THE EFFECT OF YEAST CULTURE ON THE PERFORMANCE OF DAIRY CATTLE FED WHEAT BASED RATIONS

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TABLE OF CONTENTS

LIST OF TABLES

Table		Page

CHAPTER I

INTRODUCTION

The primary purpose of dairy cattle is to transform feeds into milk. Some important factors to consider when deciding what to feed are the price, availability and nutritive value, especially energy and protein content of different feedstuffs. It is known that dairy cows require high levels of energy to meet the demand of milk production. Energy and protein play an important role in the rearing of the dairy calf whether for veal, beef or as a dairy herd replacement.

Feeding large amounts of grain has been one method of increasing the energy density of the ration and thus, providing more energy for milk production. Wheat as a cereal grain has characteristically been utilized for human consumption and generally is not considered as a feed grain. According to the Wheat Outlook and Situation Yearbook for 1987, the utilization of wheat for human consumption is projected to reach 750 million bushels in 1988, which is 23% more than was consumed in 1980 and approximately 45% more than was consumed in 1970.

High levels of wheat production have exceeded domestic needs, making wheat exports possible. However, overproduction has led to surplus stocks of wheat in 1987 exceeding 1,980 million bushels. This situation has lowered the price of wheat making it competitive with other feed grains as an energy source in dairy rations. However, the extent to which wheat can replace other feed grains in concentrate mixtures for dairy cattle appears to be limited because of reduced feed intake and milk yield when large amounts of wheat are used. This suggests that something has to be done in order to take advantage of such a promising feedstuff, without incurring the problems noted above.

Very little research on supplementing ruminant rations with yeast culture has been reported during the last two decades, although many nutritionists recommend the inclusion of yeast in rations for high producing dairy cows and calves (McCullough, 1986; Huber, 1987; Gomez-Alarcon et al., 1987; Arambel and Tung, 1987; and Fallon and Harte, 1987). Others have found little benefit from adding yeast culture to diets (Lassiter et al., 1958; Jordan and Ward, 1959; Harris and Lobo, 1987; Phillips and Von Tungeln, 1985).

Factors which may have contributed to the variability in responses obtained by feeding live-cell yeast to ruminants animals include levels of feed intake, number and kind of organisms in the yeast culture, viability of the cultures, and specific ingredient combinations in the rations.

Information is needed concerning the response of dairy animals to the feeding of yeast cultures currently available in rations typical of those used in the livestock industry. Therefore, the objectives of these studies were:

1. To determine the effect of a viable yeast culture on feed intake and production of dairy cows fed concentrate mixtures containing a high percentage of either corn or wheat grain.
2. To evaluate the effect of supplementing concentrate rations for dairy cows with a viable yeast culture on the proportion of ruminal volatile fatty acids and on digestibility of different nutrient components of the ration.
3. To determine the effect of a viable yeast culture on feed intake, daily gain and feed to gain conversion of dairy calves fed concentrates mixtures containing either corn or wheat grain.

CHAPTER II

LITERATURE REVIEW

The name cereal is given to those members of the graminae which are cultivated for their seeds (McDonald et al., 1981). Wheat as a cereal grain has characteristically been utilized for human consumption and, therefore, has generally not been considered to be a feed grain. Wheat (Triticum aestivum) as we know it today originated in the highlands of Ethiopia and Mesopotamia (today known as Iraq). There is documented evidence that wheat was used by Swiss lake inhabitants as early as 10,000 to 15,000 years ago, and that wheat was introduced to North America around 1530 (Waldern, 1970).

Due to high levels of wheat production domestic requirements for the United States have been exceeded, making possible the exportation of wheat to other countries. However, this overproduction has led to large surplus of wheat stocks, depressing the price of the wheat and making it competitive with other feed grains as an energy source in dairy rations. The feeding of wheat is not a very common practice for dairyman, and thus, they are generally unfamiliar with its inclusion in dairy rations. Moreover, they may be reluctant or cautious about replacing traditional feed grains with wheat. There is a shortage of data as to the relative nutritive value and acceptability of wheat for dairy cows, especially when feeding hard red winter wheat.

The feasibility of feeding wheat is going to depend on its nutritive value, availability, prices and perhaps special diet considerations. In the State of Oklahoma, wheat and wheat by-products will likely be in the feeding picture as the price of corn and other grains keep soaring. This may be especially true for the dairy farmer who has some homegrown wheat or who can buy it from a neighbor at a competitive price (Richardson, 1988).

Nutrient Composition of Wheat

Cereal grains are essentially carbohydrate concentrates, the main component being starch. Toland (1978) reported starch contents of 66.8% and 65.8% on a dry matter (DM) basis for soft and hard wheat varieties, respectively, and Fulkerson and Mitchell (1985) and Toland (1976) reported starch contents of 57.5% and 51.5%, respectively for some soft wheat varieties.

Wheat grain appears to be quite variable in composition. According to Waldern (1970), composition can vary due to many different factors: type, variety of wheat, climate, soil fertility, and geographical area where the wheat is grown. Variations in crude protein content of 12 to 19, 10 to 15, and 8 to 12% for hard red spring, hard red winter, and soft wheats, respectively, were reported by Waldern (1970), showing that crude protein is one of the highly variable nutrients in wheat.

The most important proteins present in the endosperm are prolamin (gliadin) and glutelin (glutenin). The mixture of proteins present in the endosperm is often referred to as 'gluten', which constitutes 80-90% of the total protein in wheat. It is insoluble in water and neutral salts (Oltjen, 1970). The amino acid composition of these two proteins differs. The main amino acids present in wheat gluten are glutamic acid (330 g/kg) and proline (120 g/kg) (McDonald et al., 1981). Wheat is deficient in lysine and methionine (Sullivan, 1970).

The energy content among different types of wheat is less variable than that of protein (Waldern, 1970). However, the United States-Canadian tables of Feed Composition (1982) report the net energy for lactation values of soft wheats to be higher than for the hard wheat varieties (Table I).

As with many of the cereal grains, wheat is an excellent source of energy for dairy cattle, a fair source of phosphorus, but is low in calcium, magnesium, and potassium and is deficient in vitamins A, D, riboflavin, and B^{12} (Waldern, 1970). Wheat is a fairly good source of certain water soluble vitamins and alpha tocopherol (Sullivan, 1970). Although the chemical composition of wheat is a useful aid in determining its feeding value,

TABLE I

NUTRIENT COMPOSITION OF DIFFERENT TYPES OF WHEAT

	Hard		Soft		
	Red spring	Red winter	Red winter	White winter	White winter PC
Dry matter	88.0	88.0	88.0	89.0	89.0
Crude protein	15.1	12.7	11.5	10.1	10.0
NE_1	1.81	1.80	1.82	1.84	1.82
Crude fiber	2.5	2.5	2.2	2.3	2.52
Ash	1.6	1.7	1.8	1.6	1.9
Calcium	.03	.04	.04	.06	.09
Phosphorus	.38	.38	.38	.32	.30
Amino Acids					
Lysine	.35	.36	.36	.31	.30
Isoleucine	.54	.51	.45	.41	.40
Leucine	.88	.89	.90	.71	.75
Methionine	.19	.21	.22	.15	.14
Phenylalanine	.66	.63	.64	.47	.48
Threonine	.36	.37	.39	.32	.31
Valine	.59	.59	.58	.46	.46
Tryptophan	.14	.17	.27	.12	.12
Arginine	.59	.64	.65	.46	.45
Histidine	.24	.30	.32	.22	.20

[a] United States - Canadian Tables of Feed Composition, 1982 (Third Revision)

other things to consider are palatability, digestibility, productive energy, and the effect on animal health.

Utilization of Wheat Grain in the Concentrate Mixtures for Dairy Cattle

a. The Nutritive Value of Wheat as Compared to Other Cereal Grains

The leading cereal grains fed to dairy cattle in the U.S. are barley, corn (maize), oats, rye, sorghum, and wheat. These grains together with other high energy feeds belong to the group known as concentrates. Concentrates feeds are those which are high in energy and low in fiber (less than 18%). The total annual U.S. wheat tonnage of wheat in the U.S. is second only to corn. When the price of wheat is favorable relative to other grains or when the grain has been damaged by insects, frost, fire, or disease, it may be more profitable to market it through animals.

Wheat has been cited as equal to or up to 5% more valuable than corn for dairy cattle (Ensminger, 1980). Copeland (1933) reported wheat and milo to have nearly equal chemical composition, concluding that the two feeds should appear to be almost equal in feeding value. However, the relative value of a cereal grain also will depend on its proportion in the total diet, type of processing, other dietary constituents and the level of productivity of the cows (Moran, 1986).

The results of trials where wheat was compared with other feed grains are variable. Looking through the older literature on feeding wheat to dairy cows and comparing its feeding value to that of other cereal grains, abundant information is available (Jacobs, 1931; Bowstead, 1930; Fitch and Cave, 1932 and Hayden and Monroe, 1931). However, recommendations derived from these early studies have little meaning considering that most of the results were obtained from experiments in which the cows were fed small amounts of concentrate compared to those used in dairy herds today.

In recent studies with beef cattle, Brethour et al. (1985) determined that the net energy values of hard wheat and soft wheat in beef cattle finishing rations were 102 and 99% that of corn. However, when wheat was fed as 100% of the grain portion of the diet, overall performance was satisfactory only when fat was included in the ration. Martin et al. (1985) conducted a feeding trial to test the feasibility of feeding wheat as 100% of the grain portion of the diet and to determine the relative energy values of cracked wheat and corn grains for feedlot steers. The effects of elevated wheat levels on feedlot performance, liver abscesses and carcass characteristics of steers also were measured. One hundred fifty yearling steers were implanted and fed cracked grain diets containing (1) 50% corn and 50% wheat (50W); (2) 25% corn and 75% wheat (75W); or (3) 100% wheat (100W). Diets contained monensin (30g/ton of feed and tylosin (90mg/hd/d) and 12% roughage. Daily feed intake was depressed by 7.6% or about 1.7 pounds per head by 75W and 100W diets, showing that feed consumption tended to be lower when wheat was included at more than 50% of the grain in the diet. However, feed efficiency was improved when corn was replaced by wheat in the diet, with 75W producing the lowest feed intake and best efficiency. Daily live weight gains for cattle fed 50W, 75W and 100W diets were 3.23, 3.09 and 3.09 lbs. with a tendency for daily gain to decrease linearly as percentage of wheat in the diet increased. Most carcass measurements, including adjusted gain, hot carcass weight, marbling score and dressing percentage, tended to favor steers fed the 50W diet. Incidence of liver abscesses tended to be greater with higher levels of wheat in the diet. The metabolizable energy values for the total diet tended to favor the diets containing more wheat for an overall mean advantage for wheat over corn of about 8% for the total ration or about 10% for the wheat component considering that 81% of the ration dry matter was grain. They concluded that based on the price of corn grain ($6.61) and wheat ($5.83) when this trial was conducted, the feed cost of gain favored diets higher in wheat. Since wheat at 75% of the grain in the diet gave the highest efficiency, little economic advantage to feeding more than 75% wheat was apparent.

Cribeiro et al. (1979) conducted a trial with dairy cattle to measure milk production and composition when different levels of maize and wheat were fed in the concentrate. They found no significant differences for 4% fat-corrected milk, average milk fat percent, protein, total solids and solids non-fat in milk when concentrates mixes were fed in which wheat was fed at levels of none, 19, 38, 57, or 77% of the mix replacing mainly corn. However, daily intake of DM and metabolizable energy from the concentrate was significantly less with 57 or 77% wheat.

More recently, Nalsen et al.(1987) conducted a study to determine the effect of substituting hard red winter wheat for corn on a weight and a protein basis. Grain comprised 75% of the concentrate mixture. The three rations fed were : a) Control (75% corn adjusted to 12.1% protein); b) wheat (75% wheat, 15.1% protein); and, c) Wheat (75% wheat, 12.1% protein). Alfalfa hay was fed as the only forage in a 50:50 ratio. Intake of dry matter from both concentrate and hay was significantly lower on the wheat rations. The same effect was found on milk yield, which was lower for the cows fed the wheat mixture containing 12.1% protein than for cows fed the control ration or the 15.1 % protein wheat diet (33.0, 34.5 and 34.0 kg/day, respectively). Percent fat, milk protein and ruminal pH were similar among the three treatments.

Similarly, Campbell et al.(1988) in a study using four different wheat and corn based rations, found higher dry matter consumption and daily milk production for cows fed a corn-based concentrate mixture than for cows fed wheat based mixtures.

In some trials, wheat was found to be nearly equal to other grains for lactating cows. However, it is important to point out that the differences in responses among trials in feeding wheat to dairy cows may be attributed to differences in level of milk production, type of forage utilized, variety or type of wheat, or method of processing (Faldet et al. 1986).

b. Levels of Wheat in Concentrates Mixtures

As the cost of wheat declines, it usually becomes economically feasible to use more wheat. Obviously, this is a situation for dairymen to take advantage of if it makes their business more profitable.

A relevant question is, "how much wheat can be included in a concentrate ration without affecting milk yields and feed intakes unfavorably or without causing digestive disturbances?"

Many researchers throughout the years have been trying to give an answer to such an important question, especially during the 30's and 40's when wheat surpluses were very abundant and wheat prices were low (Burtner, 1940; Hayden and Monroe, 1931; Jacobs, 1931; Copeland, 1933 and Fitch and Cave, 1932). Few studies with wheat were conducted in the following decades (1940 through 1960) due to high wheat prices, which restricted availability and use of the grain. It was not until surpluses caused decreased wheat prices that interest in wheat research was renewed.

In work by Mcpherson and Waldern (1969), feed intake and milk yield were similar for cows fed rations in which Gaines soft white wheat replaced barley in concentrates mixtures up to 93% of the grain mixture. In contrast, Cunningham et al. (1970) observed that milk yield was significantly lower when soft red winter wheat replaced corn at a level of 66.7% compared to only 33.3% wheat in a concentrate mixture.

In recent work at the Oklahoma Station (Faldet et al., 1986), cows were fed concentrate mixtures containing 0, 40, 60, and 80% hard red winter wheat, replacing corn and some protein supplement, so that protein content was held constant. Intake of both concentrate and hay was lower when cows were fed the rations containing wheat. Moreover, milk yield declined as the amount of wheat in the concentrate increased (30.4, 29.7, 29.6 and 28.9 kg/cow/day for cows fed mixes with 0, 40, 60 and 80% wheat) respectively. The amounts of rumen undegradable protein (RUP) and rumen undegradable lysine (RUL) also were reduced as the amount of wheat was increased.

The Use of Yeast Culture in Animal Feeding

Wheat can be incorporated in diets for dairy cows. However, there is a need to explore cost effective measures for enhancing feed intake and milk yield of cows, and performance of improving calves, when fed concentrate mixtures containing large amounts of wheat. One alternative may be to include yeast cultures in the concentrate mixtures for dairy cattle. There is a need to acquire information concerning the responses that can be obtained from feeding yeast cultures currently available in the feed trade, using rations typical of those available in the livestock industry.

Yeasts are, perhaps, the most important group of micro-organisms commercially utilized by man (Stewart and Russel, 1981). The total amount of yeast produced annually in the world reported is on the order of one million tons (Lyons, 1987). Commercial yeast consists of three main types of products, categorized according to the relationship of the product to the biochemistry of the organism. Specifically, these are: (a) cell constituents; (b) excretion products; (c) compounds produced by the action of cellular enzymes on specific substrates. The first group can be subdivided into (i) dry whole cells, which have a composition broadly similar to all other living matter and may, therefore, be used as a food supplement; (ii) lipids and macromolecular constituents such as proteins, enzymes and nucleic acids; (iii) extractables compounds, including coenzymes and vitamins; (iv) breakdown products, for example amino acids formed by the hydrolysis of proteins, and purines and pyrimidines derived from nucleic acids. Most commercial applications are in group (b), comprised of excreted compounds such as ethanol and glycerol and carbon dioxide. Typical examples from group (c) include the synthesis of ephedrine via benzaldehyde, and the formation of thiamine from its thiazole and pyrimidine moieties.

Of the 39 genera of yeast listed by Lodder (1970). The genus Saccharomyces is of greatest interest to the industrial world. Although this genus consists of 41 species, only Saccharomyces cerevisiae and the related species Saccharomyces uvarum are utilized to any extent by industry (Lyons, 1987). Saccharomyces cerevisiae has round or oval cells and is able to take up and ferment a wide range of sugars, including sucrose, glucose, fructose and maltose. It is intimately involved in baking and alcohol production and has the special virtue of possessing particularly efficient aerobic and anaerobic metabolic capabilities (Rose and Harrison, 1970). Rose (1987) postulated that the growth and metabolism characteristics of the yeast species, Saccharomyces cerevisiae, made it the ideal yeast for yeast culture production. A cultured yeast, or yeast culture, is one grown for a particular application. In 1957 the Association of American Feed Control officials (AAFCO) defined it, as a "dry product composed of yeast and the media on which it was grown, dried in such a manner as to preserve the fermenting capacity of the yeast. The media must be stated on the label".

According to Bhattacharjee (1970), brewer's yeast (Saccharomyces cerevisiae) is generally accepted as an alternative by-product feed for livestock because of its high nutritive value and relatively low toxicity. However, because of its high nucleic acid content (50-120 g/kg DM), umpalatability and bulkiness, nonruminant animals have shown digestive disturbances when supplemented with diets containing high levels of yeast (Carter and Phillips, 1944). In cattle diets, yeast is still limited to small amounts as a source of vitamins and unidentified growth factors for stimulating intake and ruminal digestion (Beeson and Perry, 1952; LeGendre et al., 1955; Wiedmeier and Arambel, 1985) or as microbial adjuvant for reducing stress, (Phillips and Von Tulgen, 1984). Studies also have examined yeasts for its potential as a protein supplement for cattle because of its high crude protein content, (50%) (Grieve, 1979). It also is believed that yeast cells aid in utilization of excess ruminal ammonia by converting it to yeast cell protein (Streeter et al., 1981). Recent research has tended to confirm on-farm reports of improved milk and butter fat production with yeast culture (Lyons, 1986). Wiedmier and Arambel (1985) reported improved dry matter and fiber digestibility in beef cattle following inclusion of yeast culture.

Currently, there is considerable practical on-farm experience with yeast culture, but a lack of research published in the scientific literature. Prior to presenting a review of what appears to be the most relevant information on yeasts, it may be helpful to look at the composition of yeast.

Composition

Yeast is a fungi, a unicellular organism that reproduces mostly by forming buds that develop into daughter cells. Yeasts can grow or can be cultured on a wide variety of substrates (Hydrocarbons, cereals, sugars, molasses, waste sulfite liquor, cheese whey, sewage; Braude, 1976). The substrate might influence the chemical composition of the final product. Nesmeyanov et al., 1971 reported yeast cultured on hydrocarbon substrates to have an amino acid composition similar to high quality animal proteins. This may explain some of the discrepancies between results of nutrition trials from different laboratories, and suggests the need for extensive nutritional studies before routine inclusion of these protein sources in livestock diets.

At the end of the nineteenth century, yeast was known to contain a high level of protein (Thaysen, 1943), but the chemical nature of the yeast protein was not known. Morrison (1936) stated that yeast was not only high in protein but of good quality. Crowther (1913) determined yeast contained 48.5% protein, 0.5% fat, 35.5% water soluble carbohydrates, 0.5% fiber and 10.7% ash. Similarly, Hawk and associates (1919) reported bakers yeast contained 52.4% protein, 1.7% fat, 37.1% carbohydrates and 8.7% ash.

Reports of different authors concerning the chemical composition of yeast are presented in Table II. Although variations in chemical composition may be due to strain of

TABLE II

CHEMICAL COMPOSITION OY YEAST AS DETERMINED
BY PROXIMATE ANALYSIS

	Component (% on dry matter basis)			
	Protein*	Fat	Carbo - hydrate	Ash
Compressed bakers' yeast[1]	52.4	1.7	37.1	8.7
Dried brewers yeast[2]	47.6	1.03	2.6	8.4
BP yeast[3]	62.0	1.6	--	5.7
Red star yeast[4]	52.9	0.3	31.2	5.4
Hydrocarbon-grown yeast[5]	57.8	3.6	30.8	7.9

1 Hawk et al., 1919.
2 Carter and Phillips, 1944.
3 Braude, 1976.
4 Vasconcellos et al., 1977.
5 Tegbe and Zimmerman, 1977.
* Protein defined as N X 6.25.

yeast, substrate residues and handling methods, the figures generally fall within a rather narrow range.

It is pertinent to point out that the crude protein values in the table are calculated from total nitrogen and hence from 12 to 18 % of the total crude protein due to large amounts of non-protein nitrogen in yeast. Therefore, simply looking at the level of yeast protein (N x 6.25) may be of limited usefulness from a nutritionist stand point of view, whereas the amino acid composition of the yeast protein is of greater importance. Table III gives the amino acid composition of some yeast proteins as compared to selected conventional protein feeds.

Yeast also contains more than ten water soluble vitamins, including para amino benzoic acid,(a growth factor for many bacteria). Unidentified compounds of the vitamin B complex, which is essential for growth of bacteria, also have been isolated in yeast (Lyons, 1986).

Feeding Yeast in The Non-Ruminant Animal

Most of the research in non-ruminants using yeast as a feed additive has been done mainly on swine and poultry. The main benefit for non-ruminants appears to be when fed to young animals which are deficient in certain digestive enzymes.

a. Swine

Reports as far back as the beginning of the century concerning the addition of yeast to swine rations are found

TABLE III

AMINO ACID COMPOSITION OF SOME SELECTED PROTEINS AS COMPARED TO YEAST PROTEINS

	Soybean meal[1]	Fish meal[1]	Blood meal[1]	Brewer's yeast[1]	Yeast SCP[2]	Candida utilis[3]
International Reference No.	5-04-604	5-02-15	5-00-380	7-05-527	-----	7-05-534
Crude protein	51.5	70.4	87.8	48.0	55.1	51.9
Amino Acids (g/100g CP)						
Arginine	7.0	4.1	4.4	4.9	3.3	4.4
Cystine	1.5	1.2	1.7	1.1	.5	-
Histidine	2.4	2.8	5.3	2.5	2.5	2.4
Isoleucine	5.4	5.0	1.3	4.7	5.1	4.7
Leucine	7.4	7.2	12.9	7.2	6.9	7.0
Lysine	6.3	9.0	8.6	6.7	6.5	8.0
Methionine	1.3	3.1	1.1	1.6	1.1	.7
Phenylalanine	4.8	4.0	7.6	4.1	4.2	3.6
Threonine	3.7	4.0	4.6	4.7	3.4	5.0
Tryptophan	1.3	.8	1.4	1.1	1.5	-
Tryosine	3.0	4.6	2.3	3.4	3.8	3.0
Valine	5.2	6.3	8.1	5.1	5.6	5.2

[1] N.R.C. 1973. Figures recalculated to give amino acid as % of protein.
[2] Tegbe and Zimmermann. 1977. Figures recalculated to give amino acid as % of protein.
[3] Goulet et al. 1976.

in the literature (Voeltz, 1912; Voltz, 1913; Shrewsbury et al., 1932; Russel et al., 1926). In the 60's and 70's, research on yeast as a source of protein for pigs was reviewed by several authors. Barber et al. (1971) conducted two experiments, a feeding and a metabolic trial, to determine the value to growing pigs of yeast+methionine as a protein supplement to diets based on barley and fine wheat offal, as compared to that of white fish meal. In the first trial small, but significant, differences in favor of the yeast treatment were found for growth rate and feed conversion ratio, but there were no consistent differences in linear carcass measurements. In the second trial, there were no significant differences in performance, N retention, apparent N digestibility or linear carcass measurements and no consistent difference in tissue components between the diets supplemented with yeast or fish meal. Therefore, they concluded that yeast+methionine may be closely equated with high-quality fish meal as a protein supplement in diets for growing pigs.

Shacklady and Van der Wal (1968) and Shacklady (1969) fed yeast in several trials to pigs and obtained acceptable results with no histological abnormalities. Consistently larger litter size was obtained with sows fed fish meal or soybean meal diets containing 10% yeast than when either fish meal or soybean meal was fed without yeast (Shacklady, 1969). In a experiment with baby pigs and growing pigs (Tegbe and Zinnerman, 1977), replacing soybean meal with increasing levels of yeast in 18.0 % CP dehulled soybean meal diets linearly decreased plasma urea nitrogen, linearly increased plasma alpha-amino nitrogen and improved feed efficiency, nitrogen digestibility and nitrogen retention. Such results indicate that single cell proteins (CSP) may be a desirable protein source for swine.

More recently, Ajeany et al. (1979) conducted three experiments to examine whey-grown yeast as a protein source for early-weaned pigs. They concluded that whey-grown yeast fed at levels up to 11% of the diet had no adverse effect on early-weaned pigs and that whey-yeast protein was superior to soybean meal protein for growth rate, feed efficiency and protein efficiency of pigs at that stage.

b. Poultry

Yeast cultures have been reported to stimulate gut microflora to increase microbial enzyme levels and thereby increase digestion efficiency and to also provide unidentified poultry growth factors (Torkinson et al., 1964). Thayer et al. (1978) suggested that the increased enzyme levels attributed to yeast cultures enhance phosphorus digestibility. Although most of the work done with yeast as a source of protein for poultry diets has been successful, occasionally poor responses have been obtained. Research on yeast in poultry diets followed the work done with man and rats in the late 1960's (Ajeany et al., 1979).

The nutritive value of yeast grown on hydrocarbon fractions, methanol and other substrates for poultry has been studied by several authors. Waldroup and Hazen (1974) conducted a feeding trial to determine the effect of feeding yeast grown on high purity alkane fractions to laying hens. The yeast was incorporated in to corn-soybean meal type diets at levels of 0, 2.5, 5, 10, and 15%, and the diets were calculated to be isocaloric (2970 M.E. kcal./kg.) and isonitrogenous (16% protein). They found that rate of egg production and other factors such as egg size and albumen quality were not impaired by the inclusion of the yeast at the levels listed, indicating that the yeast sample used was an adequate protein source for layer hen diets to the extent of the maximum level used in this study (15%). Higher levels should be examined with caution in light of the feed intake problems associated with higher usage levels in broiler diets as reported by Waldroup et al. (1971). Chick performance was found to be excellent when a hydrocarbon-grown yeast preparation known as TOPRINA, replaced all of the supplemental protein from fish meal or soybean meal (Shannon and McNab, 1972, 1973). On the other hand when Waldroup and Flynn (1975) compared 9 samples of yeast produced on different hydrocarbon feedstocks to an isolated soybean protein diet, they found that chicks fed the diet containing the reference soybean protein had significantly greater body weight gain, consumed more nitrogen, and had superior nitrogen efficiency ratios (NER) and net protein utilization (NPU) scores than chicks fed any of the diets containing yeast. They concluded: "A large portion of the nitrogenous fraction of the yeasts is not in the form of amino acids which tend to downgrade the value of these products when compared on the basis of total nitrogen. Edmonds and Teeter (1983), at the Oklahoma agricultural Experimental Station, conducted two experiments utilizing 270 chickens to evaluate the efficacy of a yeast culture (YC) for both broiler and layer avian types. In the first experiment, three dietary levels (0, 1.25, 2.5 percent) of yeast culture were included in a nutritionally complete starter ration and fed to 14-day-old broiler chicks for 8 days, whereas in the second experiment, yeast culture was fed at two dietary levels (0, 2.5, percent) to 14-week old shaver pullets receiving two rations types varying in nutrient density, a high fiber ration and a low fiber ration. In both experiments, there were no significant effects of the yeast culture on body weight gain, feed consumption feed efficiency and digestibility of dry matter and phosphorus. Addition of yeast culture apparently did not supply unidentified growth factors that were not supplied by the starter ration and the yeast culture did not appear to improve the ability of gut microflora to digest fiber and phosphorus, as reported by Tonkinson (1965) and Thornton (1960). However, the researchers pointed out that since the studies were conducted using relatively low fiber rations that varied in source of fiber, the effect may have been due to sources of fiber and not to yeast culture itself.

Feeding Yeast to The Ruminant Animal

Ruminants provide a unique example of a symbiotic relationship between a microbial population and a host animal. Microorganisms help the host animal carry out digestive processes that can not be initiated by the animal's own enzyme system while the host animal provides in return a suitable environment which is conducive to microbial activity (Dawson, 1987). Rumen microorganisms, for instance, hydrolyze the proteins contained in foods to peptides and amino acids, but most amino acids are degraded further to organic acids, ammonia and carbon dioxide. The ammonia produced is utilized by the rumen organisms to synthesize microbial protein and when the organisms are carried through to the abomasum and small intestine their cell proteins are digested and absorbed (McDonald et al., 1984). Even at the highest rate of microbial protein synthesis in the rumen, the animal may still be protein deficient unless substantial amounts of dietary protein bypass the rumen. To increase passage of dietary protein into the abomasum and small intestine of ruminants, various methods have been employed, but most of them are expensive and may lower the postruminal protein digestibility as well. Yeast protein seems to play an important role in that respect, since some yeast protein is a washed precipitation product; therefore, it may resist ruminal degradation and partially escape the rumen (Smith et al., 1977). High postruminal digestibility of yeast cell protein is expected since microbes are normally digested in the intestine of ruminant animals and since the digestibility of yeast protein by non-ruminants is high (Condon, 1977).

Facts like these have focused the attention on studying the potential of this single cell protein for improving the performance of ruminant animals. However, very little research on supplementing rations of ruminants with yeast culture has been reported during the last two decades.

This section will briefly discuss the most relevant studies with yeast culture, considering primarily studies related with beef and dairy cattle. Discussion of studies will be separated into beef and dairy.

Beef Cattle

Numerous benefits are attributed to the inclusion of yeast in rations for beef cattle. The addition of yeast cultures in diets for cattle have been shown to enhance the number of cellulolytic bacteria and increase the digestibility of cellulose and to increase the synthesis of microbial protein (Huber, 1987). Sniffen (1986) suggested that yeast products could provide the necessary amino acids to provide adequate isoacids for bacterial growth and action. Less stress due to shipping and improved mineral consumption also have been reported for cattle fed yeast culture (Phillips and vontungeln, 1985; Streeter et al., 1981).

LeGendre et al. (1957) reported that the addition of a live-cell yeast preparation to either a low quality, high quality or fattening type steer ration depressed the digestibility of ether extract in all cases, but had no significant effect on the utilization of other nutrients. The addition of yeast to the high roughage ration tended to increase the retention of nitrogen. Phillips and VonTungeln (1985) studied the value of yeast for steer and heifer beef calves (208 kg). In order to simulate the sequence of events found in marketing channels, animals were subjected to weaning, fasting, re-feeding and fasting a second time. Poststress dry matter intake was measured and found to be depressed by about 50% of maximum intake. Yeast culture was then added to the poststress diet to study its effect on dry matter intake and poststress performance. They found that adding yeast culture to the diet at 1% or 2% of the dry matter did not consistently increase dry matter intake or average daily gain and concluded that "the mode of action by which yeast culture can increase dry matter intake and average daily gain in cattle is not known, nor is the inconsistency in response to yeast culture understood. The stressed beef calf probably has a higher nutrient requirement than the non-stressed calf."

Streeter et al. (1981) in a study conducted to determine the effect of a yeast culture on free-choice mineral consumption by cattle grazing wheat pasture, selected five hundred steers and heifers averaging 422 pounds. Animals were allotted by sex to four separate wheat pastures and given free-choice mineral, with and without yeast culture. A commercial high calcium (16%), high magnesium (7.5%) mineral was fed during winter grazing period lasting 100 days. Yeast culture comprised 33% of the mineral mixture during the first month and 50% during the last 2.5 months. The addition of yeast culture to a high calcium-magnesium mineral significantly increased daily mineral intake. Mineral consumption nearly doubled when two parts mineral were mixed with one part yeast culture and tripled when mixed in a 50:50 ratio. Based in these results, it appeared that yeast culture had a "masking" effect on the unpalatable mineral components, resulting in improved mineral acceptability and consumption. Similarly, Burkitt (1983) measured the effect of yeast culture vs barley as a mineral intake stimulant for cow-calf pairs. He demonstrated a 75% preference for mineral containing 10% yeast culture over control mineral, and a 51% preference over the ground barley.

Horn et al. (1981), concerned about the effects of nitrate toxicity attempted to look for feed ingredients that would reduce toxicity in ruminants fed and/or grazing forages which tend to accumulate nitrates. Knowing that yeast cultures are palatable, conducted a trial to evaluate the effect of yeast culture on blood methemoglobin concentration of lambs and steers challenged with a high-nitrate sorghum-sudan hay. Lambs and steers were fed low-nitrate hay and supplements that supplied 0 or 4.5 gr (lambs) or 0.11 kg (steers) of yeast culture per head per day for 14 and 12 days, respectively, before being fed high-nitrate sorghum-sudan hay. Nitrate consumption by lambs 6 hr after being fed the high-nitrate hay was similar among treatments (0.3 to 0.5 g/kg body weight during the three challenge days). Similar rates of nitrate consumption were observed for steers. Blood methemoglobin concentrations of lambs and steers fed yeast culture were similar between to that of control animals. They concluded that yeast culture will not decrease the toxicity of high-nitrate forages consumed by sheep or cattle. Yeast also has been tested in feedlot rations to determine its effect on performance of the animals since performance is influenced by the condition and health of the rumen microflora. If rumen fermentation is upset for any reason, cattle may go off feed and performance may suffer. Several researchers have conducted experiments to test this belief. Nicholson (1977) randomly allotted six pens of twelve animals to three test diets. The control diet consisted primarily of dry rolled barley (75%) and ground brome-alfalfa hay (20%). Dried brewers yeast and yeast culture were each substituted for barley at the rate of 1.5% for the first 28 days and 0.9% for the remainder of the study. The study lasted 71 days. Cattle fed yeast culture had a 25.9% greater average daily gain, consumed 9.0% more feed per day than the control cattle and required 13.3% less feed per pound of gain. A 57.4% lower incidence of liver abscesses also was noted. In another experiment (Kiesling, 1978), crossbred yearling heifers were fed a basal ration consisting of 78% steam rolled corn, 10% cottonseed hulls, 6% cottonseed meal and 5% molasses. Corn was replaced by yeast culture and/or sodium bicarbonate to form four treatments for a 56-day study. Average daily gain and feed conversion were more favorable for the yeast culture group than for the control group (1.70 kg and 7.01 vs 1.5 kg and 8.40) by 13.6% and 16.5% respectively. Sodium bicarbonate reduced daily gain slightly with no improvement in feed conversion. The combination of yeast culture and sodium bicarbonate appeared to suppress animal performance. Similar results were reported by the Dainakanoko Agricultural Cooperative Association (1979) where 40 Holstein steers were assigned into two treatment groups in an 84-day feeding trial, and fed a ration consisting of 15% rice straw, 15% wheat bran, 20% flaked corn, 19% ground corn, 1% fish meal, and 30% commercial supplement. The steers receiving yeast culture (110 g/day) out-performed the control animals with an 11% improvement in daily gain and a 9% improvement in feed efficiency.

Contrary to these promising results, several undocumented accounts of digestive disturbances in cattle fed yeast, specifically live brewer's yeast slurry, have been noted. Bruning and Yokoyama (1988) conducted studies to examine the physical and compositional characteristics of live and killed brewer's yeast slurries and to determine the possible toxicity of intraruminal administration of loading doses of these by-products. Three ruminally cannulated Hereford bull calves (227 kg) were used for the intraruminal loading dose studies. The calves were individually stanchioned in metabolism stalls, adjusted to corn silage (8.0 % crude protein) and fed twice daily. Water and trace mineral supplement were provided ad libitum. The treatments consisted of four dosages (0, 2.3, 4.5 and 6.8 kg) of either a live or killed brewer's yeast slurry. Clinical intoxication was induced at the 4.5 kg and 6.9 kg dosages of live brewer's yeast slurry. No acute intoxication was induced with either the 0 kg or 2.3 kg dose levels. In marked contrast to these effects, the intraruminal administration of killed brewer's yeast slurry produced no symptoms of acute intoxication at any dose level. Both plasma ethanol and ruminal ammonia concentration increased after intraruminal administration of increasing dosages of live brewer's yeast slurry.

<u>Dairy Cattle</u>

Very little research on supplementing rations of ruminants with yeast culture has been reported during the last two decades, although many nutritionists recommend their inclusion in rations for high producing dairy cows (McCullough, 1986). A number of field observations have suggested an improvement in fat percent, milk yield and dietary digestibility when yeast culture was added to rations for lactating dairy cows. Increases in food intake, nutrient digestibility and live weight gain have been reported when yeast culture was fed to calves (Hughes, 1987). Recent work (Wiedmeier et al., 1987) showed that the addition of yeast cultures (1% DM) to the diet of Holstein cows increased total bacteria numbers in the rumen and percent cellulolytic bacteria. The same was observed by Arambel and Tung (1987) after supplemented diets of Holstein heifers with yeast.

A summer field trial with mid-lactation Holstein cows was conducted at a large dairy in north Florida (Harris and Lobo, 1987) to study the effect of yeast culture on milk production and composition on cows under stress conditions. Cows were divided into two groups, balanced for pretreatment milk yield and days in milk. The two groups were managed in such a way that all second lactation or older cows freshening entered the groups (1 and 2) with a similar number removed each month. Animals were fed twice daily, milked 3 times per day and while in corrals had free access to fair quality bermuda hay. All cows received rations containing corn silage, wet brewers grains, distillers grains and concentrate. However, group 2 rations contained the daily equivalent of 4 oz of yeast culture/cow. The cows completing the 90 day study showed no significant differences in the parameters measured. However, there was a trend for an advantage for feeding yeast culture in both actual and 4% FCM (0.36 and 1 kg/day). Also there was a slight increase in fat percent (0.13 percent units). On the other hand, for cows in early lactation being fed yeast culture, there was a slight advantage in actual milk production (31.5 vs 31 kg) and a significant increase in fat percent (3.57 vs 3.36%) and 4% FCM (29.4 vs 28.0 kg) with a decrease in protein (2.97 vs 3.05%). There was an advantage to feeding yeast culture during the summer. Yeast culture was more effective when fed prior to or beginning at the time of calving or over a long period.

Two experiments, a production and digestibility trial, were carried out to evaluate the inclusion of yeast culture (YEA-SACC), in the concentrate diets of calves weaned after 42 days on milk replacer (Fallon and Harte, 1987). For experiment one, 80 Friesian bull calves of approximately 7 days of age were randomly allocated to four treatments, as follows: a) Barley/soybean meal, b) Treatment "a" plus yeast culture (2 kg/ton), c) Corn gluten/barley, d) Treatment "c" plus yeast culture (2kg/ton). Yeast culture increased concentrate dry matter intake by 12.5 kg in the period 1 to 84 days when included in the barley/soybean meal diet; however, its inclusion in the corn/barley diet had no effect on DM intake. Live weight gain was increased when yeast was added to the barley/soybean diet by 10.1 kg and by 3.4 kg in the corn gluten/barley diet. Also, feed conversion efficiency for both the barley/soyabean and the corn gluten/barley diet was improved by the inclusion of yeast. In experiment two, 16 calves from the production trial were put in digestibility crates on day 65. Following a 2-day preliminary period, total collection of urine and feces for each calf was made over a 10 day period. The inclusion of yeast increased dry matter and organic matter digestibility by 4 to 5 percentage units and fiber digestibility by 4 to 6 units regardless of the type of concentrate diet offered. However, since the fiber level was low overall, the increased digestibility made little contribution to overall diet digestibility. The inclusion of yeast culture had a variable effect on feed intake. It increased intake in the barley/soyabean diet but not in the corn gluten barley diet. Therefore, they concluded, "That yeast culture simply acted a palatability enhancer and encouraged the calf to eat more solid food. However, it could also be suggested that yeast culture had a positive effect on improving fermentation conditions in the developing rumen".

Similar results were reported by Hughes (1987) in an 84 day trial conducted to measure calf performance when yeast culture was included in the concentrate mixture. Animals were randomly assigned to one of the following treatments (16 calves/treatment): a) Control diet, b) Control diet + yeast culture. Calf liveweights were recorded on days 1, 35, 56, and 84. Feed intakes were individually recorded until day 56 and group intakes were recorded thereafter. The inclusion of yeast culture in the concentrate diet resulted in an 8.5 kg increase in liveweight gain and an 18 kg increase in feed intake. Feed conversion efficiency also was improved by the addition of yeast.

Peters et al. (1977) reported that yeast culture reduced the rate of decline of normal lactation when used over a four-week period. The cows entering the study were producing an average of 23 kg of milk containing 3.6% fat. The declining slope for the first period (control) was -2.79, the second period (yeast culture) -0.80, and the third period (control) -1.57. Milk fat percent averaged 3.1% for each of the three 4-week periods, milk yield averaged 21.0, 18.5, and 16.6 kg per day, and dry matter intake was 20.2, 20.5 and 19.3 kg for the three respective periods. Milk production was not significantly different when all periods were compared.

Hoyos et al. (1987) showed that the addition of a viable yeast culture to two groups (high- and low-yielding) lactating cows increased milk yield by 6% in the high yielding cows and milk fat content by 19.4% and 14% in high- and low-yielding cows, respectively. Gomez-Alarcon et al. (1987) conducted a series of trials (production and digestibility) to evaluate the effect on milk production and rumen digestion, by cows when Aspergilllus oryzae (AO) culture-extract, a fungal feed additive was added to the concentrate diets. Forty six Holstein cows in early lactation, paired according to pre-treatment milk production and by parity, were assigned to either a control group or an AO supplemented group. The cows were fed a 60% concentrate total mixed ration. The treated group received 3 g of the fungal extract mixed with 87 g of ground milo a day. Cows remained in the trial for at least 90 days. Chromium oxide, used as marker, was administered for 12 days. Fecal spot samples were collected the last 5 days of the period . Cows receiving the AO had higher milk yields than the control group (40.4 vs. 37.1 kg/d) while feed intake and feed efficiency were similar (production trial). In the digestibility trial, feed intake and dry matter digestibility were higher for the AO that control groups. Apparently the higher milk yields with the fungal additive resulted from increased digestion in the rumen with greater synthesis of microbial protein available for the animal.

In most all the studies above, the inclusion of various forms of yeast in dairy cattle rations increased milk production and composition, but in other cases reported in the literature the inclusion of yeast had no effect on milk yield and composition.

Lassiter et al. (1958) concluded that the addition of live yeast culture at the rate of 1% of a grain ration had no significant effect on production of 4% fat-corrected milk, fat test or feed intake by dairy cows. Digestibility of crude protein and ether extract were significantly reduced upon inclusion of yeast in the ration and cows fed yeast gained less weight than those receiving a control ration. Similarly, Jordan and Ward (1959) found that a live yeast culture added at 2% of the grain mixture had no significant effects on milk production or fat test of Holstein cows.

Steckley et al. (1978) decided to conduct a study to determine the effects of inclusion of brewer's yeast slurry as a source of protein in complete rations for dairy cows on milk yield and composition. Ration digestibility and fermentation patterns in the rumen were also measured. Thirty Holstein cows were blocked by age, stage of lactation, and milk yield and assigned to 5 treatments within blocks. Treatments consisted of brewer's yeast slurry and soybean meal incorporated in complete rations at 6 and 12% of dry matter to increase crude protein from 13% (negative control) to 15 and 17%. Milk yield, milk component yields, and percent of protein were higher on the supplemented rations than on the negative control. However, comparison of soybean with yeast rations showed no differences in any of the milk traits. Molar percent of rumen acetic acid was higher on the yeast supplemented rations while propionic and isovaleric acids were lower. Blood urea nitrogen was also lower. Apparent digestion coefficients for dry matter, gross energy, crude protein and acid detergent fiber were all higher on the yeast supplemented rations than on soybean diets.

More recently Arambel and Kent (1988), at the Utah Station, conducted a trial to measure the effect of a yeast culture on milk production and apparent nutrient digestibility in early lactating dairy cows. Twenty cows were allocated equally, based on milk production and days in milk, to one of two treatments. Treatments consisted of a total mixed ration (containing rolled barley, whole cottonseed, brewers dried grains, beet pulp, molasses) with or without added yeast culture (Saccharomyces cerevisiae, 90 g/d). Treatment groups were fed the total mixed ration ad libitum for 10 weeks. Individual feed intakes and milk yield were recorded daily. Milk composition was analyzed weekly (am-pm composite) for percent protein, fat, lactose, and solids-not fat (SNF). Individual feed and fecal samples were collected for 3-d at the end of the experimental period and composited to determine apparent nutrient digestibility.

Mean daily milk yield was not significantly different (P>.05) between treatments (37.9 versus 36.5 kg/d, for control and yeast culture respectively). Percent milk fat, protein, lactose and SNF were not significantly affected (P>.05) by treatment. Therefore, they concluded that the addition of yeast culture to the diet of early lactation cows, had no significant effect on daily milk yield, milk fat percent, protein, lactose or solids-not fat. Also, overall apparent nutrient digestibility was unaffected by the inclusion of yeast.

Factors likely contributing to the variability in responses obtained to feeding live-cell yeast to ruminant animals include levels of feed intake, number and kind of organisms in the yeast culture, viability of the cultures and the specific ingredient combination in the rations.

These factors must be taken into consideration by the experimenter when interpreting data obtained from research done on this subject.

CHAPTER III

EFFECT OF YEAST CULTURE ON INTAKE AND PRODUCTION OF DAIRY COWS FED HIGH WHEAT RATIONS

Abstract

The effect of supplementing rations with yeast culture (Sacharomyces cerevisiae, YEA-SACC) on milk yield and feed intake was evaluated using 24 Holstein cows. Treatments were: (a) control corn based concentrate mixture, (b) control plus 1.5 g Yea-Sacc/kg (c) wheat mixture (60% wheat), and (d) wheat mixture plus Yea-Sacc. Concentrate mixtures were calculated to be isonitrogenous and approximately equal in energy content. Concentrates and alfalfa hay (50:50) were each fed separately in individual stanchions twice each day at about 12-hour intervals. Dry matter intake by cows fed the corn mixtures was higher ($P<.001$) than that of cows fed the wheat mixtures (23.9 and 23.6 vs. 21.8 and 21.5 kg/day). Milk yield was higher ($P<.003$) for cows fed the corn rations than for those fed wheat (32.0 and 31.2 vs. 30.5 and 30.4 kg/day). Dry matter intake and milk yield were unaffected by the addition of yeast. Ruminal pH was higher ($P<.01$) and digestibility of dry matter and protein was lower ($P<.001$) in cows fed corn than in those fed wheat. Milk protein, ruminal NH_3-N

and blood urea-N were not affected by treatment (P>.05).

Introduction

In many areas of the U.S., wheat is competitive in price with other feed grains used as an energy source in dairy rations. However, the extent to which wheat can replace other feed grains in concentrate mixtures for dairy cows appears to be limited because of reduced feed intake and milk yield when large amounts of wheat are used.

In work by McPherson and Waldern (1969), feed intake and milk yield were similar for cows fed rations in which soft white wheat replaced barley in concentrate mixtures up to 93% of the mixture. In contrast, Cunningham et al. (1970) observed that milk yield was significantly lower when soft red winter wheat replaced corn to the extent of 66.7% than when it comprised only 33.3% of a concentrate mixture.

In recent work at the Oklahoma station (Faldet et al., 1986), cows were fed isonitrogenous concentrate mixtures in which hard red winter wheat replaced 0, 40, 60 and 80% of the corn and some protein supplement. Intake of both concentrate and hay was lower when cows were fed the rations containing wheat. Milk yield declined as the amount of wheat in the concentrate increased (30.4, 29.7, 29.6 and 28.9 kg/cow/day for cows fed mixes with 0, 40, 60 and 80% wheat).

Very little research on supplementing rations of ruminants with yeast cultures has been reported during the last two decades, although many nutritionists recommend their inclusion in rations for high producing dairy cows (McCullough, 1986). Rumen studies suggest that the inclusion of yeast cultures in diets for cattle enhance the number of cellulolytic bacteria and increase the digestibility of cellulose and the synthesis of microbial protein (Huber, 1987). In one recent report (Gomez-Alarcon et al., 1987) adding yeast to diets for dairy cows at a rate of 3g/d increased milk production and feed intake. Arambel and Tung (1987) supplemented the diets of Holstein heifers with yeast and found that the number of cellulolytic bacteria in the rumen and the digestibilities of DM, protein and hemicellulose were increased.

Sniffen (1986) suggested that yeast products could provide the necessary amino acids to provide adequate isoacids for bacterial growth and action; however, no evidence for this was presented. Phillips and Von Tungeln (1985) found that the addition of yeast culture to the poststress diet of feeder calves did not significantly increase either dry matter intake nor poststress performance. On the other hand, Fallon and Harte (1987) observed that DM intake and live weight of calves were increased when a barley/soya diet included yeast culture.

Lassiter et al. (1958) reported that addition of live yeast culture at the rate of 1% of a grain ration had no significant effect on production of 4% fat-corrected milk (FCM), fat test or feed intake by dairy cows. Digestibility of crude protein and ether extract were significantly reduced upon inclusion of yeast in the ration and cows fed yeast gained less weight than those receiving a control ration. Similarly, Jordan and Ward (1959) found that a live yeast culture added at 2% of the grain mixture had no significant effect on the milk production or fat test of Holstein cows.

Harris and Lobo (1987) in a study conducted with 2 groups of midlactation Holstein cows supplemented with 40 g of yeast culture per cow found no significant differences on milk yield, fat, protein and FCM for cows completing the 90 day study. Since groups were maintained at about 150 cows per group, some cows were removed each month. Results showed a significant increase in milk fat, FCM and decrease in milk protein for cows entering the groups during the experiment.

Factors that may contribute to the variability in responses to live-cell yeast include level of feed intake, number and kind of organisms in the yeast culture, viability of the cultures, and specific ingredient combinations in the rations.

This research was conducted to explore the possibility that adding yeast culture to a wheat based concentrate mixture might impact the microbial action in the rumen in a manner which would be improve performance of lactating cows.

Materials and Methods

The responses of lactating dairy cows to rations with and without yeast culture (YEA-SACC) at a level suggested by the manufacturer, were measured in a feeding trial. The experimental rations were: (1) corn-based concentrate mixture, (2) corn-based mixture plus 1.5 g/kg YEA-SACC, (3) wheat-based concentrate mixture, and (4) wheat-based mixture plus YEA-SACC. The concentrate mixtures and alfalfa hay were fed in a 50:50 ration. (Table IV).

Twenty-four Holstein cows received the experimental rations in a switchback design with three 4-week periods (Lucas, 1956). The first two weeks of each period were allowed for adjustment to rations with data from the final two weeks used for comparisons among treatments. Cows were assigned by calving date to one of twelve treatment sequences (Appendix, Table XIV). Each treatment sequence included two treatments, one of which was applied during the first and third period, while the other was applied during the second period. All treatments were applied the same number of times. The concentrate and forage were fed in individual stanchions in two equal portions twice daily at 12-h intervals. The hay was fed separately from the concentrate mixture at approximately 4 hours after feeding of the concentrate mixtures. Feed intake was recorded daily and feed orts for each cow were composited on a weekly basis for dry matter (DM) and crude protein (CP) analysis. Dry matter was determined by drying the fecal samples in a forced-air oven at 60 ^{o}C for 48 hours and for crude protein (N x 6.25) by the macro-kjeldahl method (A.O.A.C., 1975).

Milk yield was recorded twice daily and samples were taken at four consecutive milkings each week for

TABLE IV

COMPOSITION OF CONCENTRATE MIXTURES

Item	Control (corn-base)	Yeast (corn-base)	Control (wheat-base)	Yeast (wheat-base)
Ingredients (%, as fed)				
Corn	65	65	18	18
Wheat[1]	--	--	60	60
Sorghum grain	6	6	--	--
Cottonseed meal, solv. ext.	9.5	9.5	2.5	2.5
Fixed portion[2]	19.5	19.5	19.5	19.5
Yeast culture (YEA-SACC)[3]	-	+	-	+
Calculated analysis (as fed)				
Net energy, Mcal NE_L/100 Kg	166.0	166.0	169.0	169.0
Total protein, %	12.0	12.0	12.0	12.0
Rumen undegradable protein, %	5.8	5.8	3.3	3.3
Crude fiber,	7.9	7.9	7.7	7.7

[1] Hard red winter wheat, No.2 grade.

[2] Fixed portion of concentrate mix: soybean hulls 15, dicalcium phosphate 2.0, salt .75, sodium bicarbonate 1.25, and magnesium oxide 0.5%

[3] Product produced by ALLTECH, Nicholasville, KY; included in mix at a level of 1.5 g/kg

determination of fat and protein content. Concentration of fat in milk was determined using a Milko Tester MK III F-3140, and protein concentration was determined by using a pro-milk MK II F-12500 by the Oklahoma State DHIA Laboratory. Each cow was weighed on two consecutive days prior to the trial and on the last and first day of each period. The cows were weighed just prior to milking and the milk weight of the subsequent milking was deducted from the respective body weights.

During the last week of each period, a rumen fluid sample was taken from each cow by stomach tube 3 to 4 h after concentrate feeding. Fluid samples were analyzed for ruminal pH, ammonia-N (NH_3-N) and volatile fatty acid concentrations. A minimum of 300 ml of rumen fluid was strained through a double layer of cheese cloth, and pH measured immediately. Two hundred milliliters of rumen fluid was then acidified with 8 ml of 50% hydrochloric acid and frozen. Rumen ammonia-nitrogen (NH_3-N) was analyzed using the spectrophotometrically phenol-hypoclorite procedure of Broderick and Kang (1980). The concentration of NH_3-N was determined using a Varian DMS 90 spectrophotometer at a wavelength of 630 nm. One hundred milliliters of the strained rumen fluid was mixed with 1 ml of saturated mercuric chloride and frozen. In the lab, these samples were thawed and centrifuged (200 x g) for 10 minutes. One ml of 25% (w/v) meta-phosphoric acid was added to 5 ml of the supernatant and centrifuged a second time for 20 minutes at

25,000 x g. One ml of supernatant was then combined with 0.2 ml of 2-ethylbutiric acid (internal standard), and vortexed. Samples were analyzed by gas chromatography. At the same time rumen fluid samples were taken, blood samples were taken from the media caudal vein. The blood was withdrawn into 15 ml vacutainer tubes and mixed with 0.15 ml of oxalic acid (12.98 g/200 ml) to prevent coagulation. Samples were immediately placed on ice and allowed to coagulate. Coagulated samples were centrifuged (2000 x g for 30 minutes) and the plasma was withdrawn and frozen. Blood urea-nitrogen was determined by the method of Fawcet et al. (1960).

Neutral detergent fiber (NDF) and CP digestibility were determined using chromic oxide ($Cr_2 0_3$) as an indigestible marker. Chromic oxide was added to the four concentrate mixtures at a level of 0.27% during the last three weeks of the second and third period. Fecal grab samples were taken from 20 cows for four days at four hour intervals. Chromium intake was estimated as the difference between feed offerred and feed refused. Chromium content in the fecal, grain and weigh-back samples was determined using a varian DMS 90 spectrophotometer at a wavelength of 400 nm. (Appendix, Table XXIII). Neutral detergent fiber content of samples was determined by the method of Goering and Van Soest (1970).

Statistical analysis was conducted by summarizing the different response variables on a "per period" basis. Analysis of variance (Lucas, 1956) was performed with block, period, cow and treatment included in the model (Appendix,

Table XV). The adjusted treatment means were compared using pre-planned orthogonal contrasts as follows: Corn mixture vs. wheat mixture;, no yeast vs. yeast and grain type x yeast.

Results and Discussion

The coefficient of variability for most variables was quite low (e.g., 3.4% for milk yield and 5.8% for total dry matter intake, Appendix Table XIX), indicating a high level of consistency in the responses of cows in the trial. Intake of dry matter on wheat diets was lower (P<.001) than on corn diets (Table V). Wheat starch is more readily fermented in the rumen than corn starch (Axe et al., 1987). Therefore, the decreased intake demonstrated by cows fed wheat based rations may have been due to altered ruminal fermentation. Faldet et al. (1986) also noticed a decrease in both concentrate and hay intakes when cows were fed rations containing wheat. However, McPherson and Waldern (1969) reported similar DM intakes when soft white wheat replaced barley up to 93% of the concentrate mixture.

In the present study intake of concentrate was affected by grain type, indicating that factors other than palatability of the concentrate mixtures were involved (Table V). Intake of DM tended to be lower for cows fed rations containing yeast culture than for those fed rations without yeast; however, the differences were relatively small (P>.3). Several authors (Fallon and Harte 1987, Hughes 1987, Lyons

TABLE V

FEED INTAKE AND MILK YIELD OF COWS

Item	Control (corn-base)	Yeast (corn-base)	Control (wheat-base)	Yeast (wheat-base)	Statistical Significance Grain type	Yeast	Inter-action	SE
Dry matter intake, Kg/day								
Concentrate mix	12.1	11.9	11.2	10.9	P<.001	NS	NS	0.49
Alfalfa hay	11.8	11.7	10.6	10.6	P<.001	NS	NS	0.47
Total	23.9	23.6	21.8	21.5	P<.001	NS	NS	0.87
Protein intake, Kg/day								
Concentrate mix	1.55	1.51	1.57	1.57	NS	NS	NS	0.06
Alfalfa hay	2.45	2.45	2.24	2.22	P<.001	NS	NS	0.09
Total	4.00	3.96	3.81	3.79	P<.02	NS	NS	0.13
Milk yield								
Milk, Kg/day	32.0	31.2	30.5	30.4	P<.003	NS	NS	0.68
Fat test, %	3.36	3.48	3.17	3.22	P<.009	NS	NS	0.07
FCM, Kg/day	29.0	28.8	26.9	26.9	P<.001	NS	NS	1.03
Protein, %	2.99	3.01	3.00	3.02	NS	NS	NS	0.02
Gross feed efficiency (Milk/total DM intake)	1.35	1.33	1.41[a]	1.43	P<.01	NS	NS	0.02

NS = Not significant (P>.05)

1986) have suggested increased DM intakes by ruminants fed yeast cultures due to a buffer capacity of the additive. Lassiter et al. (1958) observed no effect of yeast culture on feed intake by dairy cows. In contrast Gomez-Alarcon et al. (1987) noted improved feed intake when yeast was included to dairy rations.

Total protein content of all the rations was calculated to be the same; therefore, the greater protein intake by cows fed rations containing corn (Table V) simply reflected greater feed intake by those cows.

As previously observed in other trials (Campbell et al., 1988; Cunningham et al., 1970; Faldet et al., 1986) milk yield of cows fed concentrate mixtures containing corn was higher ($P<.003$) than that of cows fed mixtures containing 60% wheat (31.59 vs 30.45 kg/day) which could be attributed to a lower DMI of cows fed wheat than of cows fed corn. Milk fat test of cows fed the corn mixtures was also increased ($P<.01$), resulting in an advantage in 4% FCM yield of 2.05 kg/day in comparison to that of cows fed the wheat mixtures (Table V). Milk yield and fat content were not affected by inclusion of yeast culture ($P>.05$). Similar results were reported by Jordan and Ward (1959) which showed no changes in any of the milk traits when yeast was added to the concentrate mixture of Holstein cows, but contradicts Harris and Lobo (1987) who reported a increase in milk fat content and FCM of the cows fed the yeast culture. Neither grain type nor addition of yeast culture affected milk protein content in this trial.

As observed by Campbell et al. (1988), the molar percentage of acetic acid in the ruminal fluid was higher ($P<.007$) for cows fed the mixtures containing corn than wheat (65.4 vs 60.9, Table VI). The molar percentage of propionic acid in the rumen fluid of cows fed the corn mixtures was lower ($P<.004$) than for those fed wheat (21.9 vs 26.6) which was consistent with the observed difference in milk fat content. No significant differences in VFA proportions were attributable to inclusion of yeast culture in the concentrate mixtures.

The pH of the ruminal fluid was higher ($P<.01$)in cows fed the corn mixtures than in those fed wheat (6.2 vs 5.9), which was consistent with the changes in VFA proportions noted above. These differences were consistent with other observations (Nalsen et al., 1987, Faldet et al., 1986) that both the protein and carbohydrate fractions of wheat are degraded very rapidly in the rumen of cows. Addition of yeast culture did not affect ruminal pH. Neither grain type nor yeast culture had any effect on concentration of ruminal NH_3-N or blood plasma urea-N (Table VII).

Apparent digestibility of total DM and protein was lower ($P<.001$) for cows fed mixtures containing corn than for cows fed the wheat mixtures (Table VII) probably due to an increase feed intake demonstrated by cows fed corn based mixtures, which could increased the passage of food particles

TABLE VI

EFFECT OF DIET ON MOLAR PROPORTION OF RUMINAL VFA

Acid	Control (corn-base)	Yeast (corn-base)	Control (wheat-base)	Yeast (wheat-base)	Statistical Significance: Grain type	Statistical Significance: Yeast	Statistical Significance: Interaction	SE
Total Conc., mm/l	450.2	335.8	470.4	472.1	P<0.03	NS	NS	32.05
Acetic	65.60	65.10	60.94	60.90	P<.007	NS	NS	1.37
Propionic	22.00	21.82	26.60	26.60	P<.004	NS	NS	1.32
Isobutyric	.35	.45	.35	.33	NS	NS	NS	0.08
Butyric	10.03	10.23	9.46	9.61	NS	NS	NS	0.67
Isovaleric	1.02	1.22	.86	.86	P<.03	NS	NS	0.09
Valeric	1.0	11.18	1.79	1.73	P<.001	NS	NS	0.11

NS = Not significant (P>.05)

TABLE VII

EFFECT OF DIET ON RUMINAL PH AND NH_3-N CONCENTRATION BLOOD UREA-N AND TOTAL APPARENT DIGESTIBILITY OF RATION COMPONENTS

Item	Control (corn-base)	Yeast (corn-base)	Control (wheat-base)	Yeast (wheat-base)	Statistical Significance			SE
					Grain type	Yeast	Inter-action	
Ruminal pH	6.18	6.27	5.86	6.01	P<.01	NS	NS	0.09
Ruminal NH_3-N, mg/dl	4.6	5.2	4.5	5.0	NS	NS	NS	0.80
Blood urea-N, mg/dl	12.4	12.3	12.0	12.9	NS	NS	NS	0.98
Ration digestibility,%								
Dry matter	68.9	68.2	72.6	70.3	P<.001	NS	NS	0.98
Total protein	65.4	64.5	71.2	69.8	P<.001	NS	NS	0.87
Neutral-detergent fiber	58.4	58.4	63.6	58.3	NS	NS	NS	2.03

NS = Not significant (P>.05)

from the rumen and depressed digestibility. Since the carbohydrate of grains is mainly starch, the lack of a difference in apparent digestibility of NDF due to type of grain was not unexpected. Addition of yeast culture had no effect on apparent digestibility of any of the ration components measured under the conditions of this trial. Harrison et al.(1988) reported no effects on apparent digestibilities of DM, NDF. acid detergent fiber (ADF), hemicellulose, or starch when yeast culture was added to medium-high concentrate rations (40% corn silage and 60% concentrate, DM basis). Eventhough an increase in number of cellulolityc bacteria was found in the yeast culture added diets, they concluded that "lack of response in apparent digestibility of the fiber fraction of the ration could be due to the fact that although yeast culture stimulated an increase in the number of cellulolityc bacteria, the activity of these organisms was somehow decreased".

Addition of yeast culture (YEA-SACC) to concentrate mixtures for dairy cows with either corn or wheat as the principal energy source did not affect performance under the conditions of this trial. There was no effect on feed intake, milk yield and composition, pH of ruminal fluid, molar proportions of VFA and concentration of NH_3-N in ruminal fluid, blood plasma urea-N concentration, and apparent digestibilities of total dry matter, protein and NDF.

Dairy cow rations need to have a relatively high forage:concentrate ratio in order to yield adequate levels of milk fat. Cows consuming diets with higher levels of grain (70% and up), will tend to produce less milk fat than those consuming higher forage diets. Most of the literature reviewed reported improvements in milk traits when yeast was added to high concentrate diets, but few positive reports are found using yeast in low concentrate rations for dairy cows. Thus addition of yeast to diets may provide little benefit to the dairy industry since positive effects of yeast occur at concentrate levels beyond those currently used in dairy cattle.

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CHAPTER IV

THE INFLUENCE OF ADDING YEAST CULTURE IN THE CONCENTRATE DIET ON CALF PERFORMANCE

Abstract

The effect of supplementing rations with yeast culture (Sacharomyces cerevisiae, YEA-SACC) on liveweight (LW), dry matter intake (DMI) and ruminal metabolites was evaluated in a 70 day trial using 24 Holstein bull calves (49.6 kg) and 24 Holstein heifer calves (45.05 kg) of approximately 3 weeks of age. Calves were randomly assigned to the following concentrate diets: a) corn-based concentrate mixture (C); b) C plus 1.0 g of Yea-Sacc/kg (CY); c) wheat-based (30 % wheat)(W); and, d) W plus Yea-Sacc (WY). In addition to the experimental diets, animals also received whole milk (8% $Bw^{.75}$) during the first 2 wk of the experimental period. The mean concentrate DMI from 1 to 70 days was similar (P>.05) (139.8, 127.6, 126.8 and 130.9 kg for treatments C, CY, W, and WY, respectively, with a slight advantage of the corn diets over the wheat diets. The corresponding LW gains were 0.86, 0.79, 0.71, and 0.76 kg/day for treatments C, CY, W, and WY, respectively. LW gains were greater for bull calves than females (P<.05) with

improved performance for the animals fed the corn rations (P<.02).

Neither DMI nor LW gains was affected by the inclusion of yeast. Animals fed corn diets had better feed efficiency than calves fed wheat diets (2.3 vs. 2.5) (P<.001). Bull calves were more efficient than heifer calves (P<.05). The pH of the ruminal fluid was not affected by treatment.

Introduction

One of the most important phases of dairy production is feeding and managing dairy calves. The need to develop good replacement animals on the dairy farm, and the desire to divert less milk to calf feeding has led to many changes in calf feeding recommendations during the last four decades.

It is well known that energy and protein play an important role in the rearing of the dairy calf whether for veal, beef or as a dairy herd replacement. Grains such as wheat, corn, or both, provide an excellent source of energy for cattle that are at high levels of production or unable to utilize forages. Preruminant calves, under 100 days of age, lack sufficient salivary amylases and other carbohydrate digesting enzymes resulting in insignificant use of starch (Roy, 1970). The inclusion of yeast culture to the concentrate rations of dairy calves appears to help that situation. According to Lyons (1987), yeast contains enzymes which are both protein digesting (proteases) and starch digesting (amylases) in addition to protein, vitamins and other nutrients. Therefore, improvements in digestibility in the diet of young calves as well as in non-ruminants diets, may be expected.

A number of field observations have suggested an improvement in fat percent, milk yield, and nutrient digestibility when yeast culture is added to rations of lactating dairy cows. In recent work, Wiedmeier et al. (1987) reported addition of yeast cultures to diets of Holstein cows increased total bacteria numbers and increased proportion of cellulolytic bacteria in the rumen. The same was observed by Arambel and Tung (1987) in Holstein heifers fed yeast supplemented diets. Lassiter et al. 1958, reported that the addition of a live yeast culture at the rate of 1% of a grain ration had no significant effect on production of 4% fat corrected milk (FCM), fat test or feed intake by dairy cows.

There have been few reports specifically related to supplementing dairy calf rations with yeast cultures. Fallon and Harte (1987) at the Agricultural Institute in Ireland carried out an eighty four day experiment to evaluate the inclusion of yeast culture in the concentrate diets of calves weaned after 42 days on milk replacer. They reported that a barley-soya starter diet containing Yea-Sacc increased concentrate DMI by 12.5 kg and LW gain by 10.1 kg during the entire trial. However, no effect on feed intake was detected when yeast was included in a corn-barley diet whereas LW gain was increased by 3.4 kg. Similar results were reported by Hughes (1987) based on a 84 day trial conducted at " Carrs Farm Foods Low Close Calf Development" in Cumbria to measure calf performance when yeast culture was included in the concentrate mixtures. The inclusion of yeast resulted in an 8.5 kg increase in LW gain and 18 kg increase in DMI for the entire trial. Feed conversion efficiency also was improved by the addition of yeast. Phillips and Von Tungeln (1985) found that the addition of yeast culture to the poststress diets of feeder calves did not consistently increase either DMI nor poststress performance.

This experiment was conducted to measure the effect of adding yeast culture to corn and wheat based concentrate rations fed to dairy calves in terms of: 1) dry matter feed intake, 2) liveweigth gain, 3) feed efficiency and 4) ruminal metabolites.

Materials and Methods

Twenty four Holstein bull calves (49.6 kg) and 24 Holstein heifer calves (45.2 kg) were blocked according to sex, then randomly assigned at 3 wk of age to the following concentrate diets: a) control corn based concentrate mixture (C); b) C plus 1.0 g of Yea-Sacc/kg (CY); c) wheat mixture (30% wheat) (W); and d) W plus Yea-Sacc (WY) (Table VIII). Two calves died and two more were removed from the data set after the trial due to a heavy incidence of diarrhea. Diets were formulated to meet established nutrient requirements of

TABLE VIII

COMPOSITION OF CONCENTRATE MIXTURES

Item	Control (Corn-Base)	Yeast (Corn-Base)	Control (Wheat-Base)	Yeast (Wheat-Base)
Ingredients (%, as fed)				
Corn	30.0	30.0	--	--
Wheat[1]	--	--	30.0	30.0
Sorghum grain	17.5	17.5	20.0	20.0
Soybean meal, solv.	20.0	20.0	16.5	16.5
Oats	7.0	7.0	8.0	8.0
Fixed portion[2]	19.5	19.5	19.5	19.5
Yeast culture (YEA-SACC)[3]	-	+	-	+
Calculated analysis (as fed)				
Net energy, Mcal NE_L /100 Kg	151.4	151.4	151.2	151.2
Total protein, %	17.0	17.0	17.0	17.0
Rumen undegradable protein, %	7.14	7.14	5.78	5.78
Crude fiber,	6.0	6.0	7.0	7.0
Calcium, %	0.56	0.56	0.55	0.55
Phosphorus, %	0.51	0.51	0.51	0.51

[1] Hard red winter wheat, No.2 grade.
[2] Fixed portion of concentrate mix: Alfalfa dehy pellets, 15.0, molasses liquid 5.0, dicalcium phosphate 1.0, salt 0.5, sodium bicarbonate 4.0%.
[3] Product produced by ALLTECH, Nicholasville, KY; included in mix at a level of 0.9 kg/ton.

growing dairy calves (National Research Council, 1978), and calculated to be isonitrogenous and approximately equal in energy content.

In addition to concentrate diets, calves were fed whole milk (8% $Bw^{.75}$) during the first two weeks of the trial. Animals were individually penned and fed at appetite with feed and water available at all times. Feed orts were removed and weighed weekly. Samples of the concentrate mixes were taken every week for analysis of crude protein (CP) and DM.

Calves were weighed weekly until the trial was completed. During the fourth and ninth week of the trial, ruminal samples were taken from each calf by stomach tube to determine ruminal pH and volatile fatty acid concentrations (VFA). A minimum of 80 ml of ruminal fluid was collected and strained through a double layer of cheese cloth and pH measured immediately. Fifty mililiters of strained rumen fluid was mixed with 0.5 ml of saturated mercuric chloride and then frozen for later VFA determination. These samples were later thawed and centrifuged (200 x g) for 10 minutes. One ml of 25% (w/v) meta-phosphoric acid was then added to 5 ml of the supernatant solution and centrifuged a second time for 20 minutes at 25,000 x g. One ml of supernatant was withdrawn, combined with 0.2 ml of 2-ethylbutiric acid (internal standard), and vortexed. Samples were then analyzed by gas chromatography.

Data were analyzed statistically as a 2 x 2 factorial experiment with a complete randomized block design with sex as the blocking factor (Steel and Torrie, 1980). An analysis of variance was performed on the data collected for the different response variables with block and treatment included in the model (Appendix, Table XVI). The adjusted treatment means were compared using pre-planned orthogonal contrasts as follows: corn-wheat; yeast-none; and grain x yeast.

Results and Discussion

Feed intake was similar for all treatments (P>.05) (Table IX) The inclusion of yeast in the concentrate diets did not significantly improve intake (P>.05). However, with the exception of the heifer calves fed the corn diets, there was a slight improvement in feed intake when yeast was added to the diets (P>.05). Calves fed the corn diets demonstrated a slightly greater feed intake than those fed the wheat rations, but the differences were too small and not significant (P>.05). These results are in agreement with observations from our first trial (Chapter III) where cows fed corn rations also had greater feed intakes (P<.05). Wheat starch is more readily fermented in the rumen than corn starch (Axe et al., 1987); therefore, production of organic acids in the rumen may overcome the ability of tissues or microbes to absorb and utilize them. Subsequently, rumen pH declines and reduced intake follows

TABLE IX

FEED INTAKE AND LIVEWEIGHT GAINS BY DAIRY CALVES

Item	Control (Corn-base)	Yeast (Corn-base)	Control (Wheat-base)	Yeast (Wheat-base)	Statistical Significance Grain type	Yeast	Inter-action	SE
Number of animals	10	12	9	12	--	--	--	--
Initial body weight, (Kg)	48.2	48.0	45.0	47.8	--	--	--	--
Final body weight, (Kg)	109	104	95.05	101.5	--	--	--	--
Liveweight gain, (Kg/d)	0.86	0.79	0.71	0.76	P<.02	NS	NS	2.65
Dry matter intake (Kg) 1-70 days	139.8	127.6	126.8	130.8	NS	NS	NS	7.07
Protein intake, (Kg/d)	0.36	0.33	0.34	0.37	NS	NS	NS	1.33
Feed conversion efficiency (Kg feed/Kg gain)	2.31	2.29	2.54	2.44	P<.001	NS	NS	0.05

NS = Not significant (P>.05)

(Britton, R.A. and R.A. Stock, 1986). Different results were reported by Fallon and Harte (1987). They found an improvement in feed intake when 2.2 g/kg of yeast culture was added to a barley-soya diet fed to a group of growing dairy calves. Inclusion of yeast in a corn-barley diet had no effect on DMI. They suggested that the inclusion of yeast culture had a positive effect on fermentation conditions in the developed rumen causing an increase in rumen pH, thus improving feed intake. In our experiment that effect was not evident. Slowly degraded diets (corn based) resulted in greater feed intake than rapidly fermented diets (wheat based), suggesting that the inclusion of 1 g/kg yeast apparently did not exert any effect in the fermentation conditions in the rumen of calves fed wheat based diets.

Protein intake (Table X) was found to be similar ($P>.05$) for all treatments over the entire trial. Rations were calculated to be isonitrogenous and feed intakes were similar.

LW gains were greater ($P<.05$) for the bull calves (Appendix Table XIX) than for the heifer calves (Appendix Table XVIII). Although, not significant, rations of bull calves containing yeast culture resulted in a slight increase (.05 g/d) in gain compared to rations without yeast. Also, animals fed corn rations gained more ($P<.02$) than animals fed wheat rations (Table X), which is in agreement with results on dairy cows reported by Tommervik and Waldern (1969), Nalsen et al. (1987), and Campbell et al. (1988) Increased gain with yeast supplemented diets and corn diets is probably a consequence of improved feed intake. Though not significant (P>.05), feed efficiency showed a similar pattern with the yeast diets being more efficient. A significant increase (P<.001) in feed efficiency was demonstrated for the corn diets over the diets containing wheat. Hughes (1987) reported that increased weight gains and feed efficiency were obtained at "Carrs Farm Foods Low Close Calf Development" in Cumbria when yeast culture was included in a calf concentrate diet at 2.2 g/kg. Similarly Fallon and Harte (1987) reported improvements in LW gain and feed efficiency of 10.1 kg and 3.4 kg fed/kg gain, respectively for the entire trial when yeast culture was included in a barley-soya diet and a corn-barley diet. The level of yeast used in our study was lower than that used in their study. Both groups of experimenters suggested that the benefit demonstrated by the inclusion of yeast culture in the concentrate mixtures of dairy calves could be attributed in great extent to the buffering capacity of the additive. Buffering prevents wide fluctuations in ruminal pH that occur with concentrate intake in the developing ruminant calf, encouraging the calf to eat more solid food. As a result, aditional LW gain is achieved from the extra solid food consumed. In our case, all the rations fed included dicalcium phosphate and sodium bicarbonate as buffering agents; therefore, it is difficult to state that fluctuations in rumen pH, if they occurred, were reduced either by the presence of yeast or the buffers added to the concentrate diets.

The molar percentage of acetic acid in ruminal fluid was lower ($P<.04$) for the calves fed mixtures containing corn than for those fed mixtures with wheat,(50.05 vs 53.3) (Table X). This result was surprising as higher values for acetic acid were expected with corn mixtures as compared with wheat diets, (Campbell et al., 1988; Faldet et al., 1986). The molar percentage of propionic, butyric, isovaleric, and valeric acid was similar ($P>.05$) for all treatments. The inclusion of yeast culture in the concentrate mixes did not cause any changes in VFA proportions.

The pH of the ruminal fluid (Table XI) was similar for all treatments. No significant differences ($P>.05$) were detected either for grain type or inclusion of yeast in the concentrate diets.

Under the conditions of this trial, inclusion of Yea-Sacc to concentrate mixtures for dairy calves with either corn or wheat as the principal energy source did not significantly improve performance. However, the slight improvements shown for DMI, LW gain and feed efficiency though not significant, suggests that some benefit might be achieved by the inclusion of yeast in diets of growing dairy calves. Identification of conditions where addition of yeast culture to rations of dairy calves might be beneficial

TABLE X

EFFECT OF DIET ON MOLAR PROPORTION OF RUMINAL VFA OF DAIRY CALVES

Acid	Control (Corn-base)	Yeast (Corn-base)	Control (Wheat-base)	Yeast (Wheat-base)	Statistical Significance Grain type	Yeast	Inter-action	SE
Total Conc., mm/l	408	370.6	363.8	369.7	NS	NS	NS	39.7
Acetic	50.7	49.4	51.8	54.7	P<0.04	NS	NS	1.51
Propionic	36.4	37.3	38.4	35.7	NS	NS	NS	1.12
Butyric	7.8	8.7	6.0	6.0	P<0.002	NS	NS	0.67
Isovaleric	0.65	0.36	0.44	0.76	NS	NS	NS	0.15
Valeric	4.36	4.20	3.37	2.73	P<0.004	NS	NS	0.39

NS = Not significant (P>.05)

TABLE XI

EFFECT OF DIET ON RUMINAL PH OF DAIRY CALVES

Item	Control (Corn-base)	Yeast (Corn-base)	Control (Wheat-base)	Yeast (Wheat-base)	Statistical Significance: Grain type	Yeast	Inter-action	SE
pH	5.7	5.7	5.6	5.8	NS	NS	NS	0.09

NS - Not significant (P>.05)

requires future research, such as type of diets, age of animals, level of yeast included in the diets, etc.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Several studies have demonstrated that as larger amounts of wheat are incorporated in dairy concentrate diets, milk yield and feed intake of cows tend to decrease. At the present time there is a surplus of wheat in the U.S.A., which has a direct influence on the price of the grain, lowering it in most cases and making it competitive with other feed grains used as an energy source in dairy rations. Two trials were conducted to explore the feasibility of feeding wheat based rations and to observe effects of addition of yeast culture (*Sacharomyces cerevisiae*, YEA-SACC) on ruminal microbial action and performance of dairy cattle. In the first trial 24 Holstein cows were fed concentrate rations with alfalfa hay as the only forage in a 50:50 ratio. The concentrate mixtures were: a) control corn based concentrate mixture, b) control plus 1.5 g/kg of Yea-Sacc, c) wheat based concentrate mixture (60% wheat), and d) wheat mixture plus Yea-Sacc. Addition of Yea-Sacc to concentrate mixtures for dairy cows with either corn or wheat as the principal energy source did not affect performance under the conditions of this trial.

There was no significant effect of the addition of yeast culture on feed intake, milk yield, milk composition, pH of ruminal fluid, molar proportions of VFA and concentration of NH_3-N in ruminal fluid, blood plasma urea-N concentration, and apparent digestibility of total dry matter, protein and neutral detergent fiber of diets.

For the second trial, the effect of supplementing rations with yeast culture was evaluated in a 70 d trial using 24 Holstein bull calves (49.60 kg) and 24 Holstein heifer calves (45.05 kg) of approximately 3 weeks of age. Complete rations were offered to the animals as follows: a) control corn mixture (C); b)C plus 1.0g/kg of yeast culture (CY); c)wheat mixture (30% wheat) (W); and d)W plus yeast. In addition to the experimental diets, animals also received whole milk (8% $Bw^{0.75}$) during the first two weeks of the experimental period. Dry matter intakes were similar for both kinds of animals (bulls and heifers) with a slight advantage with corn diets over the wheat diets. The inclusion of yeast in the concentrate diets did not significantly improve intake. However, with the exception of the heifer calves fed the corn diets, there was a slight improvement in feed intake when yeast was added to the diets. The corresponding liveweight gains were greater for bull calves than heifers calves. Though not significant, rations containing yeast culture resulted in a slight increase in gain compared to rations without yeast. Feed efficiency followed a similar pattern as above, calves fed the corn based diets had better feed efficiency than calves receiving the wheat diets ($P<.001$), bull calves were more efficient ($P<.0002$) than heifer calves and yeast added rations were slightly better than non yeast diets. No significant differences were detected on the pH of the ruminal fluid, regardless of the treatment.

Both trials demonstrated that under the conditions provided, the addition of yeast culture in concentrate mixtures for dairy cows and calves had no significant effect on the parameters measured. In both trials, most of the significant differences observed were due to the type of grain rather than the yeast treatment. However, the slight improvements shown for some of the traits meassured in the calf trial suggests that some benefit migth be achieved by the inclusion of yeast in diets of dairy calves. Finally, it is important to remember that there may be many factors contributing to the variability in responses obtained to feeding live-cell yeast to ruminant animals. Level of feed intake, number and kind of organisms in the yeast culture, frequency of feeding, viability of the cultures, and specific ingredients combinations in the rations may contribute to variation in results.

LITERATURE CITED

Adams, D.C., M.L. Galyean, H.E. Kiesling, J.D. Wallace and M.D. Finker. 1981. Influence of viable yeast culture, sodium bicarbonate and monensin on liquid dilution rate, rumen fermentation and feedlot performance of growing steers and digestibility in lambs. J. Anim. Sci. 53:780-789.

A.O.A.C. 1975. Official methods of analysis. 12th edition. Association of Official Analytical Chemists, Washington, D.C.

Ajeani, Y.C., C.V. Maxwell, F.N. Owens, D. Holbert, K.B. Poling and J.S. Schooley. 1979. Whey-grown yeast as a protein source for baby pigs. Oklahoma Agr. Exp. Sta. MP-104:166-172.

Arambel, M.J. and B.A. Kent. 1988. Effect of yeast culture on milk production response and apparent nutrient digestibility in early lactating dairy cows. ADSA 83-RD annual meeting. June 26, pp. 220.

Arambel, M.J. and T. Tung. 1987. Fungal additives for lactating cows. Proc Pacific N.W. Nutr. Conf., Portland, OR.

Axe, D.E., K.K. Bolsen, D.L. Harmon, R.W. Lee, G.A. Milliken, and T.B. Avery. 1987. Effect of wheat and high-moisture sorghum grain fed singly and in combination on ruminal fermentation, solid and liquid flow, site and extent of digestion and feeding performance of cattle. J. Anim. Sci. 64:897.

Barber, R.S., R. Braude, K.G. Mitchell and A.W. Myers. 1971. The value of hydrocarbon-grown yeast as a source of protein for growing pigs. Br. J. Nutr. 25:285.

Beeson, W.M. and T.W. Perry. 1952. Balancing the nutrition deficiencies of roughages for beef steers. J. Anim. Sci. 11:501-515.

Bhattacharjee, J.K. 1970. Microorganisms as potential sources of food. Adv. Appl. Microbial 13:139.

Bowstead, J.E. 1930. Wheat as a concentrate for dairy cows. Dept. of Anim. Husbandry, Univ. of Alberta, June Animal Feeder's Day.

Braude, R. 1976. New sources of protein for pigs. Proc. Nutr. Soc. 35:93.

Brethour, J., B. Lee and J. Riley. 1985. New developments in feeding wheat to cattle. Kansas Agr. Exp. Sta. 474.

Britton, R.A. and R.A. Stock. 1987. Acidosis, rate of starch digestion and intake. In: F.N. Owens (ed.) feed intake by beef cattle. Oklahoma Agri. Exp. Sta. MP-121:125-137.

Broderick, G.A. and J.H. Kang. 1980. Automated simultaneous determination of ammonia and total amino acids in ruminal fluid and in vitro media. J. Dairy Sci. 63:64.

Bruning, C.L. and M.T. Yokoyama. 1988. Characteristics of live and killed brewer's yeast slurries and intoxication by intraruminal administration to cattle. J. Anim. Sci. 66:585-591.

Burkitt, W.H. 1983. Beef report. Research Briefs. Diamond "V". Rb-92.

Campbell, C.G., L.J. Bush and G.D. Adams. 1988. High wheat concentrate mixtures containing different sources of protein for lactating dairy cows. Oklahoma Agr. Exp. Sta. MP-125:214.

Carter, H.E. and G.E. Phillips. 1944. The nutritive value of yeast proteins. Federation proceedings, 3:123.

Condon, R.J. 1971. Metabolism of exogenous nucleic acid by ovines. Ph.D. thesis, University of Illinois, Urbana, IL.

Copeland, O.C. 1933. Wheat versus milo for dairy cows. Texas Agr. Exp. Sta. Bull. 480.

Criberio, T.C., A. Elias and I. Denis. 1979. Substitution levels of maize by wheat in concentrates and their effects on milk production and composition. Cuban J. Agr. Sci. 13:19.

Crowther, C. 1913. Dried yeast as food for farm stock. Journ. Bd. Agr. 22:1, pp. 1-10.

Cunningham, M.D., J.L. Albright and W.T. Howard. 1970. Percent protein and amounts of soft red winter wheat for lactating cows. J. Dairy Sci. 53:1787-1790.

Dainakanoko Agricultural Cooperative Association. 1979. Feedlot Report. Research Briefs. Diamond "V". Rb-66a.

Edmond, M.S. and R.G. Teeter. 1983. The effect of yeast culture on the performance of two poultry types fed under various regimes. Oklahoma Agr. Exp. Sta. MP-114:242-244.

Ensminger, M.E. 1980. Dairy cattle science. Second edition. The Interstate Printers & Publishers, Inc. U.S.A.

Faldet, M.A., L.J. Bush and G.D. Adams. 1986. Influence of different levels of wheat in the concentrate mixture on production responses of lactating dairy cows fed alfalfa hay as the only forage. Okla. Agric. Exp. Sta. MP118:71-76.

Fallon, R.J. and F.J. Harte. 1987. The effect of yeast culture inclusion in the concentrate diet on calf performance. ADSA 82nd annual meeting. June 21. pp 143.

Fawcet, J.K. and J.E. Scott. 1960. A rapid and precise method for the determination of urea. J. Clin. Path. 13:156.

Fitch, J.B. and H.W. Cave. 1932. Ground wheat versus ground corn for dairy cows. Kansas Station Biennial Report.

Fulkerson, W.J. and P.J. Michell. 1985. Production response to feeding wheat grain to milking cows. Aust. J.Exp. Agr. 25(2):253-256.

Fulton, W.R., T.J. Klopfenstein and R.A. Britton. 1979. Adaptation to high concentrate diets by beef cattle. 1. Adaptation to corn and wheat diets. J. Anim. Sci. 49:775.

Goering, H.D. and P.J. Van Soest. 1970. Forage fiber analysis (apparatus, reagents, procedures and some applications). Agricultural Handbook 379. USDA, ARS.

Gomez-Alarcon, R., C. Dudas and J.T. Huber. 1987. Effect of aspergillus oryzae on rumen digestion and milk production in dairy cows. Rumen Function Conference. Nov. 18.

Goulet, G., G.J. Brisson and J. Goulet. 1976. Effect of various treatments on the digestibility of single-cell protein (Rhodotomla glutions in rats. Nutr. Rep. Inter. 14:709.

Grieve, D.G. 1979. Feed intake and growth of cattle fed liquid brewer's yeast. Can. J. Anim. Sci. 59:84-89.

Harris B., Jr., and R. Lobo. 1988. Feeding yeast culture to lactating dairy cows. 65th Annual Meeting, Southern Dairy Sci. Assoc. January 31 1988.

Harrison, G.A., R.W. Hemken, K.A. Dawson, and R.J. Harmon. 1988. Influence of addition of yeast culture supplement to diets of lactating cows on ruminal fermentation and microbial populations. J. Dairy Sci. 71:2967.

Hawk, P.B., H.R. Fishback and O. Bergeim. 1919. Compressed yeast as food for the growing organisms. Am. J. Physiol. 43:211.

Hayden, C.C. and C.F. Monroe. 1931. Wheat as a substitute for corn in the dairy ration. Ohio Agr. Exp. Sta. BiMonthly Bull. 153.

Horn, G.W., G.E. Burrows and K.S. Lusby. 1982. Effect of yeast culture on nitrate toxicity of lambs and steers fed high-nitrate sorghum-sudan hay. Oklahoma Agr. Exp. Sta. MP-112:58-66.

Hoyos, G. 1987. Effects of feeding viable microbial feed additives on performance of lactating cows in a large dairy herd. Abstract J. Dairy Sci. 70 (Supp.1):217.

Huber, J.T. 1987. Fungal additives for lactating cows. Proc Pacific N.W. Nutr. Conf.

Hughes, J. 1987. Yeast culture applications in calf and dairy diets - a brief appraisal. In: Biotechnology in the feed industry. Alltech Technical Publications. Nicholasville, KY.

Jacobs, E.E. 1931. Can low priced wheat be fed to dairy cows at a profit? Panhandle Agr. Exp. Sta. Bul. 29.

Jordan, H. and G.M. Ward. 1959. Feeding value and in vitro performance of live yeast cultures. J. Dairy Sci. 42:1742.

Kiesling, H. 1978. Feedlot Report. Research Briefs. Diamond "V". Rb-65a.

Lassiter, C.A., C.F. Huffman and C.W. Duncan. 1958. Effect of a live yeast culture and trimethylalkyammonium stearate on the performance of milking cows. J. Dairy Sci. 41:1077-1080.

LeGendre, J.R., R. Totusek and W.D. Gallup. 1955. Effect of live-cell yeast on nitrogen retention and digestibility of rations by beef cattle. J. Anim. Sci. 16:671-674.

Lodder, J. 1970. The Yeasts. North Holland Publishing Co., Amsterdam.

Lucas, H.L. 1956. Switchback trials for more than two treatments. J. Dairy Sci. 39:146.

Lyons, T.P. 1986. Out of the black box. Feed management 37:8-14.

Lyons, T.P. 1987. The role of biological tools in the feed industry. In: Biotechnology in the feed industry. Alltech Technical Publications, Nicholasville, KY, pp.25.

Martin, J.J., C.A. Strasia, F.N. Owens and D.R. Gill. 1985. Wheat to corn ratios for feedlot cattle. Oklahoma Agr. Exp. Sta. MP-117:286.

McCullough, M.E. 1986. Feed for 20,000 pounds of milk - an update. Hoard's Dairyman. April 10. pp 357.

McDonald, P., R.A. Edwards, and J.F.D. Greenhalgh. 1981. Animal Nutrition. 3rd edition. Longhman, London.

McPherson, R.G. and D.E. Waldern. 1969. Pacific northwest soft white wheat for lactating cows. J. Dairy Sc. 52:84.

Moran, J.B. 1983. Barley, wheat or oats grain as cereal sources for dairy cows. Proc. of the Second Symposium of the International Network of Feed Information Centers. p. 429.

Morrison, F.B. 1936. Feeds and feeding. 20th edition. Morrison Pub. Co., pp.663-28.

Nalsen, T., L.J. Bush and G.D. Adams. 1987. Substituting wheat for corn in a concentrate mixture for dairy cows on a weight basis. Oklahoma Agr. Exp. Sta. MP-119:149.

National Research Council. 1973. Nutrient requirements of swine. National Academy Press, Washington, D.C.

National Research Council. 1982. United States-Canadian tables of feed composition. 3rd revision. National Academy Press, Washington, D.C.

National Research Council. 1985. Ruminant nitrogen usage. National Academy Press, Washington, D.C.

National research council. 1978. Nutrient requirements of dairy cattle. 5th rev. ed. Natl. Acad. Sci., Washington, D.C.

Nesmeyanov, A.N., S.V. Rogoshin, G.L. Slonimsky, V.B. Tolstoguzov, R.V. Golovnya, D.G. Valkovsky and M.O.

Rozhansky. 1971. Proc. 8th World petroleum Congress. 5:141.

Nicholson, H.H. 1977. Feedlot Report. Research Briefs. Diamond "V". Rb-58a.

Oltjen, R.R. 1970. Metabolic aspects of feeding wheat to beef cattle. Proc. International Symposium on Wheat in Livestock and Poultry Feeds. June 18-19, pp.126-133.

Peters, J.W., D.G. Braurd, R.G. Goings, K. L. Dolge and R.L. Steele. 1977. Effects of yeast culture added to complete mixed (all-in-one) dairy rations on milk and milk fat production, intake and feed efficiency. J. Anim. Sci. (Suppl. 1) 45:313.

Phillips, W.A. and D.L. Vontungeln. 1985. The effect of yeast culture on the poststress performance of feeder calves. Nutrition Report International. August. 32:287.

Richardson, C.W. 1988. Wheat in the dairy ration. An.Sci. Facts for Oklahoma Extension Workers. July-August. Okla. State Univ., pp.43.

Rose, A.H. 1987. Yeast culture, a microorganism for all species: a theoretical look at its mode of action. In: Biotechnology in the feed industry. Alltech Technical Publications, Nicholasville, KY, pp. 114-117.

Rose, A.H. and J.S. Harrison. 1970. The yeasts, yeast technology. Vol.3. Academic Press, London and New York.

Russel, M.E. 1926. Yeast for pigs. Wisc. Bull. Annual Report 388:134.

Schacklady, C.A. 1969. The production and evaluation of protein derived from organisms grown on hydrocarbon residues. Proc. Nutr. Soc. 28:91.

Shacklady, C.A. and P. Van der Wal. 1968. The use of hydrocarbon-grown yeasts in feeds for growing pigs. Second World Conference on Animal Production. College Park, MD.

Shannon, D.W.F. and J.M. McNab. 1972. The effect of different dietary levels of an n-paraffin-grown yeast on the growth and feed intake of broiler chicks. Brit. Poultry Sci. 13:267.

Shannon, D.W.F. and J.M. McNab. 1973. The digestibility of the nitrogen, amino acids, lipid, carbohydrates, ribonucleic acid and phosphorus of an n-paraffin grown ribonucleic acid and phosphorus of an n-paraffin grown yeast when given to colostomized laying hens. J. Sci. Fd. Agri. 24:27.

Shreswsbury, C.L., C.M. Vestal and S.M. Hauge. 1932. The effect of yeast and casein supplement to corn and soybean rations when fed to rats and swine. Journ. Agr. Research 44:267-274.

Smith, W., M. Lane and C.F. Stewart. 1977. Pilot plant studies on the reduction of chemical oxygen demand of cottage cheese whey by Kluyveromyces fragilis. Animal Science Research Report O.S.U., pp. 176.

Sniffen, C.J. 1986. Natural growth stimulators: Micronutrient requirements of the rumen - the role of yeast cultures in the rumen. Proc. Alltech's 2nd Annual Biotechnology Symposium.

Steel, R.G.D. and J.H. Torrie. 1980. Principles and procedures of statistics. A biometrical aproach. 2nd edition. McGraw-Hill book Co., Inc., New York.

Steckley, J.D., D.G. Brieve, G.K. Macleod and E.T. Moran, Jr. 1979. J. Dairy Sci. 62:947-953.

Stewart, G. and I. Russell. 1981. Yeast. A step to energy independence, Alltech Technical Publications. Lexington, KY, 113-166.

Streeter, C.L., G.W. Horn and J.E. McClung. 1981. Yeast culture in a free-choice mineral supplement for stocker cattle grazing wheat pasture. Oklahoma Agr. Exp. Sta. MP-108:102.

Sullivan, T.W. 1970. Utilization of wheat in turkey feeding programs. Proceedings of an international symposium. June 18-19. Okla. State Univ., Stillwater.

Tegbe, S.B. and D.R. Zimmerman. 1977. Evaluation of a yeast single cell protein in pig diets. J. Anim. Sci. 45:1309.

Thayer, R.H., R.F. Burkett, R.D. Morrison and E.E. Murray. 1978. Efficiency of utilization of dietary phosphorus by caged turkey breeder hens when fed rations supplemented with live yeast culture. Oklahoma Agr. Exp. Sta. MP-103.

Thaysen, A.C. 1943. Value of microorganisms in nutrition (food yeast). Nature 151:406.

Thornton, E.J. 1960. Yeast culture research brief. Diamond "V". Rb-47a.

Nesmeyanov, A.N., S.V. Rogoshin, G.L. Slonimsky, V.B. Tolstoguzov, R.V. Golovnya, D.G. Valkovsky and M.O. Rozhansky. 1971. Proc. 8th World petroleum Congress. 5:141.

Nicholson, H.H. 1977. Feedlot Report. Research Briefs. Diamond "V". Rb-58a.

Oltjen, R.R. 1970. Metabolic aspects of feeding wheat to beef cattle. Proc. International Symposium on Wheat in Livestock and Poultry Feeds. June 18-19, pp.126-133.

Peters, J.W., D.G. Braurd, R.G. Goings, K. L. Dolge and R.L. Steele. 1977. Effects of yeast culture added to complete mixed (all-in-one) dairy rations on milk and milk fat production, intake and feed efficiency. J. Anim. Sci. (Suppl. 1) 45:313.

Phillips, W.A. and D.L. Vontungeln. 1985. The effect of yeast culture on the poststress performance of feeder calves. Nutrition Report International. August. 32:287.

Richardson, C.W. 1988. Wheat in the dairy ration. An.Sci. Facts for Oklahoma Extension Workers. July-August. Okla. State Univ., pp.43.

Rose, A.H. 1987. Yeast culture, a microorganism for all species: a theoretical look at its mode of action. In: Biotechnology in the feed industry. Alltech Technical Publications, Nicholasville, KY, pp. 114-117.

Rose, A.H. and J.S. Harrison. 1970. The yeasts, yeast technology. Vol.3. Academic Press, London and New York.

Russel, M.E. 1926. Yeast for pigs. Wisc. Bull. Annual Report 388:134.

Schacklady, C.A. 1969. The production and evaluation of protein derived from organisms grown on hydrocarbon residues. Proc. Nutr. Soc. 28:91.

Shacklady, C.A. and P. Van der Wal. 1968. The use of hydrocarbon-grown yeasts in feeds for growing pigs. Second World Conference on Animal Production. College Park, MD.

Shannon, D.W.F. and J.M. McNab. 1972. The effect of different dietary levels of an n-paraffin-grown yeast on the growth and feed intake of broiler chicks. Brit. Poultry Sci. 13:267.

Shannon, D.W.F. and J.M. McNab. 1973. The digestibility of the nitrogen, amino acids, lipid, carbohydrates, Tokinson, L.V., E.W. Gleaves, K.E. Dunkel Gold, R.H. Thayer, R.J. Sirny, and R.D. Morrison. 1965. Fatty acid digestibility in caying hens fed yeast culture. Poultry Sci. 44:159-164.

Toland, P.C. 1976. The digestibility of wheat, barley or oat grain fed wither whole or rolled at restricted levels with hay to steers. Aust. J. Exp. Agr. and Animal Husb. 16:71.

Tommervick, R.S. and D.E. Waldern. 1969. Comparative feeding value of wheat, corn, barley, milo, oats and a mixed concentrate ration for lactating cows. J. Dairy Sci. 52:68.

Vasconcellos, J.A., M.W. Miller, W.C. Weir and A.J. Clifford. 1977. Growth and metabolism of rats fed heat dried and freeze dried yeast. Nutr. Reports Intl. 15:199.

Voeltz, W. 1912. Utilization of dried yeast in the rapid fattening of hogs. Chem. Abs. 6:2474.

Voltz, W.P. and A. Braudnexel. 1913. The utilization of dry yeast for farm animals. Chem. Abs. 7:1067.

Waldern, D.E. 1970. Nutritive value and suitable levels of wheat for diary cattle. Wheat in livestock and poultry feeds. Proceedings of an international symposium. June 18-19, Okla. State Univ., Stillwater.

Waldroup, P.W. and K.R. Hazn. 1975. Yeast grown on hydrocarbon fractions as a protein source in the diet of laying hens. Poultry Sci. 50:1022.

Waldroup, P.W. and N.W. Flynn. 1975. Comparison of the nutritive value of yeasts grown on hydrocarbon feedstocks under varying processing conditions. Poultry Sci. 54:635.

Waldroup, P.W., C.M. Hillard and R.J. Mitchell. 1971. The nutritive value of yeast grown on hydrocarbon fractions for broiler chicks. Poultry Sc. 50:1022.

Wheat outlook and situation yearbook. Sept. 1987. United States Department of Agriculture, Economic Research Service.

Wiedmeier, R.D. and M.J. Arambel. 1985. Effects of supplemental saccharomyces cerevisiae and/or aspergillus oryzae on rumen fermentation. Proceedings XVIII conference on rumen function, Chicago, IL, 23.

APPENDIXES

TABLE XII

TREATMENT SEQUENCE CODES
TRIAL 1

Treatment Sequence[a]	Code Number
1-2-1	1
2-3-2	2
3-4-3	3
4-1-4	4
1-3-1	5
2-4-2	6
3-1-3	7
4-2-4	8
1-4-1	9
2-1-2	10
3-2-3	11
4-3-4	12

[a]Corn = 1; Corn + Yeast = 2; Wheat = 3; Wheat + Yeast = 4

TABLE XIII

LACTATION, CALVING DATE, TREATMENT SEQUENCE, POSTPARTUM DAYS WHEN STARTED
AND MILK PRODUCTION PER PERIOD FOR EACH COW
TRIAL 1

Cow No.	Lact. No.	Calving Date, 86	TRT Code	Postpartum Days	Average Milk Yield (Kg/day)		
					Per.1	Per.2	Per.3
316	5	09-29-86	1	43	32.97	33.45	29.97
658	2	09-30-86	2	52	30.11	27.07	23.61
551	3	10-31-86	3	21	30.55	29.09	23.64
360	5	10-05-86	4	37	35.64	36.75	30.20
616	2	10-06-86	5	53	30.97	28.23	28.02
465	3	10-10-86	6	49	36.11	31.48	28.89
620	2	10-14-86	7	45	28.52	28.91	23.14
383	4	10-15-86	8	44	33.66	31.64	29.66
626	2	10-18-86	9	55	30.68	26.61	28.16
303	5	10-19-86	10	54	36.20	32.73	27.29
630	2	10-22-86	11	51	30.98	27.79	24.11
076	7	10-23-86	12	50	34.16	29.20	29.00
456	4	10-23-86	1	50	30.95	27.09	25.52
656	2	10-24-86	2	49	26.45	23.09	20.09
376	4	10-26-86	3	47	34.32	29.86	29.84
546	3	10-31-86	4	49	28.07	23.89	23.02
631	2	10-28-86	5	51	31.86	31.20	29.59
077	6	11-01-86	6	48	43.50	39.84	36.16
398	4	11-04-86	7	45	34.11	34.27	30.50
547	3	11-15-86	8	62	34.77	32.59	33.75
665	2	11-18-86	9	59	29.57	29.41	28.36
381	4	11-24-86	10	53	31.91	31.57	30.57
968	7	12-04-86	11	43	38.05	38.20	37.73

TABLE XIV

LIVEWEIGHT GAIN OF CALVES
TRIAL 2

Calf No.	Initial Body Weight (Kg)	Final Body Weight (Kg)	Gain (Kg)
Heifer Calves			
4040	47.8	101.4	53.6
4041	52.3	110.0	57.7
4042	46.4	94.5	48.1
4043	45.5	93.6	48.1
4044	40.0	79.8	39.8
4045	32.3	62.0	29.7
4046	49.5	82.0	32.5
4048	46.4	98.9	52.5
4050	44.6	91.3	46.7
4051	47.2	91.6	44.4
4052	49.8	110.0	60.2
4055	42.8	89.6	46.8
4057	47.9	108.2	60.3
4059	49.5	118.2	68.7
4062	43.0	92.2	49.2
4063	45.5	97.6	52.1
4064	46.8	108.2	61.4
4065	42.3	98.2	55.9
4068	46.1	115.5	69.4
4069	44.5	105.5	61.0
4070	44.0	94.5	50.5
4071	39.6	82.7	43.1
Bull Calves			
026	45.2	88.4	43.2
027	49.3	98.2	48.9
028	47.5	100.9	53.4
029	52.1	108.2	56.1
030	53.0	117.3	64.3
031	43.2	103.6	60.4
038	49.3	105.5	56.2
043	53.0	130.9	77.9
044	51.3	114.5	63.2
045	51.9	116.4	64.5
046	45.0	96.3	51.3
048	51.1	110.0	58.9
050	43.8	92.2	48.4
051	55.0	119.1	64.1
052	50.9	104.5	53.6

TABLE XIV (Continued)

Calf No.	Initial Body Weight (Kg)	Final Body Weight (Kg)	Gain (Kg)
053	50.1	115.5	65.4
054	47.3	115.0	67.7
055	52.0	117.3	65.3
058	45.6	97.8	52.2
060	51.4	103.6	52.2
061	53.2	120.0	66.8

TABLE XV

ANALYSIS OF VARIANCE FOR MILK YIELD
TRIAL 1

Source[a]	Degrees of Freedom	Sum of Squares	F Value	P>F[b]
Blk	2	431.29	41.58	0.0001
Cow (Blk)	20	4277.13	41.24	0.0001
Per	1	1122.66	216.49	0.0001
Per x Blk	2	145.25	14.01	0.0003
Per x Per	1	0.31	0.06	0.8095
Per x Per x Blk	2	44.18	4.26	0.0316
Per x Cow (Blk)	20	150.05	1.45	0.2229
Treatment	3	79.03	5.08	0.0108

[a] Abbreviation for Period (Per)
Abbreviation for Block (Blk)

[b] Probability of a larger F value

TABLE XVI

ANALYSIS OF VARIANCE FOR LIVEWEIGHT GAIN
TRIAL 2

Source[a]	Degrees of Freedom	Sum of Squares	F Value	P>F[b]
Block	1	603.35	8.14	0.0072
Trt	3	570.11	2.56	0.0704
Block x Trt	3	372.95	1.68	0.1898

a Abbreviation for Treatment (Trt)

b Probability of a larger F Value

TABLE XVII

COEFFICIENTS OF VARIATION FOR RESPONSE VARIABLES

Response	Trial 1	Trial 2
Conc. DM intake	6.4	17.55
Forage DM intake	6.41	
Total DM intake	5.82	
Conc. CP intake	6.09	17.53
Forage CP intake	6.43	
Total CP intake	5.40	
Feed efficiency	5.93	7.45
Milk yield	3.38	
Milk fat percent	7.32	
4 % FCM	5.69	
Milk protein percent	1.93	
Rumen pH	5.01	5.20
Rumen ammonia-N	55.43	
Blood plasma urea-N	24.75	
UFA		
Acetic	7.20	9.54
Propionic	17.89	9.87
Butyric	22.96	30.31
Isobutyric	73.33	
Valeric	27.31	35.25
Isovaleric	32.50	88.55
DM digestibility	3.14	
CP digestibility	2.89	
NDF	7.61	
Liveweight gain		15.67

TABLE XVIII

FEED INTAKE AND LIVEWEIGHT GAINS OF HEIFER CALVES

Item	Control (Corn-base)	Yeast (Corn-base)	Control (Wheat-base)	Yeast (Wheat-base)	SE
Number of animals	5	6	5	6	--
Initial body weight, (Kg)	45.9	46.1	41.6	46.6	--
Final body weight, (Kg)	107.5	94.2	88.0	97.2	--
Liveweight gain, (Kg/d)	0.87^{a}	0.69^{b}	0.66^{b}	0.72^{ab}	3.68
Dry matter intake (Kg) 1-70 days	146.1^{a}	113.9^{b}	127.3^{ab}	130.2^{ab}	9.8
Protein intake, (Kg/d)	0.38	0.30	0.35	0.37	1.86
Feed conversion efficiency (Kg feed/Kg gain)	2.40^{ab}	2.36^{a}	2.71^{c}	2.60^{bc}	0.07

[ab] Means in the same row with different superscripts differ (P<.05)
[abc] Means in the same row with different superscripts differ (P<.05)

TABLE XIX

FEED INTAKE AND LIVEWEIGHT GAINS OF BULL CALVES

Item	Control (Corn-base)	Yeast (Corn-base)	Control (Wheat-base)	Yeast (Wheat-base)	SE
Number of animals	5	6	4	6	--
Initial body weight, (Kg)	50.4	49.8	49.0	49.1	--
Final body weight, (Kg)	110.4	113.3	102.1	105.8	--
Liveweight gain (Kg/d)	0.86	0.91	0.76	0.81	3.79
Dry matter intake (Kg) 1-70 days	133.6	141.2	126.3	131.5	10.15
Protein intake (Kg/d)	0.35	0.37	0.34	0.37	1.92
Feed conversion efficiency (Kg feed/Kg gain)	2.22	2.22	2.39	2.31	0.07

TABLE XX

EFFECT OF DIET ON MOLAR PROPORTION OF RUMINAL VFA OF HEIFER CALVES

Acid	Control (Corn-base)	Yeast (Corn-base)	Control (Wheat-base)	Yeast (Wheat-base)	SE
Acetic	48.26[a]	49.16[ab]	50.68[ab]	53.93[b]	2.11
Propionic	38.61	37.30	39.18	35.22	1.55
Butyric	8.19	8.89	6.32	6.86	0.93
Isovaleric	0.56	0.49	0.42	0.92	0.21
Valeric	4.38	4.16	3.39	3.07	0.55

[ab] Means in the same row with different superscripts differ ($P<.05$).

TABLE XXI

EFFECT OF DIET ON MOLAR PROPORTION OF RUMINAL VFA OF BULL CALVES

Acid	Control (Corn-base)	Yeast (Corn-base)	Control (Wheat-base)	Yeast (Wheat-base)	SE
Acetic	53.19^{ab}	49.75^{b}	53.0^{ab}	55.55^{a}	2.17
Propionic	34.18	37.22	37.57	36.15	1.60
Butyric	7.55^{ab}	8.54^{a}	5.62^{b}	5.29^{a}	0.96
Isovaleric	0.74	0.24	0.47	0.61	0.22
Valeric	4.34^{a}	4.25^{a}	3.35^{ab}	2.41^{b}	0.57

^{ab} Means in the same row with different superscripts differ (P<.05).

TABLE XXII

EFFECT OF DIET ON RUMINAL PH OF CALVES

Type	Control (Corn-base)	Yeast (Corn-base)	Control (Wheat-base)	Yeast (Wheat-base)	SE
Bull calves	5.76	5.71	5.69	5.72	0.13
Heifer calves	5.73	5.66	5.59	5.93	0.13

TABLE XXIII

Cr_2O_3 DETERMINATION PROCEDURE

Ash 0.4 g of sample

Transfer ashed sample into 100 ml Erlemmeyer flask

Add 6 ml of acid mixture[a]

Bring to boil

Add 3 ml of 4.5 % KBrO and continue boiling until one minute after SO_3 fumes appear

Remove from heat and cool for 10 minutes

Bring up to 100 ml

Transfer 5 ml to centrifuge tube

Add 7.5 ml of 5% NaOH

Vortex no less than 15 minutes

Allow to settle at least 45 minutes

Centrifuge for 15 minutes at 2000 rpm

Read at 400 nm

---

[a]Acid mixture

500 ml distilled water
250 ml H_2SO_4
250 ml H_3PO_4
50 ml 10% solution $MNSO_4$-$4H_2O$

VITA [2]

Jorge Alberto Quinonez A.

Candidate for the degree of

Master of Science

Thesis: THE EFFECT OF YEAST CULTURE ON THE PERFORMANCE OF DAIRY CATTLE FED WHEAT BASED RATIONS

Major Field: Animal Science

Biographical:

Personal Data: Born in Tegucigalpa, D.C., Honduras, February 18, 1952, the son of Anibal E. Quinonez and Ella Abarca de Quinonez, married to Sonia E. Zepeda de Quinonez. Children: Elha Enid, Jorge Alberto and Javier Enrique Quinonez Z.

Education: Graduated from Instituto Salesiano San Miguel, as a Bachiller en Ciencias y Letras, Tegucigalpa D.C., Honduras, November, 1968; received an Agronomist degree from Escuela Agricola Panamericana, Tegucigalpa D.C., Honduras, December, 1972; received Bachelor of Science in Agriculture from New Mexico State University, Las Cruces, New Mexico, January 1975. Completed the requirements for the Master of Science Degree in Animal Science at Oklahoma State University in May, 1989.

Experience: Agricultural Extension Agent for Ministerio de Recursos Naturales at La Ceiba, Honduras, Jan.-Aug., 1973. Livestock Technician for Banco Nacional de Fomento at La Ceiba, and Tegucigalpa, Honduras, Jan., 1975-Sept., 1979. Assistant Manager, Operational Deparment, Banco de Honduras (City Corp) at Tegucigalpa, D.C., Honduras, Oct, 1979 - December 1980. Private business from January 1981 through May 1983. Head of the Livestock Research Department of the Ministerio de Recursos Naturales at Tegucigalpa, D.C., Honduras, May, 1983-July, 1986.

Membership: Asociacion Hondurena de Produccion Animal, American Dairy Science Association, Colegio Hondureno de Ciencias Agricolas, Asociacion de Graduados Escuela Agricola Panamericana, New Mexico State University Alumni.