Effects of Yeast (***Saccharomyces cerevisiae***) Supplement on Rumen Fermentation and NDF Digestion of Forage Sorghum (Abu 70) Hay in Goats

By

RANIA MOAWIA ABDELHALIM ABDELRAZIK ABUSAMRA

B.Sc ANIMAL PRODUCTION

UNIVERSITY OF GEZIRA (2000)

Supervisor

Dr. Abdel Nasir Mohammed Ahmed Fadel Elseed

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DEPARTMENT OF ANIMAL NUTRITION
FACULTY OF ANIMAL PRODUCTION
UNIVERSITY OF KHARTOUM

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DIDICATION

To the love of my life, Mother, Father and Brothers.

Rania

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ABSTRACT

Twelve male Nubian goats' kids fed a basal diet of Abu 70 hay were used to investigate the effect of yeast (*Saccharomyces cerevisiae*) supplementation (0, 2.5, 5 g/day) on feed intake, OM and NDF digestibility and rumen fermentation's end products (pH, ammonia-N and VFA) in a completely randomized design. Yeast supplementation resulted in a numerical increase in ruminal pH, ammonia-N concentration, and total VFA concentration, however, no significant ($P>0.05$) effects were observed among treatments. The yeast supplementation increased OMD by 12.1% and 10.1% and NDFD by 13.3% and 10.5% for 2.5 and 5 g/day yeast culture, respectively, compared with the control diet. Moreover, unsupplemented kids had lower ($P < 0.01$) ADG (5.5 g per day) than those with 2.5 and 5 g/day yeast supplement (20.8 and 16.3 g per day) respectively.

This study demonstrated that NDF digestibility, feed intake and therefore, the average daily gain of Abu 70 hay would be improved by yeast (*Saccharomyces cerevisiae*) supplement. However, both levels of yeast supplement have similar effects.

ملخص الأطروحة

فى تجربة ذات تصميم كامل العشوائية تمت تغذية عدد 12 من ذكور صغار الماعز النوبى على عليقة أساسية من دريس ابوسبعين لدراسة تأثير اضافة الخميرة (*Saccharomyces cerevisiae*) بمستويات مختلفة (صفر, 2.5 , 5جرام/ يوميا) على كمية الغذاء المتناول , المهضوم من المادة العضوية و الالياف الذائبة فى المنظفات المتعادلة (NDF) و نواتج عملية التخمر فى الكرش (الأس الهيدروجيني ,الأمونيا والأحماض الدهنية الطيارة).

أدت اضافة الخميرة الى زيادة رقمية ولكنها غير معنوية (P>0.05) فى مستوى الأس الهيدروجينى, الامونيا والاحماض الدهنية الطيارة الكلية مقارنة مع العليقة الشاهد.

اضافة الخميرة أظهرت زيادة معنوية (P<0.01) فى معدل المادة العضوية المهضومة بنسبة 12.1 - 10.1 % وNDF المهضوم بنسبة 13.3 - 0.5 1 % لمستويي الاضافة من الخميرة (2.5 و5 جرام يوميا) مقارنة بالعليقة الشاهد على التوالى. كما اظهرت النتائج متوسط زيادة وزنية يومية منخفضة (P < 0.05) لصغار الماعز ذات التغذية الخالية من الخميرة (5.5 جم يوميا) مقارنة بالزيادة الوزنية 20.8 و 16.3 جم يوميا للصغار المغذ ية على عليقة بمستويي الخميرة 2.5 و 5 جرام يوميا على التوالى.

هذة الدراسة اوضحت ان هضمية NDF ومتوسط الزيادة الوزنية اليومية والمادة المتناولة من دريس ابوسبعين قد زادت باضافة الخميرة (*Saccharomyces cerevisiae*) باى من المستويين بنفس القدر.

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CHAPTER ONE

INTRODUCTION

In Sudan ruminants which are estimated to be over 130 million heads of cattle, sheep, goats and camels (FAO, 2002) depends mainly on natural pasture and crop residues in addition to considerable quantities of irrigated forages which are available in irrigated areas. However, during the rainy season grasses provide sufficient feed supplies with a fair amount of essential nutrients which may reflect in good performance of animals. In dry season when grazing offers animals scattered grasses at its least palatable and poor feeding value agricultural residues and irrigated forages emerge as important available feed resources and comprise the entire diet because the energy and protein rich feed sources are expensive and their use in ruminant nutrition competes with monogastric and human nutrition.

When plant advances in age water soluble carbohydrates decreases and the ß-linked carbohydrates, associated with lignin, increases. Whoever, roughages contains considerable quantities of cellulose and hemi-cellulose which may average of 400g per kilogram dry matter in mature herbage (Mohammed and Salih, 1991). The ability of the ruminant to digest cellulose and the complex structural matter of the plant through the activity of the enormous population of microorganisms encourage use of roughages. The high cell wall content and the low crude protein content combine to make poor quality roughages and mature hay low digestible (Owen, 1994). Therefore, poor performance will be obtained on such diets.

Under the feeding of low quality agricultural residues, supply animal’s rumen microbes with the necessary nutrients needed allow the animal to maximize the usage of the low quality feed (Fadel Elseed, 2005). However, researchers in the field of ruminant nutrition had been interested in manipulating the ruminal ecosystem to increase production efficiency of ruminants. Manipulating rumen digestion system through the addition of direct feed microbial (DFM) and a fibrolytic enzyme to ruminant rations so as to enhance cellulose digestion and improves the performance of the animal is the most interest in recent years (Salama *et al*., 2002; Nocek *et al*., 2003; Giger-Reverdin *et al*.,2004; Haddad and Goussous, 2005; Kim *et al*.,2006). Addition of yeast into the diets increased the numbers of total viable bacteria by 30 to 80% concomitant with increases of cellulolytic bacteria by 50 to 188% (New bold *et al*., 1991). Even though the mode of action related to the increase of microbial numbers has not been elucidated ,it has been proposed that elimination of oxygen in the rumen by yeast culture (*Saccharomyces cerevisiae*) my increase bacterial viability by preventing toxic effect of oxygen on anaerobic bacteria (Martin *et al*., 1989). Feeding yeast culture to dairy cows on concentrates diet increased dry matter intake (DMI) (Kim *et al*., 2006), dry matter (DM) and neutral detergent fiber (NDF) digestion (Carro *et al*., 1992), decreased lactic acid production (Erasmus *et al*., 1992) milk yield (Robinson and Garrett, 1999). However, few studies address the effect of yeast (*Saccharomyces cerevisiae*) on cell-wall break down of roughages when fed as a sole diet.

Therefore, the objective of this study was to assess effect of yeast (*Saccharomyces cerevisiae*) supplementation on NDF digestibility and rumen fermentation's end products of poor quality hay fed as an only feed.

CHAPTER TWO

LITERATURE REVIEW

2.1 LIVE STOCK IN SUDAN:-

Livestock populations in Sudan are estimated to be over 120 million head of cattle, sheep, goats and camels (FAO, 2002). This huge number of animals owned mainly by nomads, with their seasonal migratory habits in search for water and pasture, and was expected to play an important role as a source of human food and growth domestic product. Livestock were mostly raised under open range grazing conditions, where tropical grasses are known for their early maturity, high cell wall constituents and low protein content, which had adversely effects on animal's reproductive and productivity performance.

Over the past twenty years, FAO (1997) Reported much more rapidly increasing in number of small ruminants in the developing countries than in the developed regions, this may well reflected to the particular ability of small ruminants to survive and produce on low cost feed, their adaptability to difficult and particular arid environments perhaps more than any thing else it reflects their suitability to the small farmers in developing countries.

2.2 FEEDS AVIALABLE TO LIVESTOCK:-

Feedstuffs are often classified as roughages and concentrates. Concentrates usually mean high quality low fiber feeds and include the cereal grains, milling by-products, protein sources, and fats. Concentrates have high digestible energy content per unit of weight or volume. The energy is derived mostly from starches, sugars, other readily available carbohydrates, and fats or oils. Roughages are characterized by being more fibrous (greater than 20 percent ADF) or bulky and generally represent the vegetative portion of a plant. The digestible energy content of roughages is usually lower per unit weight or volume than concentrates, with most of the energy derived from cellulose or hemi-cellulose.

2.2.1 ROUGHAGES:-

Roughages are bulky feeds high in lignocellulosic materials and low in energy, protein and other essential nutrients. Roughages in Sudan include pasture, irrigated forages and agricultural crop residues. The major component of forages and other fibrous feed was cellulose, the most abundant organic compound on earth with about 10^4 million tons synthesized by plants every year (Goodwin and Mercer, 1983), other components of the cell wall include hemi-cellulose, lignin and silica. Cellulose and lignin provide structural strength of the cell wall, while hemi cellulose is complex carbohydrates containing mixture of sugars. Tropical forages were higher the structural carbohydrates that related to their C_4 type of photosynthesis and the high proportion of the slowly digested vascular tissue and a low content of readily digested mesophyll cell (Akin , 1982).

High fiber content in ruminant diets may significantly increase heat load, and production of acetate which has a lower efficiency of utilization as compared to propionate or glucose, however, adequate fiber in the diet was essential to maintain rumen health (Leng, 1990).

2.2.2 CONCENTRATES:-

A concentrated feed is one that is high in protein or energy. It is a high quality and can be of plant or animal origin. The high energy concentrates include cereal grains and its milling by-products, industrial by-product like molasses and fats. However, protein concentrates include oilseed cakes, legumes grain and animal by-products. The primary limiting nutrients for production on most tropical feed resources are fermentable nitrogen, glucogenic precursors and bypass protein and dietary long chain fatty acids (Leng, 1993). Oilseed cakes, cereal milling byproducts and animal byproduct meals are the logical supplements when available. However, there are many situations where farmers do not have access to these supplements either because they are not locally available or are too expensive. Moreover, several kinds of animal and vegetable fats or oils are available for feeding. Amounts to feed and responses from feeding will vary with fatty acid (saturated or unsaturated) composition of the fat. Total added fat in diets should not exceed 4 percent (DM basis) to avoid its adverse effect on rumen fermentation and fiber digestion.

2.3 RUMEN MICROBIOLOGY AND FERMENTATION:-

Upon birth the digestive tracts of animals are naturally colonized by variety of micro-organisms, however, under healthy and non stressful conditions beneficial micro-flora colonize gut surfaces in symbiotic relationship with the host and undesirable microbes which may be pathogenic suppresses by beneficial gut microorganism (Savage, 1987).

The efficiency of Rumanians to utilize such a wide variety of feeds was due to highly diversified rumen microbial ecosystem consisting of bacteria (10^{10} - 10^{11} cell / ml) ciliate protozoa (10^{4} - 10^{6} / ml) and anaerobic fungi (10^{3} - 10^{5} zoospore/ ml). The synergism and antagonism among the different groups of microbes and even among different genera of the same group are so differs and complicates the net result of these reactions. Fermentation going on in the rumen by micro-organism is responsible for the bioconversion of feed into such form that is utilizable by the animal as a source of energy in form of short chain volatile fatty acid VFA, micro-organisms then pass through the omasum into the abomasum and thence the small intestine to supply the host animal with amino acids. The microbial ecosystem of the rumen is stable and at the same time dynamic , stable as it is will established and had been performing the function of bioconversion of feed into VFA , dynamic as the microbial population changed considerably on change of diet so as to adapted it to the new feed ingredients (Van Soest, 1982).

2.3.1 FIBER DIGESTION IN THE RUMEN:

The rumen is an environment with a diverse population of microorganisms. Bacteria and protozoa dominate the fermentation both in terms of numbers and metabolic processes. Of the bacteria present in the rumen, several general types of bacteria can be described based on metabolic functions. Amylolytic bacteria specialize in fermenting starch (from concentrates) while cellulolytic bacteria ferment fiber. Different populations of bacteria will dominate the rumen fermentation depending on the type of diet being fed. Animal fed diets solely of forage with high fiber will have a ruminal bacterial population that is high in cellulolytic bacteria. Simplistically, the fermentation of fiber results in the production of acetic acid that is used by the animal for energy and is the primary precursor of fat in milk. In contrast, digestion of sugars and starches yields propionic acid that is converted to glucose in the liver of the cow and used for energy (Van Soest, 1982).

The amount and size of fiber particles in the diets of animal is important to maintaining optimal rumen function. Long fiber in the rumen forms the rumen mat. The mat is where fibers are entangled because they are too long to pass to the lower gut. Fiber from the mat is regurgitated and chewed producing large amounts of saliva that naturally buffers the rumen. When large feed particles are chewed, the surface area for rumen bacteria to attach, and then digest the feed is increased. In order for a feed particle to pass out of the rumen and into the lower gut, it must attain a size of about 1-mm (Fadel Elseed *et al*., 2004). Passage of particles from the rumen is important because without digestion and passage, food would fill the rumen and depress intake. There must be a balance between retention time in the rumen for microbial digestion and passage. The normal process of particle size reduction in the rumen leads to increased surface area for microbial attachment and digestion.

Digestion of fiber in the rumen varies greatly and is dependent on a number of different factors. For example, lignin acts as intracellular cement that gives plant rigidity but unfortunately, it also has negative effects on fermentability.

The pH of the rumen has profound effects on the growth of rumen microbes and the digestion that takes place in this forestomach. A pH of 7 is considered neutral, where the amount of acid and base are equal. When pH falls below 7, we consider the medium to be acidic in nature. The lower the pH falls below 7, the more acidic it is. A number of different factors can affect ruminal pH. Lack of sufficient fiber or fiber that is chopped too finely, reduces chewing times and thus, reduces saliva production causing a decrease in ruminal pH. The ratio of forage: concentrate in the diet of lactating cows also affects ruminal pH. As concentrates increase in the diet, total acid production in the rumen increases, causing a decrease in pH. The type of concentrate can also affect ruminal pH as the starch in barley is more readily fermented to acids in the rumen than the starch from corn. Besides requiring carbon skeletons, ammonia-N and energy for growth, cellulotic bacteria in the rumen grow best when the pH of the rumen is between 6.2 and 6.8. If rumen pH falls below 6.0-6.2, fiber digestion in the rumen begins to decline. As rumen pH decreases, cellulolytic bacteria in the rumen become less active and fiber digestion is decreased. When ruminal pH falls below 5.8-5.9, the rumen is mildly acidic and fiber digestion in the rumen ceases completely. When ruminal pH drops below 5.2 to 5.5, animals can succumb to acidosis (Dawson and Allison, 1988). Because the digestion of fiber in the rumen leads to acetic acid production, and because acetic acid is a major precursor for milk fat, reduction in ruminal fiber digestion leads to a decrease in milk fat. Thus, any factor that helps to maintain ruminal pH above 6.0 is generally beneficial.

2.3.2 MANIPULATION OF RUMEN ENVIRONMENT:

Researchers in the field of ruminant nutrition have been interested in rumen ecosystem manipulation to increase production efficiency of ruminant. Supplementing the deficient nutrients, synchronized supply of energy and nitrogen to rumen micro-organism, fauna-free animals and growth promoters are some of the methods of manipulation of rumen environment to create an efficient ecosystem for fermentative digestion (Kim *et al*., 1999; Nhan *et al*., 2001). Growth promoters include anti-microbial agents, metabolic modifiers, probiotic or direct-fed microbial (DFM), enzymes and high available minerals.

2.4 PROBIOTICS AND PREBIOTICS:-

The use of microbial preparation had been largely based on empirical observations that some types of live micro-organisms in feeds may beneficially influence animal performance in many types of production systems (Wenk, 2000).

As the result of increasing public campaign against the use of the traditional growth promoting substances for livestock, probiotics and other non-traditional feed additives become viable alternatives.

Microbial feed supplements that beneficially affect the host by improving its intestinal microbial balance was generally called probiotics. However, the use of oligosaccharides derived from bacterial or yeast cultures are generally called prebiotics.

2.4.1 PROBIOTICS FUNCTION AND MECHANISM:

The goal of using probiotics and prebiotics (DFM) is to stimulate beneficial micro-organisms in the gastrointestinal tract on the one hand and on the other hand suppress Pathogens by competitive exclusion, and stimulate the growth of cellulose degraders and lactic acid utilizers in rumen. The consequence of increased number of cellulolytic bacteria might be the elevated concentration of VFA with the increased ratio of acetate to propionate. Furthermore, stimulation of NH_3 production by the mixed ruminal population through DFM addition suggests that DFM may enhance proteolysis in the rumen (Martin *et al*., 1989).

Probiotics ensure the establishment or re-establishment of healthy microbial population which prevents the growth of pathogens (Fuller, 1989), by competitive exclusion where the desirable microbes out compete the pathogens for either nutrients or colonization sites (Nurmi and Rantala, 1973) or by the production of metabolites which are inhibitory to the growth of adhesion of pathogen thus preventing their establishment in the gut (Blomberg *et al*., 1993). The metabolites can include short chain fatty acids which are either inhibitory to growth of many pathogens or lower the pH such that the pathogens grow poorly. In addition some Probiotics microbes have immune modulating properties, its effectiveness in stimulating beneficial effects in the ruminants most probably because as the yeast respires it consumes traces of oxygen thus allowing the more anaerobic rumen bacteria to develop.

2.4.2 DIRECT FED MICROBIAL (DFM)

Many micro-organisms like lactobacilli, fungal and yeast are used in the form of Probiotics or prebiotics in animal nutrition.

2.4.2.1 BACTERIAL DFM

In general, most would agree that DFM based on bacteria must be live thus, they must survive processing, storage and the gut environment. However, future research may prove that end products such as bacteriocins (narrow spectrum antimicrobial substances) and not the actual organism itself may be beneficial. *Lactobacillus acidophilus* (and other Lactobacillus species), *L. casei, Enterococcus diacetylactis*, and *Bacillus subtilis* are commonly used as DFM products for ruminants. These organisms appear to have little effect on ruminal fermentation (Ware *et. al*., 1988) and the site of action from these organisms appears to be in the lower gut but solid and repeatable data is lacking. Initial research with these organisms in ruminants was first centered on stressed animals with the general assumption that feeding beneficial organisms would decrease or prevent intestinal establishment of pathogenic microorganisms (Vandevoorde *et al*., 1991). In addition, it was hypothesized that massive doses of beneficial organisms would re-colonize a stressed intestinal environment and return gut function to normal more quickly. In ruminants, much of this research involved feeding *lactobacillus*-based DFM to young calves fed milk, calves being weaned or shipped cattle (Jenny *et al*., 1991; Hutcheson *et al*., 1980) because these conditions were often classified as times of high stress. Calves fed *L. acidophilus* have been reported to have reduced incidence of diarrhea (Beecham *et al*., 1977) and reduced counts of intestinal coliform bacteria (Bruce *et al*., 1979). Data summarizing more than 30 trials with incoming feedlot cattle showed an advantage of 10.7 and 5.4% in average daily gain and feed efficiency, respectively, for cattle fed a DFM (Pioneer Hi-Bred International, 1988). Only a few studies have documented positive effects of feeding bacterial DFM to lactating dairy cows. High producing cows in early lactation would be the best candidates for such products because these cows are in negative energy balance and have diets that contain highly fermentable carbohydrates that sometimes lead to acidosis. Jaquette *et al*. (1988) and Ware *et al*. (1988) reported increased milk production from cows fed *L. acidophilus* (1×10^9 colony-forming units per head per day).

2.4.2.2 FUNGAL DFM:

The two types of DFM receiving the most interest in recent years are yeast (*Saccharomyces cerevisiae*) culture and fungal (*Aspergillus oryzae*) fermentation extract. These yeast and fungi are known to produce enzymes such as amylases, proteases, lipases, and cellulases and also good source of B vitamins. Thus, one can assume that they may aid digestion and supply nutrients.

There was more extensive use of *Saccharomyces* and *Aspergillus oryzae* alone or together with lactic acid bacteria, these microbes had been shown to assist in the development of rumen structure. Arambel *et al*., (1987) reported that, *A. oryzae* dosage stimulates rumen development with higher counts of total, amylolytic, pectioloytic, cellulolytic and hemicellulolytic bacteria.

2.4.2.2.1 BAKER'S YEAST (*Saccharomyces Cervisiae*):

Several studies have demonstrated that not all yeast strains are equally capable of stimulating ruminal bacteria only 7 strains of over 50 strains tested had the ability to stimulate the growth of fiber digesting bacteria from the rumen, other studies suggest that few strains of yeast have the ability to stimulate both the beneficial digesting bacteria and the bacteria associated with lactate utilization (Newbold *et al*., 1996).

Very few species of yeast are used commercially e.g *Saccharomyces cerevisae* (SC), also known Bakers Yeast. It was widely commercialized species, Yeasts were facultative anaerobe which means that they can survive and grow with or without oxygen. The aerobic processes where the yeast converted oxygen and sugar through oxidative metabolism into carbon dioxide usable free energy for efficient yeast cell growth. An aerobic fermentation was much less efficient resulting in the form of ethyl alcohol, and carbon dioxide. There were variable yeast products, active dry yeast (95% DM), wet yeast (30% solids) and cream (18-20% solids) (Johnson, 1976).

Active dry yeast consists of pure dried yeast cells with viability counts ranging from 15-25 billion live yeasts cells or colony forming units (CFU) per gram (Stone, 1998).

Unlike active dry yeast, yeast culture products are defined as containing yeast and the media on which it was grown, they may also contain a Cartier such as rice hulls (Sniffen *et al*., 2004). The yeast cultures were complex fermented products content yeast and the metabolic by products produced by the yeast fermentation. Yeast cultures are not fed as a source of live yeast cell, but as a supplement to provide undefined fermentation factors which were recognized to simulate bacteria in the digestive tract (Stone, 1998).

The effects of specific yeast culture preparations on performance of ruminants have been well documented (Beharka *et al*., 1991; Yoon and Stern, 1996; Miller-Webster *et al*., 2002).

Yeast supplementation had been shown to increase ration palatability, which leads to increment in feed intake in concentrated diets (Bodine *et al*., 1999) and low quality forage supplemented with concentrate (McCollum and Horn, 1990). It also improved digestibility of ingredients, the rumen function and increased dry matter feed intake of concentrated diets in dairy cows (Wohlt *et al*., 1991; Shaver and Garrett, 1995; Dann *et al*., 2000).

In animals fed high energy diet yeast had ability to prevent the accumulation of lactic acid in the rumen and hence hinder the fall in rumen pH. Study by Dawson (2003) suggested that lower lactic acid concentrations were likely due to enhanced growth and activities of lactic acid utilizing bacteria in the rumen and were not a result of a direct inhibition of starch-digesting lactate producers

The effect of yeast culture on fiber digestion were highly variable with some authors recommending increases in the rate of fiber digestion within the rumen (Miranda *et al*., 1996) and others shows no changes in fiber digestibility (Yoon and Stern, 1996) .

Feeding low quality hay with other fiber or grain-based supplement containing adequate degradable protein maintained forage intake with no or only minimal changes in ruminal parameters were observed (Swartz *et al*., 1994; Yoon and Stern, 1996; Boding *et al*., 1999; Lynch and Martin, 2002).

A variety of mechanisms have been put forth to explain changes in ruminal fermentations and improvements in performance when ruminants are fed fungal-based DFM. For example, yeast may have a buffering effect in the rumen by mediating the sharp drops in rumen pH, which follows feeding. Martin and Streeter (1995) suggested that fungal cultures improve the use of lactate by the ruminal organism *Selenomonas ruminantium* by providing a source of dicarboxcylic acids (e.g., malic acid) and other growth factors. Thus, yeast may help to buffer excess lactic acid production when ruminants are fed high concentrate diets. The effects on buffering are subtle; as added yeast cannot prevent lactic acidosis if the rumen is challenged with a diet rich in fermentable carbohydrates (Aslan *et al*., 1995; Dawson and Hopkins, 1991). However, a higher pH may be one reason for the finding of increased numbers of rumen cellulolytic bacteria and improvements in fiber digestion with fungal cultures (Arambel *et al*., 1987). Newbold *et al*. (1995) reported that the stimulation of rumen bacteria by *Saccharomyces cerevisiae* different with specific strains. Yeast may also stimulate rumen fermentation by scavenging excess oxygen from the rumen (Newbold *et* *al*., 1996). They have also been shown to stimulate acetogenic bacteria in the presence of methanogens (Chaucheryas *et al*., 1995). The effect of fungal cultures on ruminal VFA has been inconsistent. Newbold (1995) reported that fungal extracts had no effect or tended to increase the rumen acetate:propionate ratios while active yeast either had no effect or decreased the acetate:propionate ratio. There is no direct evidence that yeast or fungal extracts affect digestion or metabolism in the lower gut.

However, the potential for such effects have not been well studied.

CHAPTER THREE

MATERIAL AND METHODS

3.1 ANIMALS, HOUSING AND DIET:

Twelve male Nubian goats' kids (about 3 months old; 10 kg average body weight) were used in this experiment. The animals were housed in individual pens (1m × 2 m). In the first day all kids were injected by Ivomic for internal parasite for 3 days, and dipped in Ciber solution for external parasite. Moreover, the pens were cleaned and disinfected by Ciber solution before the onset of the experiment. The animals offered Abu 70 hay (11.2% CP, 68.9% NDF, and 53.6% NDIP of total CP; on DM basis) once daily for *ad libitium* intake, with free access to water.

3.2 TREATMENTS AND EXPERIMENTAL DESIGN:

Animals assigned randomly to one of three different treatments with four animals per treatment following the completely randomized design. The animal on the different treatments received the same basal diet of Abu 70 hay and supplemented with 0, 2.5, 5 g/day yeast culture (*Saccharomyces cerevisiae*). Yeast culture (YC) was added to 5 g of wheat bran as inert material and 5 ml of molasses as appetizer and fed shortly before offering the basal diet.

3.3 *IN VIVO* STUDY:

Feed intake was recorded daily throughout the 72-day experimental period, after 12 days as adaptation period. From day 61 the animals were fitted with fecal-collection bags, the first two days for adaptation to bags followed by 8 days for total fecal collection. Orts and feces produced during the 8-day period were recorded every morning and were pooled for each animal with a fixed proportion of the total and then dried prior to analysis. The body weight of the animals was recorded at the beginning and the end of the experimental period.

For determination of ruminal ammonia–N (NH_3-N) and volatile fatty acid (VFA) concentration, ruminal fluid samples were delivered through esophageal stomach tube at 2-h interval for 6 hrs after morning meal on the last 2 days of the experimental period. Rumen fluid samples were strained through double layer cheesecloth and pH was immediately measured with a portable pH meter then the samples were acidified using concentrated H_2SO_4 to pH <3.0 and kept frozen prior to analysis.

3.4 Chemical Analysis:-

Feed and feces samples were analyzed for DM, OM, and N according to AOAC (1990). NDF and ADF were determined according to Robertson and Van Soest (1981). Total NH_3 -N and VFA were analyzed following Abdulrazak and Fujihara (1999).

3.5 Statistical Analysis:

Data were subjected to analysis of variance according to Steel and Torrie (1960). The comparison among means was analyzed by the least significant difference using LSD procedure of the Statisticx® (Analytical Software, 2000).

CHAPTER FOUR

RESULTS DISCUSSION AND CONCLUSION

All YC supplement was consumed within ten minutes throughout the experimental period.

4.1 RUMEN FERMENTATION:

YC resulted in a numerical increase in ruminal pH, ammonia-N concentration, and total VFA concentration, however, no significant effects were observed among treatments (Table 2) in agreement with results obtained by Yoon and Stern (1996) and Miller-Webster *et al.* (2002). Others (Harrison *et al.*, 1988; Williams and Newbold, 1990; Enjalbert *et al.*, 1999) have observed a reduction in ammonia concentration.

The lowest values of the diurnal changes in NH_3-N (Fig 1) observed before offering morning feed for all treatments, with the highest values 2 and 4 h after provision for control and YC supplement, respectively. Because neutral detergent insoluble protein (NDIP) represent 53.6% of total CP The enhancement in NDF digestion of YC supplemented diets may improve protein digestibility which could be attributed to the elevation in ruminal NH_3-N concentration at 4 and 6 h after yeast supplement (Fig. 1).

4.2 INTAKE, DIGESTIBILITY AND BW GAIN:

Table 2 presents means for digestible organic matter intake (DOMI), organic matter (OMD) and neutral detergent fiber digestibility (NDFD), and average daily gain (ADG). DOMI, OMD, NDFD, and ADG were significantly ($P<0.01$) influenced by adding YC at both concentrations to Abu 70 hay.

The YC improved OMD by 12.1% and 10.1% and NDFD by 13.3% and 10.5% for 2.5 and 5 g/day YC respectively, compared with the control diet. However, the effects of yeast culture on fiber digestion are highly variable, with some authors recording increases in fiber digestion of low quality forages (Plata *et al*., 1994; 1996; Miranda *et al*., 1996; Lynch and Martin, 2002), while others have recorded no effect (Avendano *et al*., 1995; Hadjipanayiotou *et a*l., 1997; Enjalbert *et al*., 1999). These inconsistent results might be partially attributed to effects of ration composition, types and amount of yeast culture used (Williams *et al*., 1991). Results from Roa *et al*. (1997) showed that quality of the forages affects NDF digestion response to yeast culture, with more benefits with good quality forages. Since the pH of all treatments in this study did not drop below 6.2, it appears that the effect on NDFD caused by YC might be explained by an increment in the number and activity of cellulolytic bacteria rather than via an effect on pH (Wallace, 1994; Koul *et al*., 1998).

The enhancement of DOMI by addition of yeast culture in the present study is consistent with the finding of Quigley *et al*. (1992); Lesmeister *et al*. (2004) with dairy calves, Kim *et al*. (2006); Dann *et al*. (2000) with dairy cows and Haddad and Goussous (2005) with lambs. Because fibrous components ferment and pass from the reticulo-rumen more slowly, they have greater filling effect over time (Allen, 1996) and therefore, the increment of NDF digestion may decreases rumen filling effect which led to enhancement in feed intake in the present study (Fadel Elseed *et al*., 2004).

Unsupplemented kids had lower ($P < 0.01$) ADG (5.5 g per day) than those with 2.5 and 5 g/day YC supplement (20.8 and 16.3 g per day) respectively. The increase in ADG observed in this study agrees with Huges (1988) and Lesmeister *et al*. (2004). The improved fiber digestion and, therefore, feed intake in response to supplemental YC may have served in stimulating a production response in term of ADG.

In conclusion, yeast culture supplementation can improve fiber digestion, feed intake and therefore enable animals, at least, to maintain weight during the dry season when offering forages as a sole diet.

Table 1. Intake, digestibility and daily weight gain of goat kids offered Abu 70 hay supplemented with yeast culture (0, 2.5 and 5 g/day *Saccharomyces cerevisiae*).

	Yeast supplement (g/day)			SEM	Significance level
	0	2.5	5		
BW gain g/day	**5.5**[b]	**20.8**[a]	**16.3**[a]	0.38	*
OMD (%)	**58.1**[b]	**70.2**[a]	**68.2**[a]	1.24	**
NDFD (%)	**52.9**[b]	**66.2**[a]	**63.4**[a]	1.55	**
DOMI g /kg BW$^{0.75}$	**30.8**[b]	**36.7**[a]	**36.1**[a]	1.28	**

[a-b]: Means with different superscript in the same row differ significantly.

* $P<0.05$.

** $P<0.01$.

SEM: Standard error of a mean.

Table 2. Rumen pH, VFA and NH_3-N of goat kids offered Abu 70 hay supplemented with yeast culture (0, 2.5 and 5 g/day *Saccharomyces cerevisiae*).

	Yeast supplement (g/day)			SEM	Significance level
	0	2.5	5		
pH[a]	**6.22**	**6.28**	**6.26**	**0.03**	**NS**
VFA (mmol/dl)[a]	**9.4**	**11.0**	**10.6**	**0.58**	**NS**
NH_3-N (mg/dl)[a]	**13.1**	**14.0**	**13.8**	**0.59**	**NS**

NS: P>0.05.
SEM: Standard error of a mean.
[a]Mean of all the 2h samples taken per day.

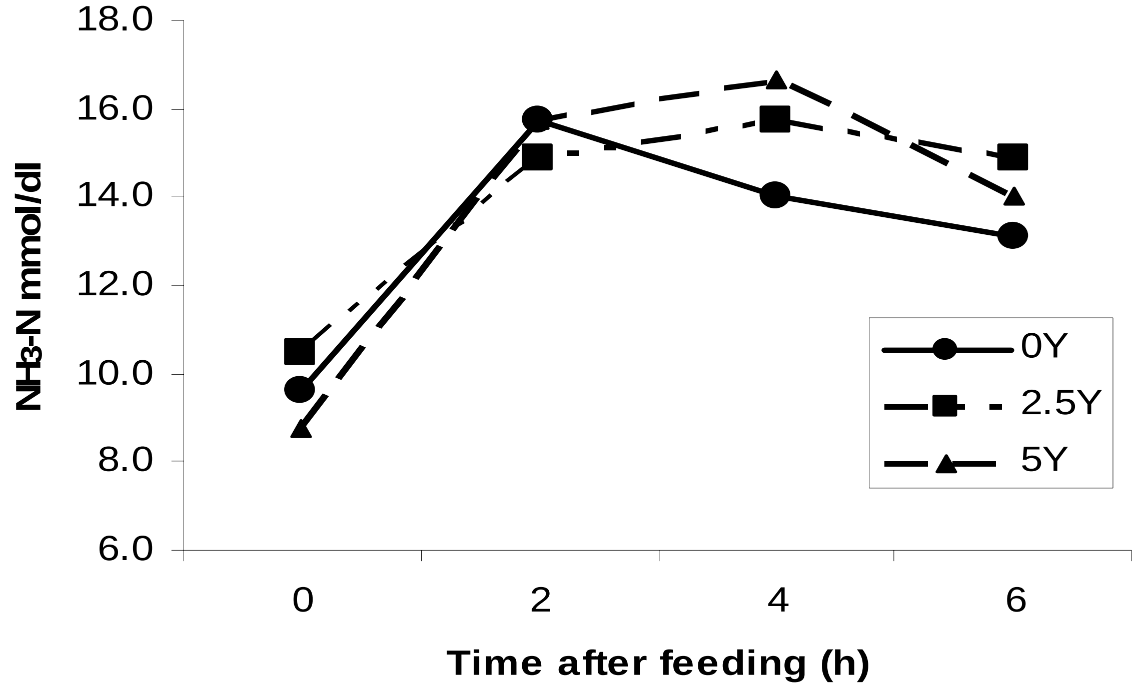

Fig.1. Diurnal changes in NH_3-N concentration of goat offered Abu 70 hay supplemented with 0 (0Y), 2.5 (2.5Y), and 5 (5Y) g/day yeast (*Saccharomyces cerevisiae*).

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