant difference between yeast addition and control in sheep on intake and average daily gain. This difference observed might be as a result of the different strain of yeast used, the yeast product itself either in the dried form of fermented form and also method of application.

5.2.2: Effect of inclusion levels of enzyme in urea treated bagasse based TMR on performance of Yankasa rams

The non-significant difference observed across all performance parameters measured implies that increasing the inclusion levels of enzyme did not affect the performance of the rams. However slightly higher values which were not significantly different from other groups were obtained in rams fed 2g inclusions levels of enzyme. This is however the recommended inclusion level by the manufacturer which agrees with the present study. This resultobtained is in line with the report of Kung *et al*. (2000), the author offered forage (60% corn silage and 40% Lucerne hay; DM basis) treated with increasing levels (0, 1, 2.5 mL/kg of TMR) of an enzyme product (Finn Feeds Int.) to cows and reported that, cows fed the low level of enzyme tends to produce more milk (39.5 kg/d)thanthosefedthecontroldiet(37.0kg/d)orthose fed the high level of enzyme (36.2 kg/d).

5.2.3: Interaction effect of yeast and inclusion levels of enzyme in bagasse based TMR on performance of Yankasa rams

Total feed intake, weight gain and average daily gain increases with yeast supplementation and an increase in the inclusion of enzyme in TMR. The possible reason for this increase is the synergy between yeast and enzyme supplementation which implies that adding yeast in urea treated bagasse based TMR and subsequent addition of enzyme at 2, 4 and 6g/kg improved the availability of soluble carbohydrate, adequate nutrient digestion leading to better nutrient utilization by the animals. Moreover, coupled with the activity of the enzymes which caused structural changes to occur, thereby making feed more amenable to degradation as cell wall hydrolysis in the rumen proceeds in an erosive manner causing the release of soluble carbohydrates. The values of average daily gain obtained in this study were lower than 86.31-110.12g/d reported by Ashiru *et al*. (2017) when Yankasa sheep were fed complete ration containing inclusion levels of ensiled sugarcane waste with poultry litter but higher than the values 28 to 47g/d reported by Lamidi *et al*. (1998) for Yankasa sheep fed graded levels of *Ficus thonnigii* leaves as replacement for fresh *Hyparrhenia rufa*.and similar to the values of 5.29-53.75g/d reported by Musa, (2016), for Yankasa rams fed cowpea haulms as supplements at different levels and frequency to a basal diet of sorghum stover.

5.2.4: Effect of yeast supplementation in urea treated bagasse based TMR on nutrient digestibility by Yankasa rams

All apparent nutrient digestibility coefficient parameters measured were similar between the treatment group but relatively higher values were obtained in rams fed TMR with yeast except for CP digestibility which was significant ($P<0.05$). The addition of yeast offers several important nutritional benefits such as naturally high levels of protein, a wide array of amino acids, a high concentration of the B vitamins and several minerals necessary for maintaining healthy animals (Habeeb*et al*., 2017). The increase in CP and other nutrient digestibility is in harmony with earlier reports of Journy,(2001); Galip, (2006). These authors have demonstrated that yeast supplementation can greatly influence digestive processes.

Also, EL-Ashry *et al*. (2001) reported that addition of yeast to the buffaloes' calves diet improved the digestibility coefficient of OM, DM, CP, EE and NFE.

5.2.5: Effect of inclusion level of enzyme in urea treated bagasse based TMR on nutrient digestibility by Yankasa rams

The inclusion levels of enzyme in urea treated bagasse based TMR on nutrient digestibility shows significant effect across parameters measured, a non-linear variation was recorded as the inclusion level increase. This may however be as a result of the enzyme level present in the TMR. Applicationofamoderate level of enzyme to ruminant feeds caused some beneficial disruption of the surface structure of the feed either before or after ingestion. When excess enzymewasapplied,thebeneficialdisruptionofthefeed surface structure may have diminished because the excess exogenous enzyme attached to feed may have restricted microbial attachment and limited digestion of feed (Nsereko *et al*., 2002).

5.2.6: Interaction effect of yeast and inclusion levels of enzyme in urea treated bagasse based TMR on nutrient digestibility by Yankasa rams

A non-linear or quadratic response was recorded across all the nutrient digestibility parameters measured. Higher digestibility coefficients were obtained for rams fed either TMR with no yeast and low level of enzyme supplementation or TMR with yeast and low level of enzyme supplementation. These differences could be attributed to the excessive enzyme addition in the TMR and this could be explained by the increase in weight gain and ADG reported in rams fed lower level of enzyme. This is in consistent with the report of Beauchemin *et al*. (1995) and kung *et al* (2000) who authors reported a non-linear response in nutrient digestibility parameters of steers fed alfalfa hay and forage (60% corn silage and

40% Lucerne hay; DM basis) treated with increasing levels (0, 1, 2.5 mL/kg of TMR) of an enzyme product respectively.

5.2.7: Effect of yeast supplementation in urea treated bagasse based TMR on nitrogen balance by Yankasa rams

Nitrogen balance was positive for rams on all the treatments. This indicates that all the nitrogen absorbed was well tolerated and utilized effectively, however, the lower level of nitrogen retained on diets containing no yeast may be due to the presence of urea being hydrolysed into ammonia more rapidly than the ammonia could be fixed into microbial protein. This could account for the greater urinary N loss and the higher blood urea nitrogen in Rams fed TMR with no yeast.

Nitrogen retention is used to assess the protein nutrition status of ruminant livestock (Abdu *et al*., 2012). Increase in nitrogen absorbed and retained as percentage intake in rams fed TMR with yeast could be attributed to the good digestibility of nutrients and or utilization by the rams which was supported by the findings of Sawar*et al*. (2005).

5.2.8: Effect of inclusion level of enzyme in urea treated bagasse based TMR on nitrogen balance by Yankasa rams

The increase in nitrogen retention and nitrogen retained as percentage of intake as the enzyme level increased most likely resulted from the better intestinal digestion and utilization of the nutrients contained in the diet containing enzyme. Nitrogen retention recorded in the present study was higher than the values (6.54-9.79g/d) reported by Mijinyawa *et al*. (2016) but percentage nitrogen retention was lower to the values (78.17-83.31%) reported earlier by Mijinyawa *et al*. (2016). However, positive nitrogen retention was obtained across all treatment groups.These variations can be partly explained by the differences in experimental

conditions viz., type of additive, dose, animal species, physiological state of animals and diets (Patra, 2012).

5.2.9: Interaction effect of yeast and inclusion levels of enzyme in urea treated bagasse based TMR on nitrogen balance by Yankasa rams

The significant difference observed in nitrogen intake, nitrogen balance, nitrogen retention and percentage of nitrogen retention in this study could suggest that rams fed TMR with yeast and higher level of enzyme inclusion had better utilization. This may be as a result of the synergy between yeast and enzyme which aid nutrient digestion and proving adequate surface area of attachment of enzyme to substrate. This can be much explained with the translated higher weight gains and average daily gain recorded in rams fed TMR with yeast. Nitrogen retention recorded in this study was lower than the values of (18.05-26.09g/d) reported by Yashim (2014),when rams were fed various inclusion levels of *F. sycomorus* leaf meal. The differences observed with previous findings might be associated to thetype of additive and compositions of the experimental diets.

5.2.10: Effect of yeast supplementation in urea treated bagasse based TMR on rumen indices of Yankasa rams

The variation observed in pH, NH_3-N and TVFA in the present study is associated with the effect of yeast supplementation. This is in consistent with the report of Marden *et al*. (2008). The authors have documented that yeast addition stabilizes pH and reduce the risk of acidosis.

As earlier reported, an increase in NH_3-N is accompanied by an increase in TVFA (Galip, 2006). The increase in TVFA recorded in the present study may be attributed to the increase in cellulose digestion due to addition of yeast as it is the building block for protein, fat and

vitamins synthesis necessary to allow for the increase in weight gain and feed efficiency (Habeeb, 2017).

5.2.11: Effect of inclusion level of enzyme in urea treated bagasse based TMR on rumen indices of Yankasa rams

Different inclusion levels of enzyme did not affect the rumen pH, however, significant differences were observed in NH_3-N and TVFA production with an increase in the inclusion level. A non liner response was recorded. Rams fed TMR with lower inclusion level (2g/kg) had the highest NH_3-N and TVFA production. The effect of this can be explained better with the increase in weight gain and average daily gain recorded in rams fed TMR with lower inclusions levels. This suggest that 2g inclusion level is the adequate inclusion level of the enzyme used in this study which is also the manufacture's recommended level of inclusion. TVFA's values obtained in this study is higher than the values of (13.14-14.56mmol/l) and (13.78-14.33mmol/l) reported by Yashim(2014) and Bello (2017) but similar to 28.8-56.8 Mmol/L reported by Adamu (2015). This can also be explained by the action of enzymes results in subtle changes to the cell wall structure and facilitates microbial access to the cell contents, as a result the N located in these structures might be exposed and digested with better extent (Colombatto *et al*., 2003). The improvement of protein digestion by enzymes has also been reported by various authors (Colombatto *et al*., 2003, Pinos-Rodriguez *et al*., 2002, Pinos-Rodriguez *et al*., 2008).

5.2.12 Interaction effect of yeast and inclusion levels of enzyme in urea treated bagasse based TMR on rumen indices of Yankasa rams

Supplementing TMR with yeast and adding enzyme varies significantly (P<0.05) across pH, NH_3-N and TVFA. The differences observed may be attributed to the synergy in action between yeast and low level of enzyme supplementation in enhancing efficient energy utilization (Gafaar *et al*., 2009) and adequate fibre digestion due to the presence of adequate amount of enzyme (Nsereko *et al*., 2002). However, the pH values obtained in the present study fell within the range of 6.0-7.0 reported by Osinowo *et al*. (1994) as the required pH level for optimum rumen microbial fermentation. NH_3-N concentration reported in this study were comparable with the findings of Yusuf *et al*. (2013). The author reported that ruminal NH_3–N concentration above 20mg/100ml is required for sufficient voluntary intake of low quality roughage. Moreover, the results were also in cognisance with the reported values of 20.08-36mg/100ml reported by Yashim (2014) when the author fed different inclusion levels of *Ficus sycomorus* leaf meal to Yankasa rams.The increase in TVFA in the ruminal fluid of Rams receiving the enzyme and yeast compared to those on enzyme only may be an evidence of their beneficial impact on the degree of degradation of starch and NDF of feeding ration.

5.2.13: Effect of yeast supplementation in urea treated bagasse based TMR on blood serum indices of Yankasa rams

The significant (P<0.05) difference observed in all the parameters measured implies that yeast supplementation have effect on blood serum indices of Yankasa rams. Rams fed TMR with yeast had higher TP, BUN, and blood glucose. This may be associated with the presence of yeast in the TMR which resulted in an increase in the production of propionic acid, which is the main substrate for glucose synthesis in ruminants and also an increase in the concentrations of mannan oligosaccharide which are precursor of VFA that stimulate an increase in energy metabolism parameters leading to higher blood glucose level. The results obtained is in consistent with the report of Lesmeister *et al*. (2004). However, the values of total glucose, blood urea nitrogen, blood glucose and creatinine reported in this study were

within the normal range (6-7.9g/dl, 10-30mg/dl, 50-80mg/dl, and 1-2mg/dl respectively) (Margi 1995).

5.2.14: Effect of inclusion level of enzyme in urea treated bagasse based TMR on blood serum indices of Yankasa rams

Significant ($P<0.05$) differences was observed in total protein and this may be attributed to the higher levels of total proteins across the treatments group which might have been resulted from the high plane of nutrition resulting to higher levels of protein digestion and absorption in the blood. The high creatinine levels obtained from rams fed TMR with lower level of enzyme is an indication of poor protein and amino acid metabolism which can lead to impaired renal function and cardiac infarction. However, such incidence was not recorded in the present study. The blood glucose obtained in this study is lower than the findings of Garba and Abubakar (2012) when the authors fed graded levels of *Tamarindus indica* leaves to Yankasa Rams and reported values of 75.0-100.0mmol/l and higher to the values (66.3-68.9mg/dl) Mijinyawa (2016) when the author fed treated or untreated bagasse with or without enzyme supplementation to red Sokoto bucks.

5.2.15: Interaction effect of yeast and inclusion levels of enzyme in urea treated bagasse based TMR on blood serum indices of Yankasa rams

Supplementing TMR with yeast and addition of enzyme had effect on blood serum indices of Yankasa rams. A quadratic response was recorded as a result of yeast supplementation and as the enzyme level increases. This implies that supplementing urea treated bagasse based TMR with yeast and with lowest inclusion level of enzyme is adequate for normal body functions. The effect of these is translated in the higher digestibility values, increased TVFA's,

increased weight and ADWG.The concentration of BUN is regulated not only by renal excretion but also by the quantity of protein consumed and /or ruminally degradable protein, provided that there is enough energy for the microorganisms in the rumen (Castelli *et al*., 1993). Mean values of total protein, blood glucose, and blood urea nitrogen and creatinine reported in this study were within the normal range of 6-7.9g/dl, 10-30mg/dl, 50-80mg/dl, and 1-2mg/dl respectively (Margi, 1995). However, the values of blood glucose reported in this study is lower to the values of 75.0-100.0mg/dl but similar to the values of 66.3-68.9mg/dl reported by Mijinyawa (2016)when the author fed treated or untreated bagasse with or without enzyme supplementation to red Sokoto bucks.

5.2.16:Effect of yeast supplementation in urea treated bagasse based TMR on methane production by Yankasa rams

The differences observed as a result of with and without yeast supplementation could be attributed to the presence of yeast which stabilizes the rumen environment and favouring the growth of cellulolytic bacteria instead of methanogenic bacteria. This is consistent with the findings of Hristov *et al*. (2013) who mentioned that the stimulation of microbial synthesis by live yeast, particularly S. *cerevisiae* has the chance to decrease CH_4 production. It has been reported that, addition of yeast in diets of ruminant animals reduces the level of methane production through reducing protozoa numbers or by increasing butyrate or propionate production and or by promoting acetogenesis (Newbold *et al*., 1998).

5.2.17:Effect of inclusion level of enzyme in urea treated bagasse based TMR on methane production by Yankasa rams

The non-significant difference recorded with respect to the models tested implies that increasing the levels of enzyme did not affect the level of methane produced by Yankasa rams. However, the reduction in the quantity of methane recorded in rams fed TMR with

lower inclusion level of enzymes can infer that the lower level of enzyme supplementation is the adequate or needed level to improve fiber degradation and digestion, this action typically decreases the acetate: propionate ratio in rumen fluid (Eun and Beauchemin, 2007), which is thought to be the primary mechanism whereby enzymes decrease CH_4 production.

5.2.18: Interaction effect of yeast and inclusion levels of enzyme in urea treated bagasse based TMR on methane production by Yankasa rams

The non-significant difference observed suggests that TMR with or without yeast supplementation and varying levels of enzyme did not affect methane production. However, the lower quantity of methane estimated across all models tested may infer that dietary substrate affects the amount of CH_4 produced (Beauchemin *et al*., 2008) due to changes in ruminal pH and microbiota present (Johnson and Johnson, 1995). It may also suggest that the lower inclusion level is the required level for adequate fibre digestion leading to adecrease in the acetate: propionate ratio in rumen fluid (Eun and Beauchemin 2007). The effect of these can be seen to have translated into weight gain and average daily gain in the rams fed TMR with 2g inclusion level.

5.2.19:Effect of yeast supplementation in bagasse based TMR on cost benefit

The significant difference observed in total weight gain and average daily gain at the end of the study could be attributed to the addition of yeastin bagasse based TMR. Cost/kg gain, value of gain,and income incurredover cost of feed at the end of this study in rams fed TMR with yeast were less compared to those fed without yeast. This has proven that addition of yeast in the diets of Yankasa ramsismore viableeconomically for fattening Yankasa ramsas evident can be seen in higher weight gain obtained in rams in the same treatment. This report is in harmony with the work of Ahiwe *et al*. (2015) when the author fed diets containing royal

yeast additive to broilers at 5g/kg and reported an improved performance with higher economic gains.

5.2.20:Effect of inclusion level of enzyme in urea treated bagasse based TMR on cost benefit

As observed at the end of this study, increasing levels of enzyme in TMR had economic benefits as greater income was obtained in rams fed TMR with 4g/kg compared to rams fed 6g/kg inclusion level. This could be attributed to higher weight gains that resulted from feeding the animals with enzyme which in turn translated to higher value gain leading to better income. Increase in income reported in this study agrees with the report of Mijinyawa *et al*. (2016) who reported an increase in net benefit by fattening Red Sokoto bucks fed TMR with or without enzyme.

5.2.21:Interaction effect of yeast and inclusion level of enzyme in urea treated bagasse based TMR on cost benefit

Significant difference obtained at the end of this study in total weight gain and average daily gain may be attributed to possible synergy between yeast and enzyme supplementation. value of gain, and income incurredsuggests that supplementing diet with yeast and addition of enzyme (Fullzyme) at 2g/kg and 4g/kg will significantly increase weight gain and average daily gain which in turn will lead to higher value gain with higher net benefits and income. This is consistent with the findings of Mijinyawa *et al*. (2016) who reported an improved

performance and increasedcost benefit when the author fed urea treated sugarcane bagasse with or without enzyme to red Sokoto bucks.

CHAPTER SIX

6.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary

Two studies were conducted to evaluate the feeding value of urea treated sugarcane bagasse supplemented with yeast and enzyme in total mixed ration on growth and fattening performance of Yankasa rams. Twenty (20) rams were used in the first study and were allotted to four dietary treatments in completely randomised design. Commercial baker's yeast was included at the rate of 5, 6 and 7g/kg with no inclusion as control.While in the second study, twenty-four (24) rams were used and were allotted to dietary treatments in a 2×3 factorial arrangement in a completely randomized design. The diets were formulated to contain 14% crude protein and a commercial cocktail enzyme (fullzyme®) was included at the rate of 2,4 and 6g/kg while the yeast was included at 5g/kg.

The results showed that rams fed TMR with 7g inclusion level of yeast had higher weight gain, average daily gain and better feed conversion ratio. Apparent nutrient digestibility of DM, CP, ADF and ADL, TVFA and Blood Glucose were also higher in rams fed TMR with 7g inclusion level of yeast. Likewise, methane was reduced with increasing inclusion level of yeast.

Feed intake, weight gain and average daily gain of rams fed treated bagasse with yeast and enzyme supplementation were significantly higher compared to rams fed treated bagasse without yeast supplementation. Digestibility of nutrients and nitrogen balance follows similar pattern. Rumen metabolites, serum metabolites measured were within the normal range for rams. However, feed cost/kg gain was reduced for rams fed treated bagasse with enzyme with higher net benefits compared to rams fed bagasse without yeast. Therefore, the results obtained from this study showedthat addition of enzyme (Fullzyme®) at 2g inclusion level supplemented with yeast at 5g/kg inclusion level in bagasse based TMR can be used to enhance performance of Yankasa rams without adverse effect.

6.2 Conclusions

1. The growth performance of Yankasa rams was improved by 34% when (7g/kg) inclusion level of yeast was used.
2. Bagasse based TMR with yeast and enzyme supplementation had positive effect on growth performance, nutrient digestibility and nitrogen retention by Yankasa rams
3. Rumen indices and blood metabolites are not affected by yeast and enzyme supplementation
4. Methane production by Yankasa rams decrease with an increase in the level of yeast in TMR
5. Bagasse based TMR with yeast (5g/kg) and enzyme supplementation at 4g/kg is cost effective (₦418.82)

6.3 Recommendations

1. Yeast should be included in the diet of Yankasa rams at 7g/kg to improve performance.
2. Farmers should include enzyme (fullzyme®) in treated sugarcane bagasse at 2g/kg for better animal performance
3. Farmers can also combine Yeast at 5g/kg and enzyme (fullzyme®) at 2g/kg to increase performance and net income with a reduction in methane production.

4. Further research is also needed to explore the effect of treated bagasse with yeast and enzyme supplementation on reproductive performance of Yankasa rams.

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APPENDIX



Plate I sugarcane bagasse



Plate II Chopping of sugarcane bagasse



Plate II urea treatment of sugarcane bagasse



Plate IV Ensiling process of urea treated bagasse