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UREA AND YUCCA (MANIHOT ESCULENTA)

FOR DAIRY CATTLE IN COLOMBIA

A Thesis

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of

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by

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TABLE OF CONTENTS

	Page
LIST OF TABLES	v
LIST OF FIGURES.	viii
ABSTRACT	ix
INTRODUCTION	1
SECTION ONE. INFLUENCE OF UREA FEEDING ON PRODUCTION AND REPRODUCTIVE PERFORMANCE OF DAIRY CATTLE.	
Introduction	7
Review of Literature	9
General.	9
Urea in Rations for Dairy Cattle	12
Effect of Urea on Reproductive Performance of Dairy Cattle	16
Pathological Effects	19
Minerals	20
Materials and Methods.	21
Results and Discussion	27
Feed Intake.	27
Production	31
Milk Fat	34
Weight Changes	34
Blood Minerals	38
Calcium.	38
Phosphorus	41
Magnesium.	43
Potassium.	45
Urea	45
Reproduction	49
SECTION TWO. COMPARISON OF CORN AND YUCCA (<u>MANIHOT</u> <u>ESCULENTA</u>) AS SOURCES OF ENERGY FOR GROWING DAIRY HEIFERS FED SUGAR CANE TOPS AS THE SOLE ROUGHAGE.	
Introduction	53
Review of Literature	56
Growth of Dairy Heifers.	56
Origin of Yucca.	58
Climate and Soils.	59

TABLE OF CONTENTS
(continued)

	Page
Planting Methods	60
Fertilization.	60
Diseases	61
Harvest.	61
Yields	62
Use of Yucca	62
Materials and Methods.	65
Results and Discussion	68
GENERAL SUMMARY.	76
BIBLIOGRAPHY	79
APPENDIX	87
VITA	112

LIST OF TABLES

Table	Page
1. Composition of Concentrates Fed on As Fed Basis . . .	26
2. Chemical Composition of the Concentrate Fed . . .	28
3. Average Chemical Composition of the Corn Silage Fed During the Experiment	28
4. Average Feed Consumption, Milk Production, Fat Percent and Body Weight Changes of Cows During the First Lactation	36
5. Average Feed Consumption, Milk Production, Fat Percent and Body Weight Changes of Cows during the Second Lactation (0 to 140 days).	37
6. Summary of Reproductive Performance of the Experimental Animals	52
7. Common Names for Yucca, Countries Growing, and Areas Under Cultivation	58
8. Chemical Composition of Yucca Roots	64
9. Composition of Supplements Fed.	67
10. Average Chemical Composition of the Feeds Used During the Experiment	73
11. Average Daily Feed Intakes and Weight Gains of Heifers	74
12. Sexual Maturity and Reproductive Performance of Heifers	75 ✓
 Appendix Table	
13. Blood Serum Calcium Levels of Animals in Group I At Different Stages of Lactation (mg/100 ml). . .	87
14. Blood Serum Calcium Levels of Animals in Group II At Different Stages of Lactation (mg/100 ml). . .	88

Appendix Table	Page
15. Blood Serum Calcium Levels of Animals in Group III at Different Stages of Lactation (mg/100 ml). . .	89
16. Blood Serum Phosphorus Levels of Animals in Group I at Different Stages of Lactation (mg/100 ml). .	90
17. Blood Serum Phosphorus Levels of Animals in Group II at Different Stages of Lactation (mg/100 ml) .	91
18. Blood Serum Phosphorus Levels of Animals in Group III at Different Stages of Lactation (mg/100 ml).	92
19. Blood Serum Magnesium Levels of Animals in Group I at Different Stages of Lactation (mg/100 ml). .	93
20. Blood Serum Magnesium Levels of Animals in Group II at Different Stages of Lactation (mg/100 ml) .	94
21. Blood Serum Magnesium Levels of Animals in Group III at Different Stages of Lactation (mg/100 ml).	95
22. Blood Serum Potassium Levels of Animals in Group I at Different Stages of Lactation (mg/100 ml). .	96
23. Blood Serum Potassium Levels of Animals in Group II at Different Stages of Lactation (mg/100 ml) .	97
24. Blood Serum Potassium Levels of Animals in Group III at Different Stages of Lactation (mg/100 ml).	98
25. Blood Serum Urea Levels of Animals in Group I at Different Stages of Lactation (mg/100 ml)	99
26. Blood Serum Urea Levels of Animals in Group II at Different Stages of Lactation (mg/100 ml)	100
27. Blood Serum Urea Levels of Animals in Group III at Different Stages of Lactation (mg/100 ml). . .	101
28. Body Weights of Animals in Group I Recorded Every 28 Days (kg).	102
29. Body Weights of Animals in Group II Recorded Every 28 Days (kg).	103
30. Individual Daily Consumption of Sugar Cane Tops by Animals in Group I, Control (kg on as fed basis).	104

Appendix
Table

Page

31.	Individual Daily Consumption of Sugar Cane Tops by Animals in Group II, Experimental (kg on as fed basis).	105
32.	Body Weight Changes and Daily Feed Consumption of Dairy Heifers According to Age.	106
33.	Dry Matter Consumption According to Body Weight Changes as Compared to NAS-NRC Allowances (1966).	107
34.	Summary of Individual Reproductive Performance of the Experimental Animals.	108 ✓
35.	Individual Feed Intakes, Milk Yields and Fat Test During 305-day Lactation.	110

LIST OF FIGURES

Figure	Page
1. Concentrate Consumption During First Lactation, 305 days, and Second Lactation, 140 days	30
2. Milk Production: Experimental Groups Compared to Herdmates During First Lactation, 305 days, and Second Lactation, 140 days	32
3. Daily Protein Consumption of Experimental Groups as Compared to NAS-NRC requirements.	33
4. Milk Fat Test of Experimental Groups Compared to Herdmates During First Lactation, 305 days, and Second Lactation, 140 days	35
5. Calcium Content of Blood at Different Stages of Lactation.	40
6. Phosphorus Content of Blood at Different Stages of Lactation.	42
7. Magnesium Content of Blood at Different Stages of Lactation.	44
8. Potassium Content of Blood at Different Stages of Lactation.	46
9. Urea Content of Blood at Different Stages of Lactation	48
10. Body Weight of Animals According to Age Compared to Two Growth Standards.	69
11. Average Sugar Cane Tops Dry Matter Intake.	71
12. Average Daily Protein Intake of Animals Related to Body Weight and Compared to NAS-NRC Allowances . .	72

ABSTRACT

Pineda Morales, Jaime Eduardo, Ph.D. Purdue University, January 1971. Urea and Yucca (Manihot Esculenta) for Dairy Cattle in Colombia. Major Professor: Dr. C. H. Noller.

Two experiments were conducted in Colombia, South America: 1) to determine the effects of urea on production and reproductive performance of dairy cows when incorporated, as a source of protein, in the concentrate mixture; and 2) to evaluate the substitution of yucca (Manihot Esculenta) for corn as a source of energy for growing dairy heifers.

On the urea experiment, twenty-four Holstein dairy cows were assigned at random to three treatments; I) control, II) 33 percent of the supplementary protein from urea, and III) 66 percent of the supplementary protein from urea. Corn silage was fed as the sole forage. The experiment was initiated about one month prepartum and continued through one lactation to 140 days into the second lactation.

Statistically significant differences ($P < .05$) were found in overall concentrate intake during the first 305-day lactation period between the control and the experimental groups. Differences in intake were not significant during the second lactation period. Concentrate intakes were 1869.4, 1548.5 and 1619.4 kg, respectively, for cows in

groups I, II and III during the first lactation period. Intakes of urea averaged 0, 118 and 216 g. for cows in the respective 3 groups.

Milk yields were 5457.9, 4915.9 and 5120.7 kg, respectively, for cows in groups I, II and III during the first 305-day lactation. Highly significant differences ($P < .01$) in percent milk fat were found between the groups during both lactations. Average milk fat percentages were 3.45, 3.54 and 3.74 for the first lactation and 3.44, 3.61 and 3.70 for the second lactation for groups I, II and III, respectively. No significant differences were found in fat-corrected milk produced.

Statistically significant differences between groups were found in blood serum levels of Ca, P, K and urea, particularly, immediately after parturition. Animals in the high urea group (Group III) consistently had the lowest levels of Ca, P and K, and the highest levels of blood urea nitrogen (BUN). BUN increased as dietary levels of urea increased. No significant differences were found in blood serum Mg.

Number of services required per conception were 1.50, 2.75 and 3.66 for the first period and 1.57, 2.71 and 2.25 for the second period, for groups I, II and III, respectively. In group I, one cow aborted, was rebred and had a normal second parturition on experiment. All animals in this group conceived after the second parturition on experiment.

In group II, one cow aborted, 7 calved a second time and all 7 were diagnosed pregnant after the second parturition on experiment. In group III, 2 cows aborted, 2 did not conceive after 5 and 6 inseminations, respectively, and 1 cow died at time of second parturition. Only 3 cows entered a second lactation. The 3 mentioned cows and one of the animals that aborted were diagnosed pregnant a second time.

On the energy experiment, 20 eight-month-old Holstein heifers were assigned at random to two treatments: Group I, corn grain as the main supplementary energy source; and group II, yucca (Manihot Esculenta), substituted for corn on a dry matter basis. Sugar cane tops were used as the sole forage in both groups.

Statistically significant differences ($P < .05$) were found in body weight gains in favor of the yucca-fed heifers between 8 and 16 months of age (224 days). Average daily weight gains were .781 and .833 kg, respectively, for groups I and II. Feed intakes, on a dry matter basis, were similar in both groups.

Average age for the first breeding was 15 and 14.5 months and average services per conception were 1.88 and 1.77 for groups I and II, respectively.

INTRODUCTION

Of the natural conditions limiting intensification of livestock production in Colombia, rainfall and temperature are the principal factors; rainfall fluctuations cause either a lack or abundance of pastures.

Depending upon the interaction between climate and soil, both quantitative and qualitative nutritional problems arise on the natural pastures. In arid regions, the vegetation cover, though acceptable in feed value, is too sparse to permit a high productivity. On the other hand, in the more fertile regions, the marked variations between dry and rainy season conditions give rise to equally sharp seasonal fluctuations in the amount and nutritive value of the pastures. Temperature per se also limits the extension of livestock production. The tropical, and even subtropical conditions prevailing over vast areas of the country, promote the degeneration of unadapted types of livestock and an increased incidence of disease. These, in brief, constitute some of the major limitations which confront the animal industry of Colombia. Of course, various breeds and types of livestock which have evolved are reasonably productive and economical within the given limits of their respective habitats. Besides, there exists an appreciable population of

purebred dairy animals which, if properly managed and bred, perform very efficiently.

Even though a high degree of progress has been achieved, attempts in the past were too frequently directed toward absolute genetic improvement without consideration of the prevailing environment. The most fundamental cause for the failure with which breeders meet in their attempts to improve their animals with imported stock is, therefore, the lack of understanding of the conditions under which the exotic breeds evolved, not only from the view of ecological environment but also from that of nutrition and management. Besides, the low overall productivity of indigenous types of livestock has been ascribed to the inferiority of their genetic make-up, while the scantiness of highly nutritive food and reasonable management conditions, as compared with foreign standards, were up to recent times completely ignored.

The first steps in the right direction have come from the realization, through investigation, that mineral deficiencies, phosphates in particular, occur in the natural pastures of vast areas. Thus, clearly showing that problems other than those of a genetic basis play their part.

During the last two decades attention has been directed mainly towards the disease aspect and, no doubt, with remarkable success. This has led not only to further territorial expansion of livestock farming, but also to a reduction in losses due to disease. The combating of many enzootic and

epizootic diseases have become largely a matter of routine, and those who are making use of the knowledge offered are deriving full benefit from it.

The cattle industry in Colombia is finally realizing that apart from mineral deficiencies and the limitations set by disease, our pastures also lack certain other essential ingredients if an acceptable level of production is to be achieved. Since the beneficial influence of protein-rich supplements is an accepted fact all over the world, the energies of research workers in Colombia have been, in the past years, directed in that way.

Detailed investigations with humans and animals have revealed that the protein problem is of the utmost significance in much of Colombia. It has also become clear that this deficiency is closely linked with shortages of total digestible nutrients or, the energy problem. It is now realized that the nutritional problem in cattle is extremely complex, and that it varies from one region to another depending upon variations in the local climatic and soil conditions. Some areas suffer from an acute lack of essential food ingredients during the dry season and experience an abundance during the early rainy months, while others maintain a reasonably high nutritional level throughout the year. From these observations it is clear that the prescription of a national livestock nutrition policy is wholly impossible.

The nature of supplementary feeds and also the extent to which it should be made available calls for a regional survey which will take into consideration the divergency of natural conditions prevailing in Colombia. During dry periods, or in low rainfall regions, for example, supplementation should be based upon the utilization of certain industry by-products such as sugar cane tops, cane baggase, cane molasses, urea, etc., and of indigenous crops like yucca (*Manihot utilissima*), plantains, etc. which should be seriously considered as alternatives for regular forages, at least, to be used in periods of nutritional scarcity for livestock; while in the more humid areas, fodder crops, silages and harvest surpluses are to be stored for periods of nutritional depression.

The last limitation in the way of livestock improvement is the climatological one. Although there is an awareness of the nutritional problems and there are resources to combat the disease factor successfully, the control of the climatic factors remains beyond our means. However, during recent years the investigations of numerous research workers have shown that even though a decline in the vigour and growth of unadapted types of livestock is a result of adverse climatic conditions, most of the poor performance of the animals under tropical conditions is due to extremely poor practices of nutrition and management and, in fact, promising results have been obtained with purebred cattle as well as

with their crosses with native cattle when the required nutrients were provided and improved management practices were used (ICA, 1968).

The need for a greater abundance of animal products is of equal importance in Colombia and most other parts of the world. In short, the demand remains unsatisfied, but the question also evidently arises whether it can be satisfied.

Equally clear are the possibilities of increasing the present output by the application of existing knowledge and by further research on the basic problems already pointed out. The scope of such an understanding is therefore practically unlimited, and only during recent years has the importance thereof begun to be fully appreciated.

It is generally accepted that the growth rates of cattle, raised exclusively on pasture exhibiting monthly variations in its feed value, will also show a seasonal trend. These seasonal fluctuations which are particularly characteristic of the general region (Cauca River Valley) where the present experiment on energy sources was conducted, are generally closely allied with the distribution of the rainfall throughout the year.

During part of the year the grazing suffices for the growth requirements of the animals, while during the extreme dry periods, when shortages prevail, growth not only ceases but a considerable loss in weight occurs (ICA, 1969). Instead of the normal growth cycle, the whole process is

thus retarded, and since reproduction and production are essentially functions of growth, these disturbances upset the whole physiological balance.

The experiment on energy presented here was designed to test the possibilities of using yucca as a source of concentrate energy and urea as a source of protein to be used as supplements to counteract the mentioned feed shortages. This research explores the possibilities of providing the cattlemen with alternatives to their common practices of management and nutrition of lactating cows and of growing dairy heifers by using non-protein sources of nitrogen, such as urea, and making full use of native sources of energy in replacement of the traditional cereal grains, and managing of the growing heifers for acceptable rates of growth and early sexual maturity.

SECTION ONE

INFLUENCE OF UREA FEEDING ON PRODUCTION
AND REPRODUCTIVE PERFORMANCE
OF DAIRY CATTLE IN COLOMBIA

INTRODUCTION

Despite widespread use of moderate amounts of urea in dairy concentrates, many dairymen and some nutritionists believe that high producing cows will not perform satisfactorily when fed urea-bearing concentrate mixtures.

Certainly, the concentration of urea in dairy rations, the level of feeding, and the nature of feeding practices have an effect on the extent to which urea can replace plant protein nitrogen for the dairy cow.

Chalupa (1968) in a recent review, summarized the basic problems in feeding urea to ruminants. Reports of Colovos, 1967; Holter, 1968; Rupel, 1943; and Van Horn et al., 1967; have dealt, at least in part, with the effect of urea on milk production. Although much has been learned about the utilization of urea and its effect on feed intake, very limited information is available in the scientific literature regarding the effect of different levels of supplemental urea on milk yield, blood minerals, and reproductive performance of lactating cows.

Many experiments have been of rather short duration (Colovos, 1964; Holter et al., 1968; Van Horn et al., 1967) and have not considered blood mineral measurements or

reproductive performance. In some other cases (Van Horn et al., 1967; Huber et al., 1967) the effect of using urea to replace plant protein nitrogen in the concentrate apparently has been masked by wide variations in the number and proportions of energy-bearing ingredients in the concentrate mixtures.

Economic advantage is the main justification for including urea in dairy concentrate mixtures. A saving is generally realized only to the extent that urea nitrogen replaces expensive oilmeal nitrogen. When medium protein cereal grain by-products comprise a major portion of a concentrate mixture containing 16 to 20 percent crude protein, the economic advantage of using urea essentially disappears. However, when a high energy concentrate is desired, as is frequently the case in medium to high producing herds fed medium to low quality forage, the opportunity to substitute urea for oilmeal nitrogen is generally maximal. At the same time the incidence and severity of concentrate refusal may be increased because of either too much urea or too limited a variety of energy-type ingredients. This problem has been discussed by Holter et al. (1968).

The objective of this work was to determine the short and long-range effects of substituting urea for natural nitrogen sources in the concentrate on milk production, feed intake, milk fat, blood mineral levels and reproductive performance of medium to high producing dairy cows in Colombia, South America.

REVIEW OF LITERATURE

General

Many studies have been conducted since 1891, when German workers (Zuntz, 1891) realized that non-protein nitrogen could be incorporated into microbial protein by the rumen microorganisms, to determine the amount of non-protein nitrogen which may be included in diets for domestic ruminants.

It has been suggested that when ruminants are being fed for maintenance only and a considerable portion of the energy of the ration comes from corn, or an equivalent energy source, urea may be used effectively to make up a nitrogen deficiency. (Albert, 1955; Brown and Jacobson, 1966; Colovos et al., 1963; Harris et al., 1940). However, there seems to be a depression of utilization of dietary nitrogen when all of the supplemental nitrogen comes from urea, or other non-protein nitrogen sources, in high roughage maintenance or growing diets (Nelson et al., 1961; Nelson et al., 1962; Raleigh et al., 1943; woods et al., 1962).

Research can be found to support either a view that urea is not as efficient as natural protein supplements (Perry et al., 1967; Smith et al., 1960; Theurer et al.,

1962), or that urea is equivalent to natural protein supplements for growing and fattening cattle and sheep (Beeson et al., 1965; Campbell et al., 1963).

Feasibility of the use of urea and other non-protein nitrogen sources in ruminant rations, particularly dairy cattle, is considered in this review. Further encouragement for using additional amounts of urea must come from introducing into feed practices new concepts developed in the last decade and diligently applying some facts that have been known for some time. As Van Horn et al., (1967) have pointed out, it is questionable whether the rule of thumb for using urea of "3% of concentrate or 1% of dry matter," is in agreement with the response that can be expected from high producing cows. It must be remembered that recent studies (Colovos, 1967; Conrad et al., 1968) show that high-producing cows responded to high levels of urea when the urea was fed with rations specifically constituted for rapid utilization of non-protein nitrogen.

The success of urea feeding is dependent on the composition of the carbohydrates fed. The quantity needed approximates 1.0 kg of readily fermentable carbohydrate per 100 g. of urea in an adapted cow. About two-thirds of the readily fermentable carbohydrate should be starch.

The total quantity of food consumed is equally important to the cow in determining the amount of nitrogen used. Nitrogen utilization has been found to be a linear function of

digestible energy input regardless of body weight of the cattle used (Conrad et al., 1968).

The pathway for utilization of non-protein nitrogen is via rumen microorganisms. As microorganisms multiply, they synthesize proteins as constituents of their own cells from nutrients available in the rumen. Ammonia, the usual end-product of urea hydrolysis, is the preferred source of nitrogen for a large majority of the rumen bacteria studied (Bryant, 1962), and is efficiently used for protein synthesis if conditions are maximal for continuous fermentation. Quantitatively, ammonia may be a growth limiting nutrient in the case of nitrogen deficiency. At dietary levels of less than 1.2% nitrogen, rumen function is impaired, feed intake reduced, and growth of the host animal stopped or markedly limited (Larris and Mitchell 1941).

Phosphorus is probably the most important mineral nutrient with urea in most rations. Mineral mixtures of various kinds have been found to stimulate urea conversion to microbial protein. The mineral mixture used by Virtanen (1966) to meet the needs of the rumen microorganisms and the cows on purified diets, contained sodium, potassium, calcium, magnesium, copper, selenium, boron, cobalt, iodine and molybdenum. Much about the contribution of microorganism synthesis to the amino acid nutrition of the cow can be concluded by consideration of the quantity of any essential aminoacid produced in the rumen. Recently (Conrad et al.,

1967) the bio-synthesis of methionine and its transfer to milk protein have been quantitated, using an inverse isotope dilution method following single doses of sulfide - ^{35}S . In this study, hay was superior to silage for stimulating ruminal methionine synthesis. The most extensive studies of aminoacid patterns in the blood of lactating cows were reported by Virtanen (1966) who used urea and ammonium salts as the sole nitrogen source in purified diets. The concentrations of most of the free aminoacids, particularly the essential aminoacids, in the plasma and whole blood of lactating cows fed purified diets were lower than those in plasma of the control cows on normal feed. The relative decrease in histidine was greater than for any other aminoacids. It is noteworthy that the plasma aminoacid patterns vary among ruminants in different physiological states. Oltjen and Putman (1966) measured the free aminoacids in the plasma of growing Angus steers fed a purified diet supplemented with isolated soy protein or urea. They found valine, isoleucine and phenylalanine to be relatively lower in urea supplemented steers, and histidine to be lower on either of the purified diets than on natural feeds.

Urea in Rations for Dairy Cattle

Conrad and Hibbs (1966) used a pelleted combination of 66% dehydrated alfalfa, 31.6% urea, 2% monosodium phosphate, 0.4% sodium metabisulfite, and a preservative, as the only supplemental protein concentrate in rations of high producing

cows. This protein supplement (Dehy-100) contained 16% nitrogen, or 100% crude protein equivalent. When added to corn meal at the 9% level, it resulted in a concentrate ration containing 13 to 19% crude protein equivalent. Milk yields of cows fed Dehy-100 were similar to those receiving soybean meal as the protein supplement. However, there was a tendency for actual milk yield to be slightly lower and milk fat to be slightly higher in the cows fed urea. From 35 to 40% of the total nitrogen consumed by these cows was urea nitrogen.

A field test (Conrad and Hibbs, 1966) was conducted with a 48-cow herd to determine the effect of inserting the high urea-containing mixture abruptly into the ration in place of soybean meal. Urea made up 2.1% of the concentrate ration. The cows were divided into two groups and changed abruptly at the end of alternate 30-day feeding periods. On a 4% FCM basis, the average milk yields were the same for cows fed the urea-containing mixture and those fed soybean meal.

The grain concentrate containing urea was eaten readily without any noticeable effects on the cows after the abrupt change-overs. This was in contrast to earlier results when the cows were allowed to eat freshly chopped alfalfa containing 20 to 24% crude protein equivalent per unit of dry matter. Urea introduced abruptly into the ration in place of soybean meal under these conditions caused the cows to eat grain

concentrate irregularly and refuse large amounts. After a two-day period, they began to eat the grain concentrate in normal amounts. It seems that the total ration in this case contained a quantity of nitrogen far in excess of the cow's requirements when freshly chopped alfalfa was fed. This instance of depressed concentrate consumption was interpreted to indicate that the critical physiological level for the readily soluble non-protein nitrogen in the diet had been exceeded.

Some of the problems in feeding urea to dairy cows are intensified by a growing emphasis on high concentrate rations to increase production and to provide increased quantities of energy. A study with high producing cows receiving various levels of urea in a high concentrate ration showed that high urea levels (20 to 40% of the total ration nitrogen) depressed both milk yield and feed efficiency (Huber et al., 1965). The same investigators conducted nitrogen balance studies which indicated that milk production efficiency decreased when urea was added due to a decreased nitrogen retention.

Many attempts have been made to improve the utilization of urea by lactating dairy cows. In a recent study, Helmer et al. (1970) used milk production, grain intake, body weight change, and the production and concentration of milk constituents as the criteria to evaluate starea, an intimate mixture of gelatinized starch and urea, as a protein

supplement for lactating dairy cows. In this experiment, cows fed grain rations supplemented with either soybean meal or Starea (23% crude protein) consumed more grain and produced more milk containing more protein than cows fed the same grain rations supplemented with urea. Starea was approximately equal to soybean meal as a protein supplement for lactating cows. In this same study the apparent direct relationship between grain intake and milk production indicates that ration acceptability affected animal performance. Other investigators (Van Horn et al., 1967) have noted a similar relationship when urea was fed to lactating cows. Using body weight changes as a criteria for comparison, Helmer et al., (1970) found that cows consuming urea in the concentrate, lost weight as compared to cows on starea and those on soybean.

In two experiments conducted in England (by Waite et al., 1968) and designed to compare urea and biuret containing concentrates to a concentrate containing natural proteins, milk production was about 10% less on the urea and biuret treatments than on the control treatments. There was no significant difference in milk yield between the urea and the biuret treatments. The percentages of fat and protein in the milk from the urea and biuret treatments were higher than from the control treatment. The above results on protein are in contrast with those obtained by Oltjen (1966) in which protein was somewhat lower in the urea treated group.

In Russia, Loskutou (1964) also found that a diet which provided 25% of the digestible protein as urea resulted in a higher protein content in milk as compared to the controls.

Effect of Urea on Reproductive Performance of Dairy Cattle

There seems to be a generalized belief among farmers, especially dairymen, that using urea as a part of the ration of dairy cattle adversely affects the reproductive behavior and efficiency of cows (Pieterse, 1967).

The present literature review shows that results have been found either to support the possibility that urea-containing feeds might have an adverse effect on reproduction, or that reproductive performance is not affected at all. In general, it can be said that data at the present time are made up of general observations made during multi-purpose studies using non-protein nitrogen. Virtanen (1966) placed several mature dairy cows on a purified diet containing urea and ammonium salts as the sole source of dietary nitrogen and reported successful reproduction by the cows. However, the cows required as many as five services to become pregnant. The possibility that a deficiency of vitamin E was the cause of the problem was eliminated when subsequent vitamin E supplementation failed to improve fertility (Virtanen, 1969). Oltjen (1967) using two sets of identical twin heifers in order to determine the effect of urea on growth and reproduction, reported increased services per

conception, shortened length of estrous cycle, a longer gestation period, increased rate of abortion, and decreased weight of calves at birth for heifers that were on a urea diet. As far as onset of puberty, it was noted that bulls and heifers fed urea diets reached puberty 2 and 6 months later than control animals. However, Pustovaja (1967) found that heifers on urea matured somewhat earlier than controls on plant proteins.

Feoktislov (1966) found that with cows fed 200 g. urea per day in a low-protein diet, the incidence of infertility was greater than in the controls fed a diet supplemented with plant protein. In a studies conducted by Udo-Aka (1970) and Patton (1970) the effect of urea on estrogen excretion rates and reproduction in 27 holstein heifers fed 100% of the supplemental dietary nitrogen as urea was compared with 27 control animals receiving soybean meal instead of urea. The control and the urea-fed heifers required 2.55 and 2.49 services per conception, respectively. Six control heifers and seven urea heifers became pregnant at first service. Each group had 16 live and 5 dead calves. There were three retained placentas in the control group and four in the urea group.

Several experiments reviewed have indicated that no deleterious effects from urea-feeding were found. Archibald (1943) fed 8 dairy cows a concentrate ration that had 42% of its nitrogen supplied by urea and 8 cows on a control ration

without urea. For two consecutive lactations, the cows consumed an average of 15 pounds per animal per day of the concentrate. Reproductive performance, as far as services per conception was concerned, was identical in each group: 1.55 and 1.50 services per conception were required by the controls and urea-fed groups, respectively. Lizal (1967) found that heifers fed a diet containing 285 g. of urea incorporated as an ingredient of a liquid supplement had regular estrous cycles. An average of 2.33 services per conception was required to settle nine of ten heifers.

Rupel (1943) did not find any adverse effects from urea on the estrous cycle when dairy cows were fed a concentrate ration which contained 3% urea. In this experiment, six lactating dairy cows consuming ten pounds of the concentrate per animal per day required a total of 13 services to obtain six conceptions. Then, during the following lactation, while on a urea-free diet, the same 6 cows required 16 services.

Pustovaja (1967) reported that heifers fed diets containing urea matured somewhat earlier than the controls, in contrast to the study by Oltjen (1967) in which heifers fed non-protein nitrogen reached puberty six months later than controls.

In the study of the possible effects of urea on reproduction, several approaches have been examined, one of them being the denaturing effect of in vitro high concentrations of urea on gonadotrophins. Ellis (1961) studied the effect

of incubation with urea on gonadotrophic activity and showed that the luteinizing activities of standard NIH-LH and NIH-FSH were greatly reduced by urea while the follicle-stimulating activity of the follicle-stimulating hormone (FSH) was only slightly decreased or unaffected.

Donaldson and Hansel (1965) found that LH incubated in the presence of 6-M urea at 40°C for 24 hours had no luteotrophic effect and could not prolong the lifespan of an in situ corpus luteum, as compared to LH not incubated in urea. It is not known if circulating levels of urea, whatever these levels may be, in blood can denature protein hormones.

Pathological Effects

Some other side effects have been attributed to urea-feeding. For example, Gorskova (1967) found that bulls fattened on a diet of corn and straw silage supplemented with urea had fatty infiltration of the liver, whereas, control animals failed to show any liver disorders. Also, Gorcevskej (1967) after examining liver tissue from 40 steers, which had been fed 80 g. of urea daily during 150 days, and from 29 control steers, found fatty infiltration of the parenchyma, and necrotic cells scattered in the liver tissues of animals fed urea. However, in disagreement with these findings is the work conducted by Colenbrander et al. (1968) in which 272 g. of urea daily as supplemental nitrogen were fed to thirteen Holstein steers from six months of age until slaughter at 11 months. Histopathological examination of the

viscera did not reveal any type of tissue damage.

Minerals

On the mineral aspect, Lomba et al. (1969), using dry and lactating cows with variable intakes of phosphorus, found that phosphorus fecal and urinary losses show wide variations and may be important. They are not influenced by phosphorus intake, and are related, among the many other nutritional factors analyzed in this research, only to ingested water and to a lesser extent to the nitrogen of the diet. The phosphorus balance is also very much variable and not really related to the composition of the ration. The low influence of the diet on the apparent fate of phosphorus can be explained by the interference of variable amounts of endogenous phosphorus excretion.

Paquay et al. (1969) reported that 3 nutritional factors, potassium, dry matter and nitrogen intakes influence the fate of dietary potassium. They pointed out that at any level of ingestion, digestion, excretion, there is a very close correlation between potassium and nitrogen. They found no significant correlation between the fate of potassium and that of calcium, magnesium or phosphorus. Also they found no difference between dry and lactating cows as far as potassium digestion was concerned.

MATERIALS AND METHODS

Twenty-four Holstein cows between the 7th and 8th months of pregnancy were chosen from the dairy herd of the Colombian Institute of Agriculture (ICA) Experiment Station at Bogota', Colombia. These animals were isolated from the regular herd and fed a ration containing urea at a level which permitted them to adapt to the urea feeding without physiological disturbances. Thus, time prior to parturition was basically an adaptation period for the animals which received the urea supplemented rations.

The animals were assigned, at random, to three treatments with 0, 33 and 66 percent of the supplemental protein in the grain mixture being supplied by urea. All animals were not available at the same time; thus, cows were assigned to the different treatments when they entered the dry period.

The criteria employed for the assignment of animals to the groups were age, body weight, previous levels of milk production, previous reproductive performance and health, to obtain as homogeneous a group as possible. In addition, twenty cows were chosen from the "Tibaitata" Experiment Station Dairy Herd. These cows were maintained under the standard management procedures for the herd, that is, silage

or grazing, and a concentrate supplement twice a day during milking. The milk production of this group, which was maintained with the regular herd, was compared to that of the control and experimental animals and also the same blood measurements were made at 28 days before parturition and at 2 and 28 days after parturition and compared with values found in both the control and experimental groups.

The treatments consisted of: a) Group I, Control, receiving a diet with all the protein from natural sources; b) Group II, receiving 33% of the supplemental protein in the grain mixture from urea; c) Group III, receiving 66% of the supplemental protein in the grain mixture from urea. The composition and estimated chemical analysis of the concentrates are presented in Table 1.

The animals were housed in individual pens in an open-shed barn and milked twice a day in a milking parlor. They remained on the experiment through one lactation and about five months into the second lactation. Once an animal was assigned to a treatment it remained on that treatment until removed from the experiment. All three groups received corn silage ad libitum twice daily as the only source of forage.

Feed refusals were recorded before the morning feeding the following day. The concentrate was fed to meet the requirements for maintenance and production and the amount was adjusted weekly according to milk production. The cows received part of the concentrate mixed with the silage and the

balance during the milking periods. The amount of grain fed to the animals was calculated on the basis of the corn silage consumption with intake balanced to meet energy, protein and mineral requirements according to NAS-NRC (1966) allowances. It was calculated that each animal would receive 6.4 g. of total digestible nutrients (TDN) per kilogram of body weight for maintenance and 330 g. per kilogram of 4 percent fat-corrected milk produced.

The measurements made were: body weight, milk yield, individual feed intake, milk fat, milk protein, chemical composition of feed based on pooled samples for chemical analysis every 28 days. Blood urea, calcium, phosphorus, magnesium and potassium were determined every 28 days throughout the experiment. The blood samples were collected consistently between 9:00 and 11:00 a.m. and feeding times were 6:00 a.m. and 4:00 p.m. Blood samples for mineral and urea determinations were drawn from the jugular vein, taken to a laboratory where plasma was obtained by centrifugation of non-coagulated blood and serum by precipitation of the proteins with a 10% trichloroacetic acid solution (TCA). Milligrams of urea in blood serum were determined then by the method described by Chaney and Marbach (1962). Phosphorus in blood serum was determined by the calorimetric technique of Harris and Ponat (1954). Calcium, magnesium and potassium were determined by the analytical methods for the determination of these minerals in biological materials

by atomic absorption spectrophotometry as published by the Perkin-Elmer manuals (1965-1966).

Body weights were recorded every 28 days throughout the experiment. Milk yield was recorded daily during the first complete lactation on experiment and then until 140 days into the following lactation. Milk fat was determined every 28 days, on pooled samples, by the Babcock technique.

Samples of corn silage and concentrate were taken daily, weighed dried and pooled for proximate chemical analysis for moisture, crude protein, crude fiber, ether extract, nitrogen-free extract and ash. All feed samples were collected during the morning feeding, and the analysis were made every twenty-eight days throughout the two lactation periods.

Veterinary observations of the animals included recording reproductive cycles, number of services per conception, normalcy of gestation and any events at parturition. During the dry period all the cows received one to two kilograms of concentrate to maintain the urea-adapted ruminal microflora in the urea-fed cows and to avoid physiological disturbances when the animal returned to normal levels of concentrate feeding after the second calving. At about one week preceding the expected date of parturition the cows were confined in a corral with adequate shelter and bedded with wheat straw until parturition when they returned to individual management under their respective treatment.

The statistical analysis was a group-treatment analysis, using the Analysis of Variance for the completely randomized design (Steel and Torrie, 1960) and the MACE operating system version 4.1 STATPRF-I of the Purdue University computer center.

Table 1. Composition of Concentrates Fed on As Fed basis.

Ingredients	Treatment		
	Group I	Group II	Group III
Yellow corn, %	44.5	55.0	76.0
Cottonseed Cake, %	26.5	9.0	--
Molasses, %	8.0	9.0	17.0
Urea, %	--	2.27	4.1
Wheat bran, %	18.0	21.5	--
Limestone, %	2.0	2.03	1.1
Dical, %	--	--	1.4
Salt, %	.8	1.0	.2
Premix, %	.2	.2	.2
Total	<u>100.0</u>	<u>100.0</u>	<u>100.0</u>
	<u>Chemical Composition^{1/}</u>		
Crude Protein, %	19.6	19.7	19.8
Total Digestible Nutrients, %	70.0	70.0	70.0
Calcium, %	.9	.9	.9
Phosphorus, %	.6	.6	.6

^{1/}Calculations based on NOPCO, 1965 feed ingredient analysis table for ruminants and on Colombian Institute of Agriculture (ICA), Nutrition Laboratory Annual Report, 1967.

RESULTS AND DISCUSSION

Feed Intake

The three concentrates fed in this experiment were balanced to be similar in percent crude protein, energy and major minerals using estimated feed ingredients composition values (NOPCO 1966; ICA 1968). Laboratory analysis performed every 28 days from pooled samples did not reveal much variation in protein content as compared to the calculated values (Tables 1 and 2). The average composition of the corn silage fed is shown in Table 3.

Average feed consumption, actual milk production, percent fat, 4 percent fat-corrected milk production and body weight changes, along with their respective standard errors for the two lactation periods recorded are summarized in Tables 4 and 5. Silage intake varied slightly without showing any significant differences between treatment groups in both the first and second lactation periods.

Concentrate intake varied widely, consumption being significantly different ($P < .05$) between the control group I and group II, 33% supplementary protein from urea, and also between the control group and group III, 66% supplementary protein from urea. There was no significant difference in

Table 2. Chemical Composition of the Concentrate Fed^{1/}

Ingredients	Group		
	I	II	III
	%	%	%
Dry matter	38.00	87.13	87.01
Crude protein	19.71	19.73	19.77
Ether extract	2.81	3.12	2.90
Crude fiber	5.95	4.70	2.00
Ash	6.00	6.13	5.01
Nitrogen-free extract	65.53	66.32	70.32

^{1/}Analysis of 28-day pooled samples.

Table 3. Average Chemical Composition of the Corn Silage Fed During the experiment.^{1/}

	%
Dry matter	27.70
Crude protein	8.17
Ether extract	3.86
Crude fiber	24.79
Ash	4.60
Nitrogen-free extract	58.58

^{1/}Analysis of 28-day pooled samples.

intake between groups II and III. These results indicate that addition of urea depressed intake ($P < .05$) as shown in Fig. 1.

It should be noted that a better consumption of the concentrate mixtures containing urea might have been achieved if the animals had been fed the concentrate ration completely mixed with the corn silage.

For management conveniences, part of the daily concentrate ration was fed at milking time. At the beginning of the first lactation grain refusals were high in the urea-fed groups. After the first month of lactation the urea-fed animals increased their intake of concentrate and milk production tended to remain constant with a rate of decrease less accentuated as compared to the control animals and to the animals in the regular herd.

Perhaps because a higher percentage of the concentrate was fed with the silage in the second lactation, differences in concentrate consumption were not significantly different during the 140 days of this lactation. Similar results have been found by other workers (Van Horn *et al.*, 1967).

Tables number 4 and 5 and Figure 3 show the levels of protein fed to the different groups of animals and also the amount of urea fed per day to the experimental groups of animals. It should be noticed that NRC requirements for maintenance and production were closely met in all three groups of animals (Fig. 3).

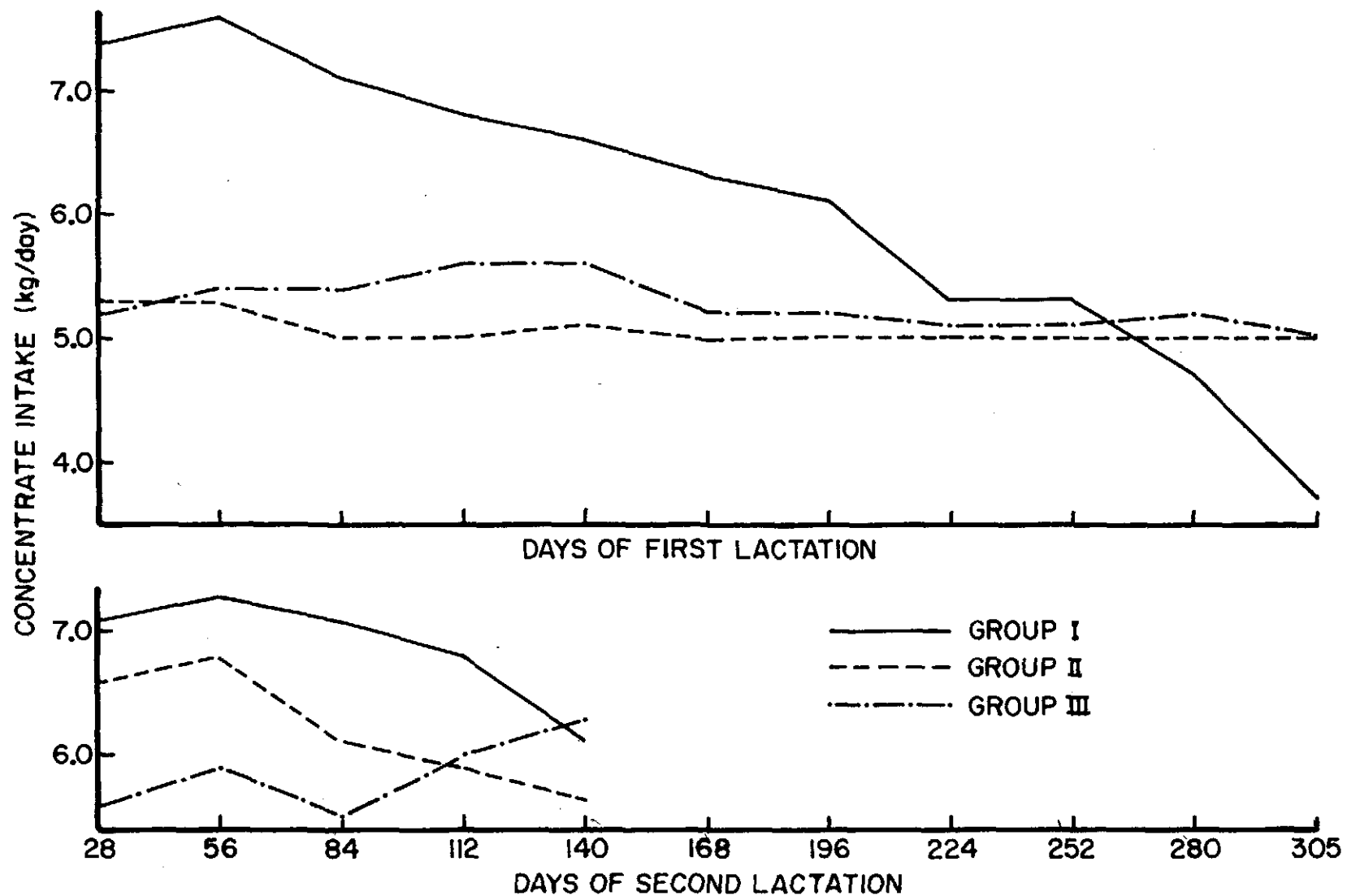


Figure 1. Concentrate Consumption During First Lactation, 305 days, and Second Lactation, 140 days.

The amounts of urea fed daily averaged 114 and 216 grams consumed per day in experimental groups II and III, respectively, during the first lactation and 141 and 240 gm. per day for the same groups, respectively during the second lactation (Tables 4 and 5).

Production

Even though the control group, which consumed the most concentrate, produced slightly more milk than each of the urea-fed groups, the differences in actual milk and 4 percent fat-corrected milk production were not statistically significant (Tables 4 and 5). The actual milk production in the control group averaged 5,457.9 kg in the 305-days lactation period and was very similar to the average production of 5,316.2 kg by the 20 herd cows in a 305-day lactation (Fig. 2).

Reports by Huber (1967), Helmer, et al., (1970) and Van Horn et al., (1967) have indicated that the depression in milk production was related to levels of urea in the concentrate. However, the present study did not show any significant differences in milk production indicating that even when there were differences in feed consumption, they were not large enough to affect production and that the three rations were used by the cows with the same degree of efficiency. These results agree with those found by Conrad and Hibbs (1966) in a field test with 48 cows in which milk yields for cows fed a urea-containing mixture and those fed

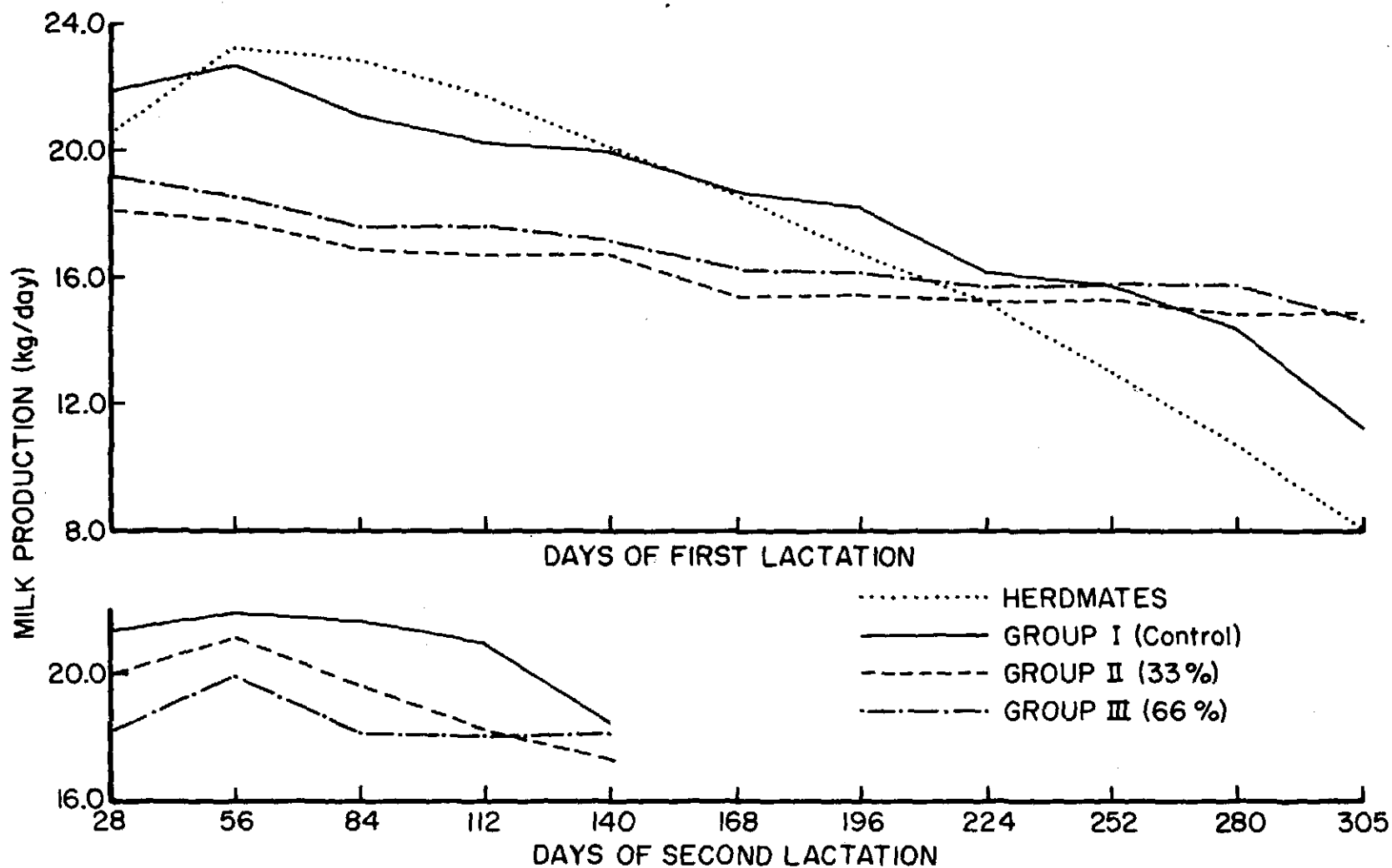


Figure 2. Milk Production: Experimental Groups Compared to Herdmates During First Lactation, 305 days, and Second Lactation, 140 days.

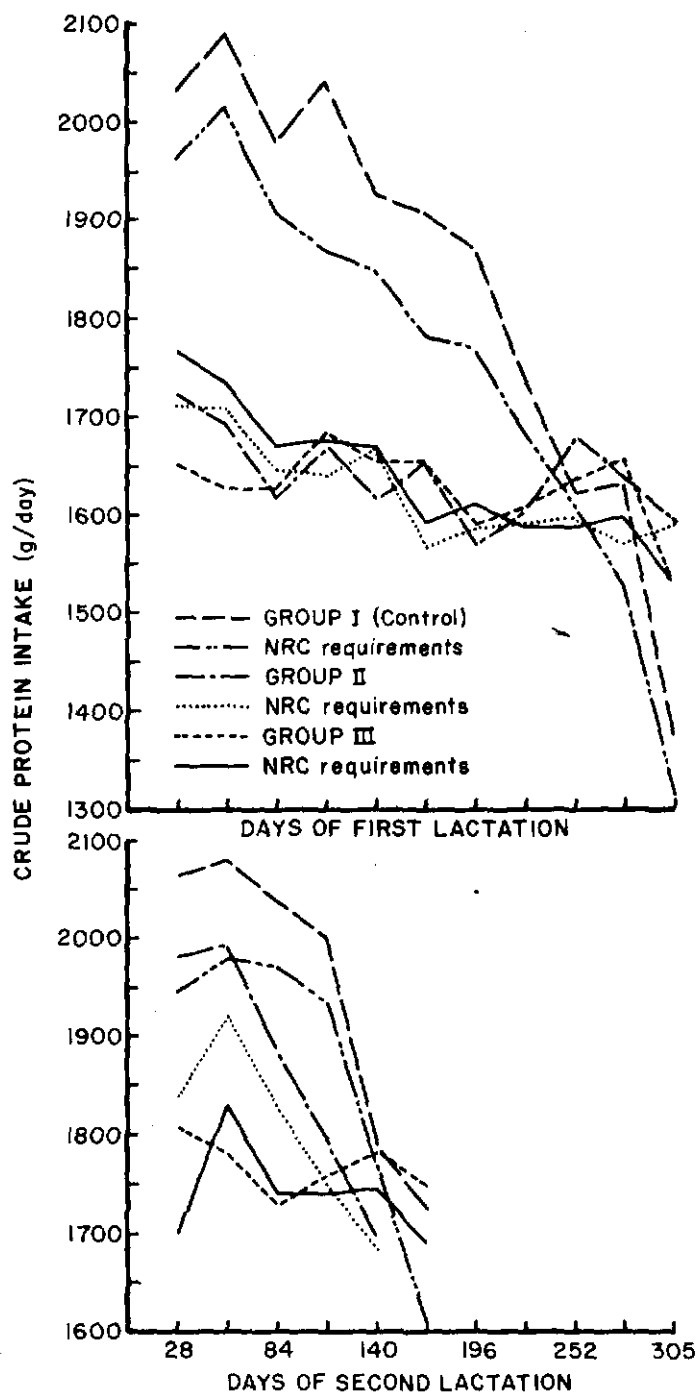


Figure 3. Daily Protein Consumption of Experimental Groups as Compared to NAS-NRC Requirements.

a soybean meal mixture were similar on a 4 percent fat-corrected milk basis.

Milk Fat

During the two experimental periods, the percentage of fat in milk was significantly different ($P < .01$) between the groups (Fig. 4). A Duncan's new multiple range test (Steel and Torrie, 1960) showed that the cows fed the highest amount of urea, Group III, showed a highly significant ($P < .01$) increased average fat content in milk as compared with groups I and II (Tables 4 and 5). The difference in fat content of milk between groups I and II also was highly significant ($P < .01$) with group II averaging higher in fat.

It appears that fat content in milk tended to increase as the levels of urea in the ration increased. Several workers (Helmer, et al., 1970 and Waite, et al., 1968) have noted similar changes in fat test when urea was introduced into the ration of dairy cows.

The average milk fat percentage in the control group (3.45%) was similar to the milk fat percentage of the herd cows (3.48%).

Weight Changes

Weight changes between calving and 305 days in the first lactation and calving to 140 days in the second lactation were very similar in the three groups. There were no statistically significant differences in body weight gains between the groups. The results obtained in this experiment

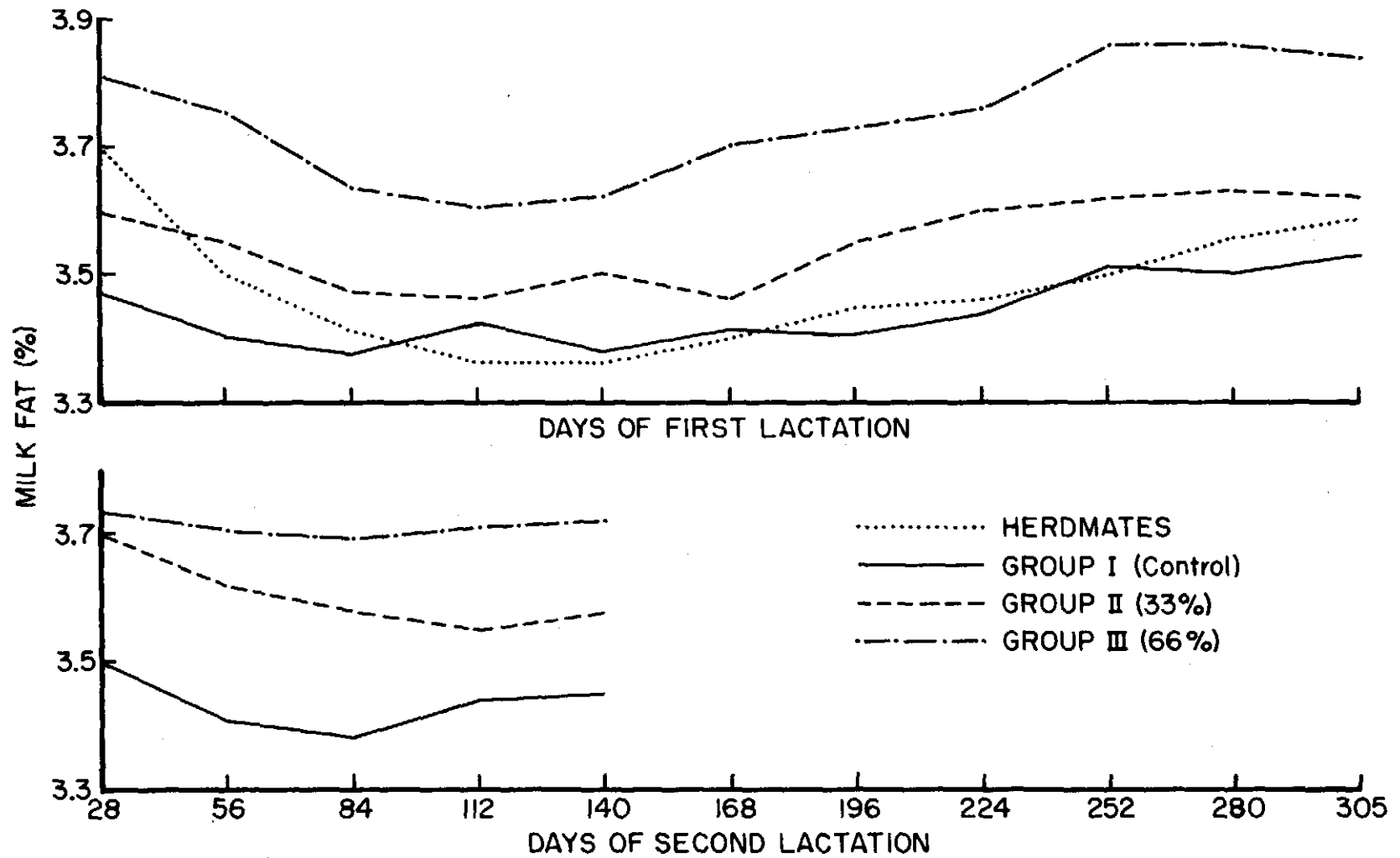


Figure 4. Milk Fat Test of Experimental Groups Compared to Herdmates During First Lactation, 305 days and Second Lactation, 140 days.

Table 4. Average Feed Consumption, Milk Production, Fat Percent and Body Weight Changes of Cows During the First Lactation.

Item	Group		
	I	II	III
Number of Animals	8	8	8
FEED INTAKE:			
Grain, kg	1869.4 ^a ± 93.6 ^{1/}	1548.5 ^b ± 62.2	1619.4 ^b ± 17.7 ^{2/}
Silage dry matter, kg	3023.3 ^a ± 81.5	2895.1 ^a ± 150.9	2708.7 ^a ± 85.3
Dry matter intake per 100 kg BW, kg	2.65	2.36	2.50
Dry matter from grain, %	35.4	32.0	34.0
Crude protein intake, gm/day	1835	1644	1630
Urea intake, gm/day	--	114	216
Protein intake from Urea, %	--	19.95	38.4
MILK PRODUCTION: ^{3/}			
Actual milk, kg	5457.9 ^a ± 247.7	4915.9 ^a ± 223.9	5120.7 ^a ± 247.9
Fat-corrected milk, kg	5006.5 ^a ± 224.4	4456.5 ^a ± 176.3	4912.1 ^a ± 237.0
Milk fat, %	3.45 ^a ± .01	3.54 ^b ± .02	3.74 ^c ± .02
WEIGHT CHANGES:			
Parturition to 305 days, kg	106.0 ^a ± 10.3	116.6 ^a ± 13.8	82.7 ^a ± 12.3

^{1/}Standard error of mean.

^{2/}Means with a different superscript within a row are significantly different (P<.05).

^{3/}The 20 herd cows produced an average of 5,316.2 kg milk with 3.48 percent fat during a 305-day lactation.

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Table 5. Average Feed Consumption, Milk Production, Fat Percent and Body Weight Changes of Cows during the Second Lactation (0 to 140 days).

Item	Group		
	I	II	III
Number of animals	7	7	3
FEED INTAKE:			
Grain, kg	976.2 ^a ± 63.8 ^{1/}	871.2 ^a ± 65.6	820.4 ^a ± 27.6 ^{2/}
Silage dry matter, kg	1370.1 ^a ± 14.8	1365.4 ^a ± 19.3	1353.6 ^a ± 9.2
Dry matter intake per 100 kg BW, kg	2.73	2.68	2.65
Dry matter from grain, %	37.3	35.5	34.5
Crude protein intake, gm/day	1995	1874	1774
Urea intake, gm/day	--	141	240
Protein intake from urea, %	--	21.72	38.90
MILK PRODUCTION:			
Actual milk, kg	2897.6 ^a ± 235.7	2704.8 ^a ± 197.4	2888.9 ^a ± 101.0
Fat-corrected milk, kg	2652.5 ^a ± 224.8	2545.8 ^a ± 182.3	2474.3 ^a ± 87.1
Milk fat, %	3.44 ^a ± .01	3.61 ^b ± .02	3.70 ^c ± .03
WEIGHT CHANGES:			
Calving to 140 days, kg	22.8 ^a ± 7.6	33.3 ^a ± 4.6	11.7 ^a ± 3.2

^{1/} Standard error of mean.

^{2/} Means with different superscripts within a row are significantly different (P<.05).

are in contrast to those presented by various workers (Helmer et al., 1970; Van Horn et al., 1966; and Huber, 1965), who indicated that animals on urea-containing rations lost weight, and agree with results of other workers, such as Waite et al. (1968), who found that liveweight changes were not affected by experimental treatments when biuret and urea were tested in concentrates for milking cows.

From the results found in this experiment, it appears that the animals fed the urea-containing rations were able to maintain normal rates of weight gain as compared to the control animals (Tables 4 and 5).

Blood Minerals

Calcium. From the one-way analysis of variance made and the use of the Duncan's new multiple range test to compare each treatment mean with every other treatment mean (Steel and Torrie, 1960), the results indicate a sharp drop in the blood values for calcium in all the experimental groups in the samples taken 2 days after calving and from there until 56 days after calving when the blood levels began to increase back to the values found before calving. Toward the end of the lactation period, at 280 and 305 days of lactation, the levels of calcium in blood decreased again in the urea-fed groups, II and III. The statistical analysis shows that there were highly significant differences ($P < .01$) in the magnitude of decrease between the control and the experimental groups when the calcium levels in blood were

compared at 28, 196, 280 and 308 days after calving. Results obtained during the second lactation were similar to those obtained in the first lactation. Highly significant differences ($P < .01$) in blood calcium levels were found between group I and group III between 56 days after parturition and 140 days after parturition (Fig. 5).

The lowest blood calcium values were found in the high urea group (8.72 mg. Ca per 100 ml. blood serum). However, these values were still between the range for nonparetic cows at the respective stages of lactation. Littledike et al., (1970) found calcium values of 10.0 ± 0.10 mg. per 100 ml. serum during the dry period and 7.6 ± 0.52 between 12 and 48 hours postpartum in normal animals. Also, Kendall et al., (1968) reports 11.26 mg % calcium before calving and 8.85 mg % in serum immediately after calving.

Blood levels of calcium analyzed in the 20 cows kept with the herd at 28 days before, and at 2 and 28 days after parturition were 9.94, 9.55 and 9.68 mg % for the three periods, respectively. The calcium data from the herd animals were similar to the 9.91, 9.01 and 9.50 mg % found in the control group animals at equivalent stages of lactation.

These results show that the blood calcium levels varied from 8.72 to 10.71 mg % with the high urea-fed animals (group III) showing the lowest values (Fig. 5). Differences between the control group and the high urea group animals were statistically highly significant ($P < .01$) at the beginning and

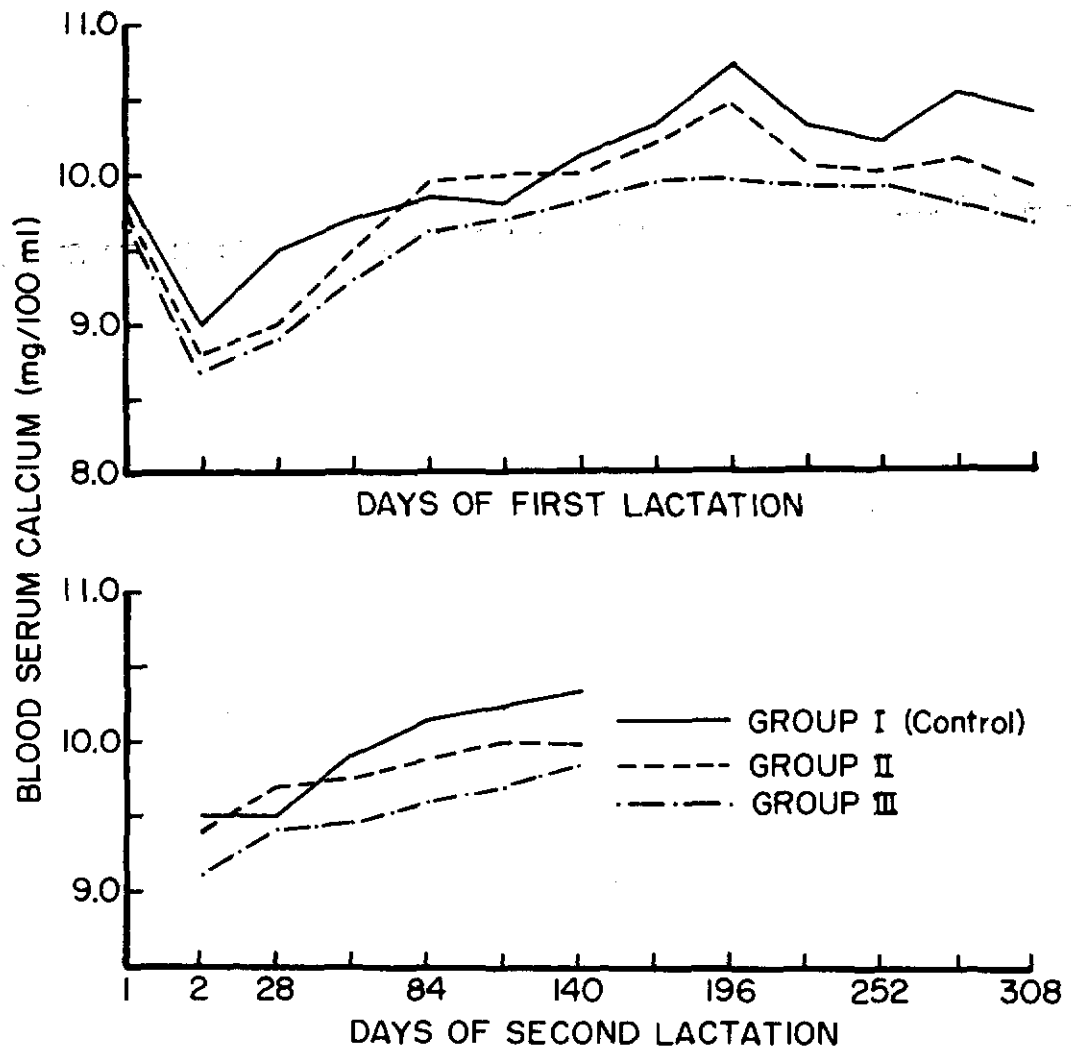


Figure 5. Calcium Content of Blood at Different Stages of Lactation.

end of lactations. No statistically significant differences were found between the two urea-fed groups (II and III). No biological significance can be attributed to the aforementioned differences at this time since all values for calcium found in the three experimental groups remained between usually considered normal ranges (Littledike et al., 1970; Maynard and Loosli, 1962; Kendall et al., 1968).

Phosphorus. Statistical analysis of the blood phosphorus values showed a trend similar to that for calcium. Results of blood serum analysis at 2 days and then every 28 days after parturition indicated that the blood levels of phosphorus decreased after parturition and that the average values found were significantly different ($P < .01$) between the control group and the two urea-fed groups at 2, 28, 56, 84 and 112 days after parturition with the highest urea group consistently having the lowest values for blood phosphorus (Fig. 6).

After about 4 months of lactation the values were similar for the three groups and continued in the normal range until the end of lactation. Again, immediately after the second parturition, blood phosphorus values dropped sharply in the three groups and once more the two urea-treated groups showed below normal levels of phosphorus as compared to low values of 3.90 mg % phosphorus immediately after parturition reported by Littledike et al., (1970). Phosphorus levels found in animals in groups II and III, immediately

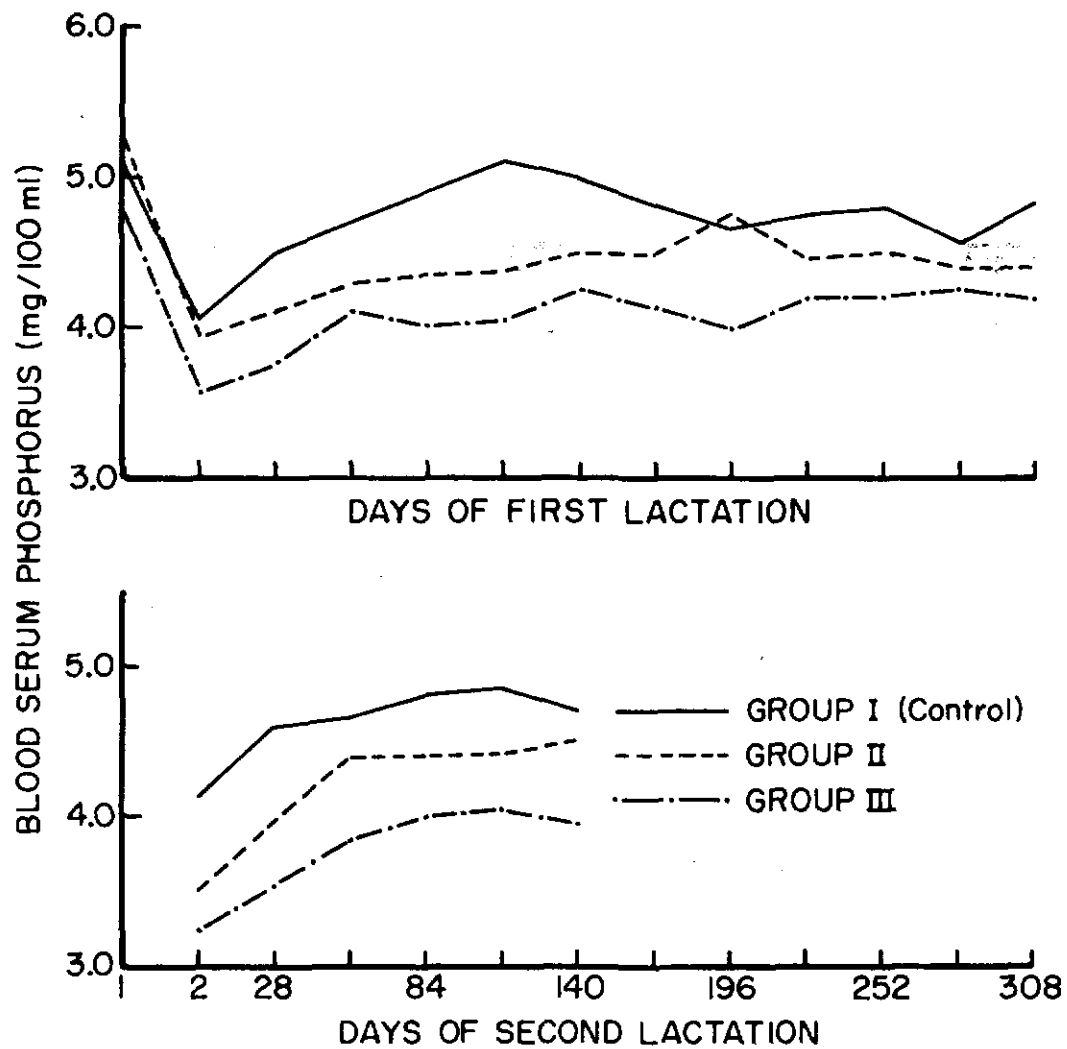


Figure 6. Phosphorus Content of Blood at Different Stages of Lactation.

after parturition, averaged 3.51 and 3.25 mg %, respectively.

Values for groups II and III decreased more than those for the control group. Significant differences ($P < .05$) were found between the control group and experimental group II which received the lowest amount of urea, at 28, 56, 84 and 112 days after the first parturition on the experiment and at 2 and 28 days after the second parturition.

These results indicate that blood phosphorus levels in the urea-fed animals were significantly lower than in the control group and that these levels reached their lowest value shortly after parturition. A return to higher levels was apparent after 28 days of lactation, but the trend was for the urea-fed groups to show significantly ($P < .01$) lower blood levels of phosphorus throughout the experiment as compared to the control group (Fig. 6).

Blood phosphorus values for the 20 herd cows used for comparative purposes, at 28 days prepartum and at 2 and 28 days postpartum were 4.73, 4.32 and 5.17 mg % respectively as compared to 5.12, 4.05 and 4.51 mg % of phosphorus in blood of the control animals at equivalent stages of lactation.

Magnesium. Blood magnesium levels remained between normal physiological ranges (Maynard and Loosli, 1962; Little-dike *et al.*, 1970) and the statistical analysis of the data collected throughout the two lactation periods indicated no significant differences due to treatments (Fig. 7).

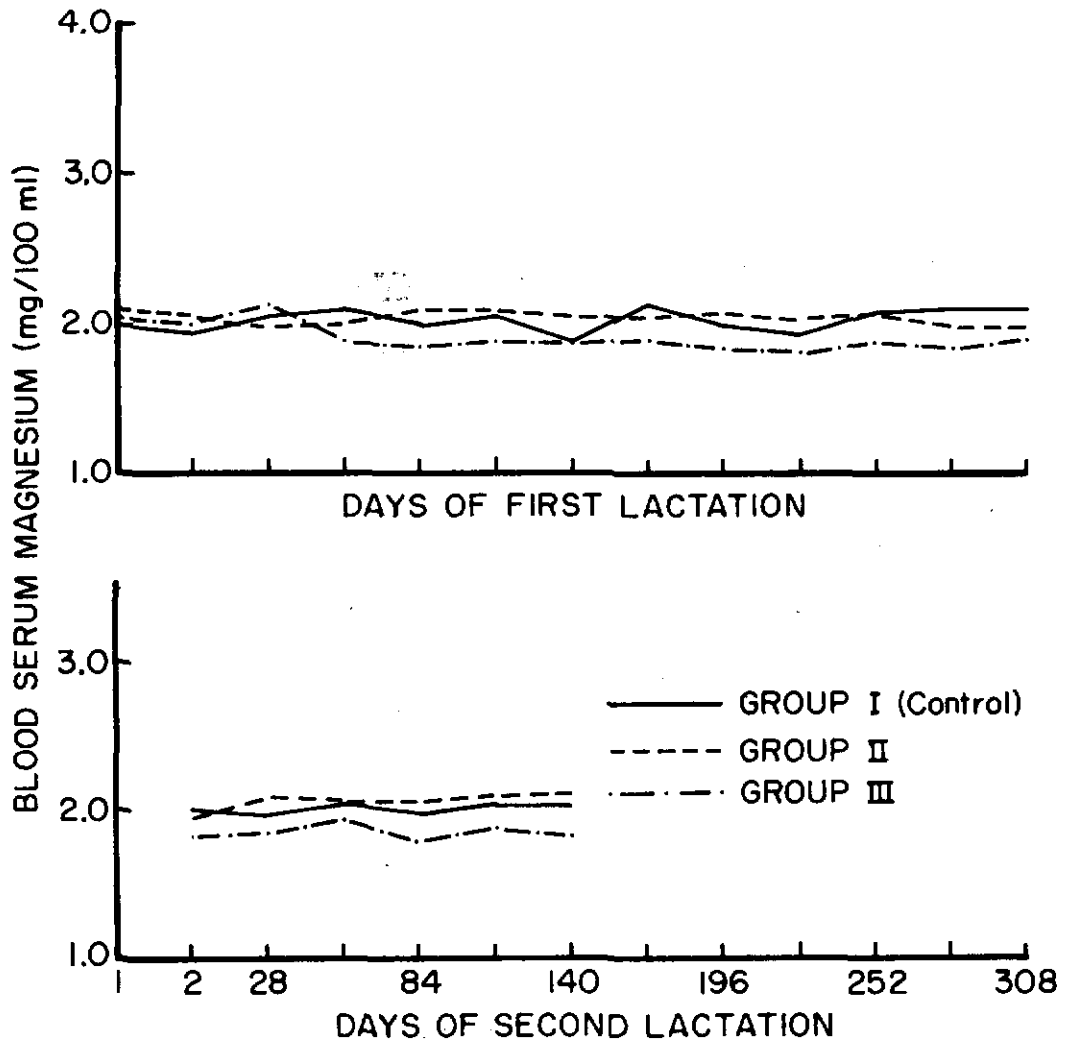


Figure 7. Magnesium Content of Blood at Different Stages of Lactation.

Potassium. All blood potassium values for the three experimental groups were consistently between normal physiological ranges (Altman 1961). The lowest and highest average blood potassium values were 17.80 and 19.64 mg %, respectively (Fig. 8). However, there were highly significant ($P < .01$) differences between group treatments beginning 56 days after parturition in both lactation periods. After 56 days lactation the urea-fed animals consistently showed significantly ($P < .01$) lower blood potassium levels as compared to the control group. These results indicated that the blood levels of potassium varied with treatments and that these differences were highly significant ($P < .01$). Again, however, no biological significance can be attributed to those differences since the values found were between generally considered normal ranges. Littledike et al. (1970) reported values of 18.7 mg % for the dry period and 13.7 mg % for 12 to 48 hours postpartum in normal cows.

Herd data for blood potassium levels in herd animals at 28 days before and at 2 and 28 days after parturition averaged 19.16, 19.28, and 19.04 mg % respectively, which compared favorably to 19.40, 19.11 and 19.03 mg % found in the control group at the equivalent stages of lactation.

Urea. During both lactation periods, the blood urea levels found showed a direct relationship to the levels of urea fed in the rations, with the lowest, intermediate, and highest blood urea levels occurring in groups I, II and III, respectively (Fig. 9).

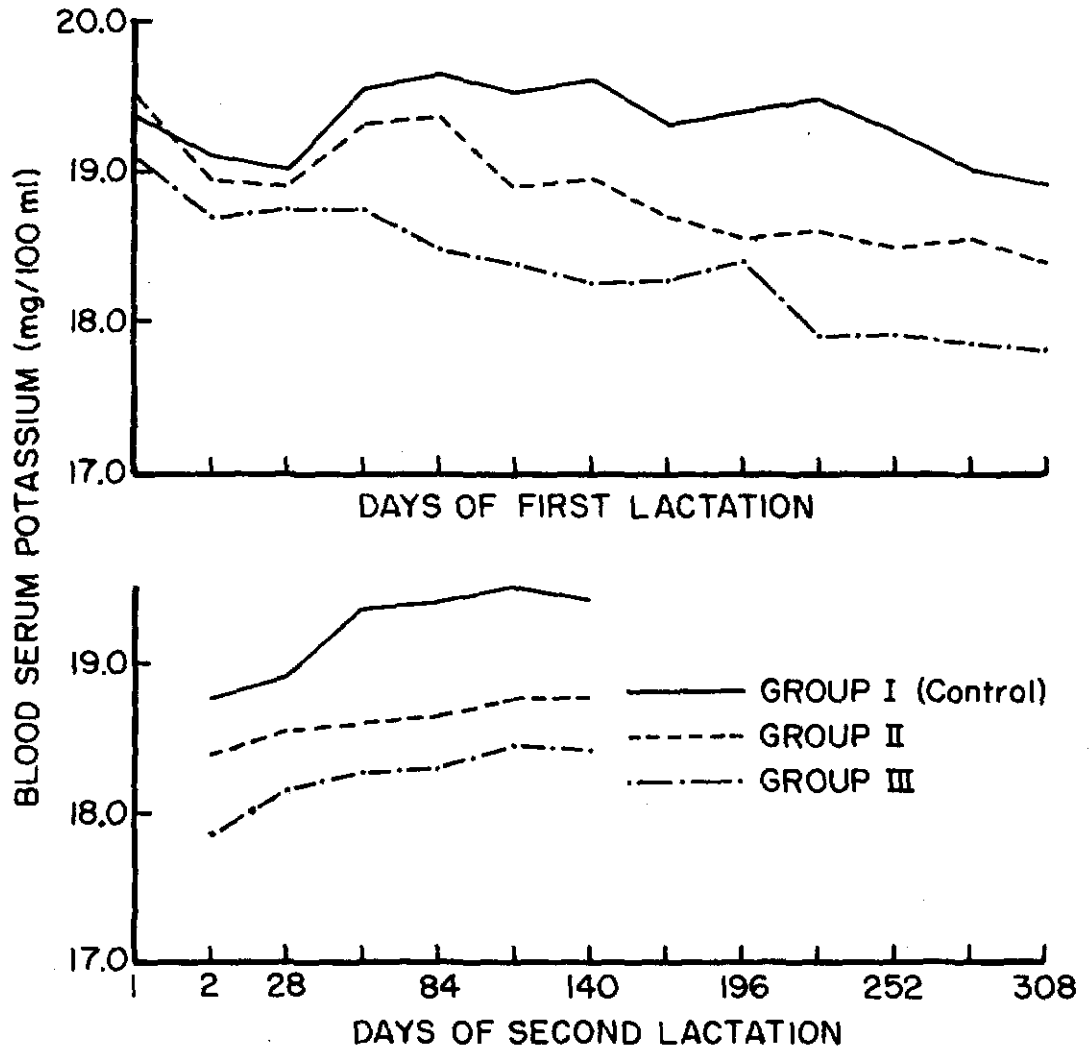


Figure 8. Potassium Content of Blood at Different Stages of Lactation.

Analysis of variance and the Duncan's new multiple range test performed with data collected every 28 days throughout the experimental period indicated highly significant differences ($P < .01$) between the treatment means at each period analyzed.

Levels of urea-N in blood were 28.30 and 24.74 mg % for groups III and II, respectively, when the concentrate consumption was highest during the first months of lactation. The level of urea in blood of the control animals showed little variation and the values remained between 13 and 20 mg %. These values were closely related to those found in the 20 herd animals which were sampled 28 days before and 2 and 28 days after parturition. The levels found were 17.23, 17.34 and 18.92 mg % for the three mentioned sampling periods respectively. These findings indicate that the control animals were behaving in a manner similar to animals in the general herd. The above results also indicate that blood urea levels increased with increasing amounts of urea in the ration and that at the highest levels of urea fed, 216 g. per cow per day on the average, the levels of urea in blood were almost double that found in the control animals.

Wide ranges of 2.9 to 22.4 mg of blood urea-N per 100 ml have been reported in cattle (Lane and Campbell, 1966). Based upon the results of this study, it is apparent that as the level of urea fed increased (Table 4) there was a concomitant increase in blood urea levels (Fig. 9).

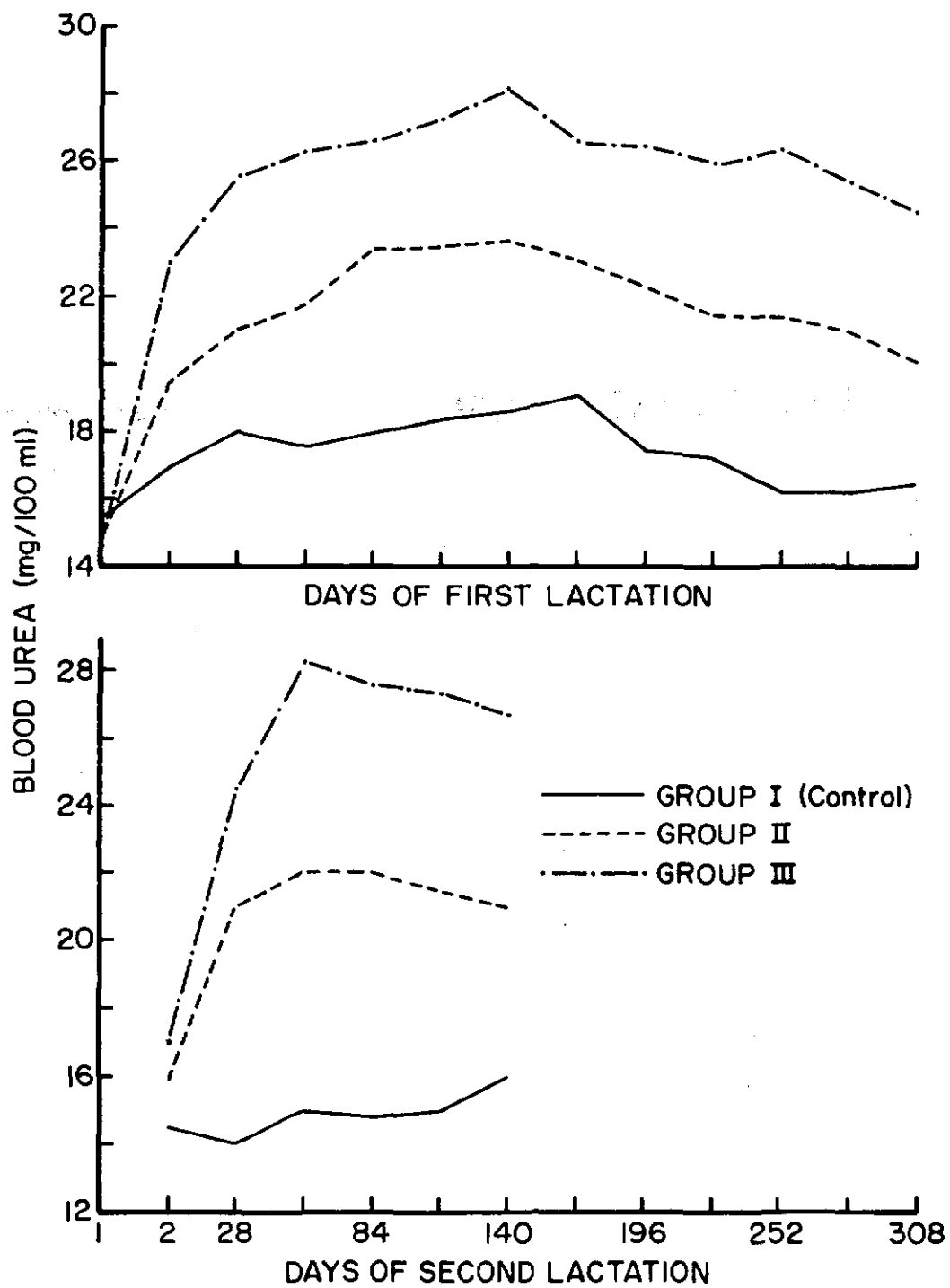


Figure 9. Urea Content of Blood at Different Stages of Lactation.

SECTION TWO

COMPARISON OF CORN AND YUCCA (MANIHOT ESCULENTA)
AS SOURCES OF ENERGY FOR GROWING DAIRY HEIFERS
FED SUGAR CANE TOPS AS THE SOLE ROUGHAGE.

Reproduction

Table 5 shows a summary of the reproductive performance of the three experimental groups. The animals in the control group behaved normally, conceived with relative ease, completed one lactation, and with the exception of one cow that aborted, seven out of eight calved normally a second time. At the present time, these seven cows are pregnant and producing normally. The number of services per conception for the first lactation was 1.50 and 1.57 in the second lactation. The general reproductive performance of the control animals was similar to that of the 20 herd cows used for comparative purposes. The number of services required per conception for the herd animals averaged 1.89.

The average number of days in milk for the first lactation on experiment, days dry, interval between parturitions and the number of days completed on the second lactation for the control group were: 355, 54, 409 and 182, respectively. The second group required an average of 2.75 and 2.71 services in the first and second reproductive periods, respectively.

In the second lactation, the average number of services per conception for group II included a cow that required 4 services, could not be settled and was diagnosed as having ovarian cysts. A second cow did not enter the second lactation period due to an abortion at 150 days of the first pregnancy. She continued milking for 530 days, was bred

and, at the time the experiment was concluded, was 127 days in gestation. The average number of days in milk during the first lactation, days dry (7 cows), interval between parturitions (7 cows), and number of days in the second lactation (7 cows) were 384, 71, 434 and 196, respectively (Table 5).

Cows in group III had a high incidence of reproductive problems. In the first lactation, 2 of the 8 cows in the group could not be settled after 4 and 6 inseminations, respectively. One of the cows was diagnosed pyometra and has been under treatment; the second was diagnosed bilateral ovarian cysts and was sold after completion of the first experimental lactation. The remaining 6 cows required 2.00 services per conception. Two of these animals aborted and a third cow gave birth, at term, to a dead female calf. Of the two cows that aborted, one conceived for a second time after 2 services, and the other one developed pyometra after the abortion. A fourth cow of the group of six that conceived died of parturient paresis at time of parturition.

Under the above circumstances, only 3 cows of the group of 8 entered the second lactation period. All 3 animals plus the cow that aborted and was inseminated again are pregnant after requiring an average of 2.25 services per conception and have completed an average of 209 days of the second lactation. It should be noted that the number of services per conception for this group of 8 animals was 1.75 prior to entering the experiment.

The reproductive performance of the three groups indicates that the incidence of reproductive problems increased with increasing levels of urea in the ration. The reproductive performance of the control group was similar to that of the general herd which did not receive urea and was on a different feeding regime. Attempts have been made to correlate reproductive response of the urea-fed groups of animals to blood minerals and urea levels in blood. However, as it was observed before, since the blood levels found, even though different, do not appear to be abnormal, the cause of the reproductive failure, particularly in the high-urea group, cannot be explained under the scope of the present work. More detailed research appears to be justified.

Table 6. Summary of Reproductive Performance of the Experimental Animals.

First Lactation	Groups		
	I	II	III
Number of animals	8	8	8
Average days in milk	355	384	400
Average dry period, days	54	71 ^{1/2}	72 ^{2/4}
Interval between parturitions	409	434 ^{3/4}	391 ^{4/4}
Services per conception, no.	1.5	2.75	3.66 ^{2/4}

^{1/} Only 7 animals included, 8th animal aborted.

^{2/} Only 4 animals included. Of the remaining, 2 aborted and 2 did not conceive.

^{3/} Only 7 animals included. One animal aborted at 159 days pregnancy, rebred.

^{4/} Only 4 animals included. See 2 above.

^{5/} Based on 8 animals. Includes 2 animals which required 4 and 6 services without conception. One animal was diagnosed pyometra and the other ovarian cysts.

Second Lactation	Groups		
	I	II	III
Number of animals	8	8	7
Average days in milk	182	196 ^{1/4}	209 ^{2/4}
Services per conception, no.	1.57 ^{2/4}	2.71 ^{4/4}	2.25 ^{5/4}

^{1/} 7 animals included, 8th animal aborted and did not enter 2nd lactation.

^{2/} Only 3 cows entered 2nd lactation. (2 abortions, 1 death, 2 did not conceive).

^{3/} 7 animals pregnant, 8th cow not bred due to recent parturition.

^{4/} 7 animals pregnant, 8th took 4 services and did not conceive a 2nd time.

^{5/} Based on 4 animals. Remaining 1 death at calving, 2 pyometra, 1 ovarian cysts.

INTRODUCTION

There is a need for basic and applied research in the fields of nutrition and physiology of dairy heifers of ages ranging from 8 months to first breeding. In Colombia, and especially in the Cauca River Valley where this experiment was conducted, dairy heifers do not always receive a diet which meets the requirements for normal growth and early achievement of an appropriate weight and size for breeding. Thus, breeding of heifers is usually delayed until twenty-four or more months with a consequent loss of valuable productive time.

According to McDowell (1963), the average growth rates of cattle kept in the lower elevations in countries within the North-South 30° latitudes are generally 10 to 50 percent below those acceptable for the 35° - 50° North latitudes. The differences are usually attributed to seasonal fluctuations in feed supplies, the direct effect of climate, disease, and parasitism, and poor genetic stocks. The first appears to have, directly or indirectly, the greatest influence on cattle production in most situations in the tropics. In the general area where the results of this type of research could have influence, neither disease nor genetic quality

appear to be the main factors determining poor results in dairying. It appears that inadequate management and nutrition are the most limiting factors affecting the dairy industry. In fact, it has been demonstrated (ICA, 1969) that generally accepted standards of growth for holstein heifers (Matthews and Fohrman, 1954; Ragsdale, 1934) can be obtained with relative ease providing that nutritional requirements are met. Goals such as 350 kg of body weight at an age of 15 months for first breeding can be achieved without a very sophisticated system of management.

Dairymen, which at the present time are not providing supplements to their heifers, or which are supplying very low amounts and on an irregular basis due to the high prices of commercial products but that are interested in an improvement of their practices, would welcome a supplement with the characteristics of low price and easy availability. On the other hand, data are needed on the effects of different energy sources on growth and reproductive performance of young adult dairy cattle grown under local conditions in Colombia.

Under the conditions in which the present experiment was conducted, the use of sugar cane tops as an alternative for other forages seems to offer an answer to the problems which the dairymen must face during certain periods of the year. It is thus necessary to be able to evaluate these kinds of forages more accurately in accord with requirements related to level of performance.

According to Conrad (1966) the total value of a forage depends upon many characteristics, the most important are those which contribute to energy availability including:

1) Factors contributing to the quantity of feed consumed per unit time by animal and 2) Factors contributing to the availability of energy per unit of feed consumed. Individual characteristics of forages may affect both sets of factors but not necessarily to the same degree.

The objectives of this experiment were to determine whether a native and easily available energy feed, such as yucca (Manihot esculenta), could efficiently replace corn in supplements for heifers between eight and sixteen months of age fed sugar cane tops as the sole roughage. The growth rates of the experimental animals were compared to growth standards (Matthews and Fohrman, 1954; Ragsdale, 1934).

REVIEW OF LITERATURE

Growth of Dairy Heifers

According to Joubert (1954), an adequate ration increases the rate of growth, especially weight, hastens the time of maturity, and allows the animal to develop to the full limit of its inheritance. However, it should be pointed out that the most important considerations in the growth of dairy animals are those which influence reproduction and lactation. Growth in body weight, aside from its effect on reproduction and lactation, is of only limited importance. The optimum growth pattern for dairy heifers is that regimen which will develop in the heifer her full lactation potential at a desired age and at a minimum of expense (Swanson, 1967). According to Crichton et al. (1959), appearance of puberty is directly and positively related to rate of growth and is dependent on size more than age. First estrous in Holsteins has been reported to occur between weights from 250 to 274 kg. At fast growth rates, averaging 0.9 kg per day, puberty appears at about 9 months in Holsteins (Reid et al., 1959). However, Reid et al. (1964) did not find significant differences in conception rates of slowly and rapidly growing heifers. Heifers growing rapidly enough to cycle at 14

months of age should be expected to conceive readily when bred.

Calving problems are inversely related to the size and physical condition of the heifer. In a comparison of slowly growing with normally growing identical twins at Tennessee, 20 percent of the low-plane heifers were lost at 24 months due to calving difficulty (Swanson and Hinton, 1964). In the New York study by Reid et al. (1964), none of 31 low-plane heifers were lost when calving at 32 months of age, but 50 percent required aid during parturition; whereas, only 25 percent of the normal and high plane of nutrition heifers required assistance. These observations have been confirmed also with identical twins by Swedish investigators (Hansson, 1956). Since difficult birth in heifers frequently results in the loss of a calf or a poor start in lactation, or both, it is recommended that a good nutritional level be provided all heifers for at least 2 months before calving.

According to Swanson (1967), the major features of an economical growing regimen for dairy heifers producing optimum lactations are outlined as: a) a moderately slow growth rate of heifer calves resulting in just enough body size and development to allow breeding at 14 months, b) continue the slow growth rate, possibly on roughage feed only until 9 to 12 weeks prepartum, c) gradually increase the level of feeding by adding concentrates, so that the heifer is gaining weight rapidly before calving, d) continue feeding the

heifer liberally through the first lactation, to allow for growth as well as lactation.

Origin of Yucca. (Manihot Esculenta)

Table 7. Common Names for Yucca, Countries Growing, and Areas Under Cultivation.

Common Names ^{1/}	Countries	Approximate Area Dedicated to Cultivation, ha. ^{2/}
Yucca	Caribbean Islands, Colombia, Central America, Ecuador, Peru	Brazil 1,600,000 Colombia 180,000
Guacamote	Mexico	India 250,000
Caxcamote	Guatemala	Indonesia 1,500,000
Macaxeira	Brazil	Paraguay 90,000
Mañoco	Puerto Rico	Africa 4,000,000
Yucuta	The Antillas	
Cassava	U.S.A.	
Tapioca	England, U.S.A.	

^{1/} Estrada et al. (1970)

^{2/} Voght and Penner (1963)

According to Mejia (1960), the cultivation of yucca is common in the equatorial and tropical regions of Latin America and the Caribbean Islands. In certain Asiatic colonies, it has been recently introduced. According to Estrada et al. (1970) yucca originated in the Amazon bay and was taken from there to Africa where almost four million hectares are cultivated today (Table 7). In South America it is very common in countries such as Argentina, Brazil, Colombia, Ecuador, Paraguay, Peru and Venezuela. Voght and Penner (1963) indicated that Brazil may be considered as the country where yucca originated but that today it is cultivated in all the

tropical regions and when the Spaniards arrived in America, yucca was already established in the Caribbean Islands, and in Central and South America.

Climate and Soils

According to Mejia (1960), yucca originated as a tropical plant and is easily adapted to the different temperatures of the tropics and for this reason it is a high yielder in a range of environmental temperatures between 16 and 30°C. Of course, there exist different varieties which give better results at a given temperature. Yucca is very resistant and not very demanding as to the chemical composition of the soils, especially in tropical soils. However, since it is a plant whose most valuable portion is located underground, loose and well-drained soils are more desirable.

Based upon the research conducted on its cultivation, (Estrada et al., 1970), it has been concluded that more attention ought to be given to the physical conditions rather than to the chemical conditions of the soils.

Yucca requires temperatures between 16 to 35°C and rain for its growth during the first months, then a dry season is convenient for the translocation of the carbohydrates, or the movement of the starches from the leaves down to the roots (Estrada et al., 1970).

Ospina (1960) reported that sandy loam soils and clay loam soils are best suited for the cultivation of yucca with the former being more efficient for high yields. The

choosing of the land, cultivation practices, physical characteristics of the soils, altitude above sea level, and climatic conditions must be considered for better results, (Montejo, 1940). The most appropriate soils appear to be those that are dry, exposed to sunlight, protected against strong winds and slightly sloping to facilitate drainage (Colom, 1939).

Planting Methods

According to Estrada and Varon (1970), even though yucca produces fertile seeds, vegetative propagation is the commercial method, utilizing stalk pieces known as "sticks," "pies" or "cangres." The sticks must be planted slightly inclined or bent and with about 8 to 12 inches remaining above ground level. Planting should be shallow in order to facilitate harvesting which is somehow difficult when the roots are too deep. Distances between rows must range from 12 to 15 inches and between plants from 15 to 30 inches. In the early stages of growth the use of weed killers is recommended. After two months of growth the shade formed by the plant controls weeds.

Fertilization

A 10-30-20 (N-P-K) fertilizer applied at a level of 400 to 500 kg per ha. significantly increases yields. A 10-30-10 can also be used at 500 kg per ha. (Estrada and Varon, 1970).

Diseases

Only two diseases are known to have some importance, both of them are produced by parasite fungi; the first of them is caused Cercospora Henningsii Alleschi which appears when the leaves have already matured and causes little damage. The second is due to the Gloscosporium Manihot, earle that initially attacks and kills the highest and immature branches and then continues down causing a lot of damage (Colom, 1939).

Harvest

Age for harvesting is variable and very dependent on the different varieties. It ranges from ten to twenty-two months. The leaves do not wither and the harvesting can be done over a period of several months. If the yucca is to be used as food for humans or animals, it must be harvested early. If it is going to be used for starch extraction, the harvesting can be delayed depending on labor or season. Mechanical harvesting is known to be more efficient with varieties of yucca with short roots. The stalks must first be cut for an easier machine job (Estrada, 1970).

The main factors determining the harvesting date are the starch content of the roots and how they will be used. Yucca, whose roots are to be used for starch production, must be harvested when the roots have achieved complete maturity and development since the content of starches varies with the age of the roots (Colom, 1939).

Yields

According to Ospina (1960), yields vary with the varieties and the climate and soil conditions. The yield range is wide and it may vary from 11 to 80 tons of yucca roots per hectare. This outstanding amount of high-energy dry matter per unit of land makes it very promising as an energy source for livestock.

Use of Yucca

Yucca is used in the human diet, as feedstuff for animals, in commercial production of starches, in starchymeal industries, in the fabrication of glucose, dextrin and alcohol, and as a substitute for barley in the beer industry (Estrada and Varon, 1970).

According to Rogers (1965), of all the plants used extensively as human foods, yucca is the least known. Corn, beans and cucurbites all are major elements in the diet of large segments of temperate and tropical populations. These have been extensively studied, not only from a botanical and ethnological standpoint, but also agronomically by many workers. Yucca assumes major importance in lowland tropical areas among people of relatively low economic status. The only product of yucca that is at all well known to temperate zone people is a minor starchy material called "tapioca."

Rogers (1963) proposed that yucca first become an important element in the diet of lowland tropical people somewhere in the Meso-American complex and was distributed

from there to the other portions of its present-day range. To millions of inhabitants of the tropical countries, yucca is as common in the daily food as potatoes are to the North Americans and Europeans.

According to Oyenuga (1955), when yucca is employed as food, only the "sweet" varieties must be cultivated since they contain less hydrocyanic acid. As livestock feed it is recommended in combination with brans, cottonseed meal or cake, and other sources of nitrogen in order to balance the protein of the rations.

In swine feeding, the digestibility and the starch content of yucca (Table 8) have been found to be very high. Significant body weight gains have been rapidly achieved when yucca was used (Ospina 1960). In one experiment conducted by Maner et al. (1970) fresh chopped yucca was fed free choice with each of six different protein supplements to weanling pigs during a 111-day trial. Average daily gains ranged from .59 kg for yucca plus cottonseed meal supplement to .73 kg for yucca plus meat and blood meal supplement. The average daily consumption of yucca by pigs ranged between 3.1 kg and 4.1 kg. The feed/gain ratio ranged between 3.07 and 3.47.

Table 8. Chemical Composition of Yucca Roots^{1/}

	ICA ^{2/}	Alba ^{3/}
Dry matter, %	35.00	87.0
Crude protein, %	3.96	2.5
Ether Extract, %	.95	1.6
Crude fiber, %	4.93	1.9
Nitrogen-free extract, %	86.25	80.0
Ash, %	3.91	

^{1/}Composition on a dry matter basis.

^{2/}Colombian Institute of Agriculture ICA (1965).

^{3/}Alba. (1954).

MATERIALS AND METHODS

An experiment with twenty 8-month -old Holstein heifers was conducted at the the "Palmira" Experiment Station of the Colombian Institute of Agriculture (ICA). The Experiment Station is located at 1000 meters above sea level, with an average temperature of 23°C and an annual rainfall of 1005 millimeters. The twenty heifers were selected from the Experiment Station herd and assigned at random to two treatments to compare yucca and corn grain as sources of energy in the supplement.

The two treatments consisted of: Group I, control animals fed sugar cane tops ad libitum plus 3.0 kg daily of a concentrate (Table 3) in which the energy source was primarily corn grain. The concentrate contained 1.5% urea on as fed basis. Group II, animals fed sugar cane tops ad libitum plus 1.23 kg of a concentrate (Table 9) and 4.5 kg of yucca containing 35% dry matter.

The dry matter intake from supplement was 2.64 kg per day for animals in both groups. In group II, the dry matter supplied by corn was replaced by an equal amount of dry matter supplied by yucca. Urea was utilized in this ration in an amount equivalent to that in the control group.

The sugar cane tops were harvested daily from a nearby sugar cane field. The material used as forage was the top part of the sugar cane plant, the material remaining after the sugar cane stalks had been removed for processing of sugar. The sugar cane tops contained the leaves and the upper part of the stalk which is enclosed between the leaf sheath.

The sugar cane tops were chopped, weighed and fed to the heifers on an individual basis. The animals were fed twice daily and the refusals were recorded daily every morning before feeding. The concentrate was fed every morning mixed with the sugar cane tops.

The yucca was harvested every morning, free from dirt, chopped in small pieces, weighed and fed to the experimental heifers. Each animal had free access to water and mineralized salt.

Individual feed intakes of sugar cane tops, concentrate and yucca were recorded for all the animals daily during the experimental period of 224 days. Samples of sugar cane tops, yucca and concentrate were taken daily, weighed, dried, ground and stored to make composite samples to be analyzed every 28 days for dry matter, crude protein, ether extract, crude fiber, ash and nitrogen-free extract (A.O.A.C., 1965).

Body weights were recorded every 28 days and the animals carefully observed for the appearance of first and subsequent estrous cycles.

The statistical analysis was an ANOVA of the completely randomized design (Steel and Torrie, 1960).

Table 9. Composition of Supplements Fed^{1/}

Ingredients	Group I ^{2/}	Group II ^{2/}
Yellow corn, %	59.0	--
Wheat bran and dried molasses mixture, %	24.0	28.2
Cottonseed cake, %	13.0	61.1
Urea, %	1.5	3.7
Bone meal, %	1.5	4.6
Microelements mixture, %	1.0	2.4
Total	100.0	100.0

^{1/}As fed basis.

^{2/}Group I received 2.64 kg supplement/day dry matter basis.
Group II received 1.08 kg DM grain mixture plus 1.56 kg DM from yucca.

Both groups received 2.64 kg DM/day from supplement.

Calculated Chemical Analysis

Crude protein, %	18.0	40.18
Total digestible nutrients, %	71.0	60.0
Calcium, %	.5	1.3
Phosphorus, %	.5	1.3

RESULTS AND DISCUSSION

The experimental animals fed yucca as a replacement for corn grain on a dry matter basis in the concentrate, had higher body weight gains than the control animals. Statistical analysis of body weight gains showed a significant difference ($P < .05$) in favor of the yucca-fed heifers during the period of time between eight and sixteen months of age (Table 11). The rate of growth of the control and the experimental animals was similar to the rates reported for Holstein heifers of the same ages by Beltsville (Matthews and Fohrman, 1954) and Missouri (Ragsdale, 1934) as shown in Fig. 10.

No statistically significant difference was found between the groups in the consumption of sugar cane tops during the experimental period. However, on a dry matter basis, a slightly higher amount of sugar cane tops was consumed by animals in the control group (Table 11). The results indicate that even though the experimental animals consumed slightly less forage and a similar amount of dry matter from concentrate as compared to the controls, the average body weight gains during the experimental period were 186.7 and 175.9 kg, respectively, for the experimental and the control groups. These differences were statistically significant ($P < .05$).

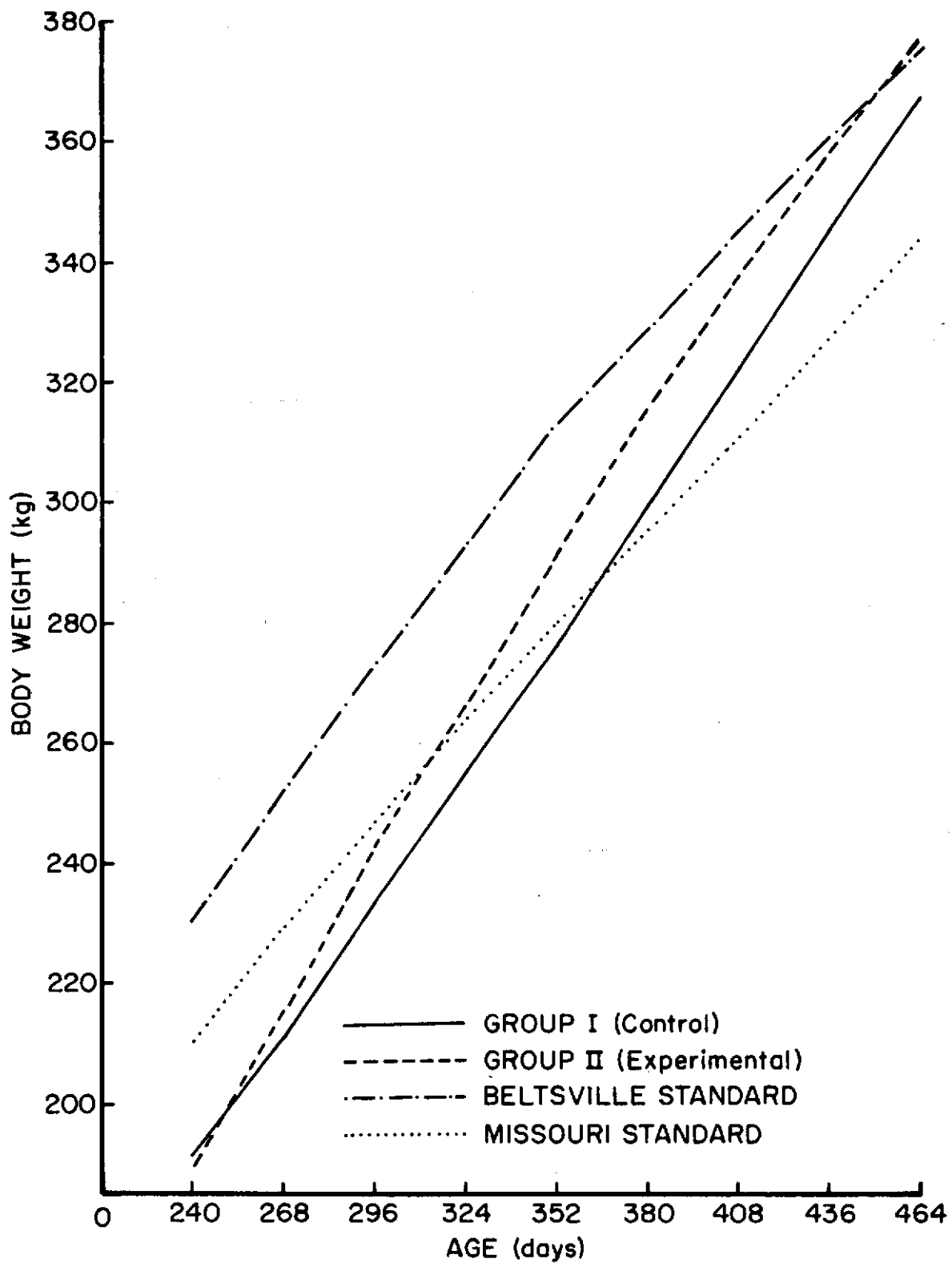


Figure 10. Body Weight of Animals According to Age Compared to Two Growth Standards.

The results also indicate that sugar cane tops are a suitable roughage substitute for growing dairy heifers and permit to expect satisfactory rates of growth when fed with an adequate supplement. On the other hand, it appears that yucca, as a source of energy (Table 10), may be used as a replacement for corn grain, on a dry matter basis, in the formulation of concentrate mixtures for growing dairy heifers up to first breeding, with growth rates approaching the current standards for growth of heifers (Fig. 10).

Figure 12 shows the average daily protein intake of both the control and the experimental groups related to body weight and compared to NAS-NRC (1966). The data show that even though the experimental animals consumed slightly lower amounts of protein per day intakes of protein from the supplement and the sugar cane tops were adequate to allow the animals to grow at a rate comparable to published standards (Matthews and Fohrman, 1954; Ragsdale, 1934).

Table 12 shows the reproductive performance of the heifers in experiment. The animals began to show signs of estrous at 11 months in both groups. The average age for first detected estrous was 11.1 and 11.3 months for the control and the experimental animals, respectively. The number of services per conception was 1.88 and 1.77 for groups I and II, respectively. At the conclusion of the experiment, eight animals were diagnosed pregnant in the control group and nine in the experimental group. The remaining

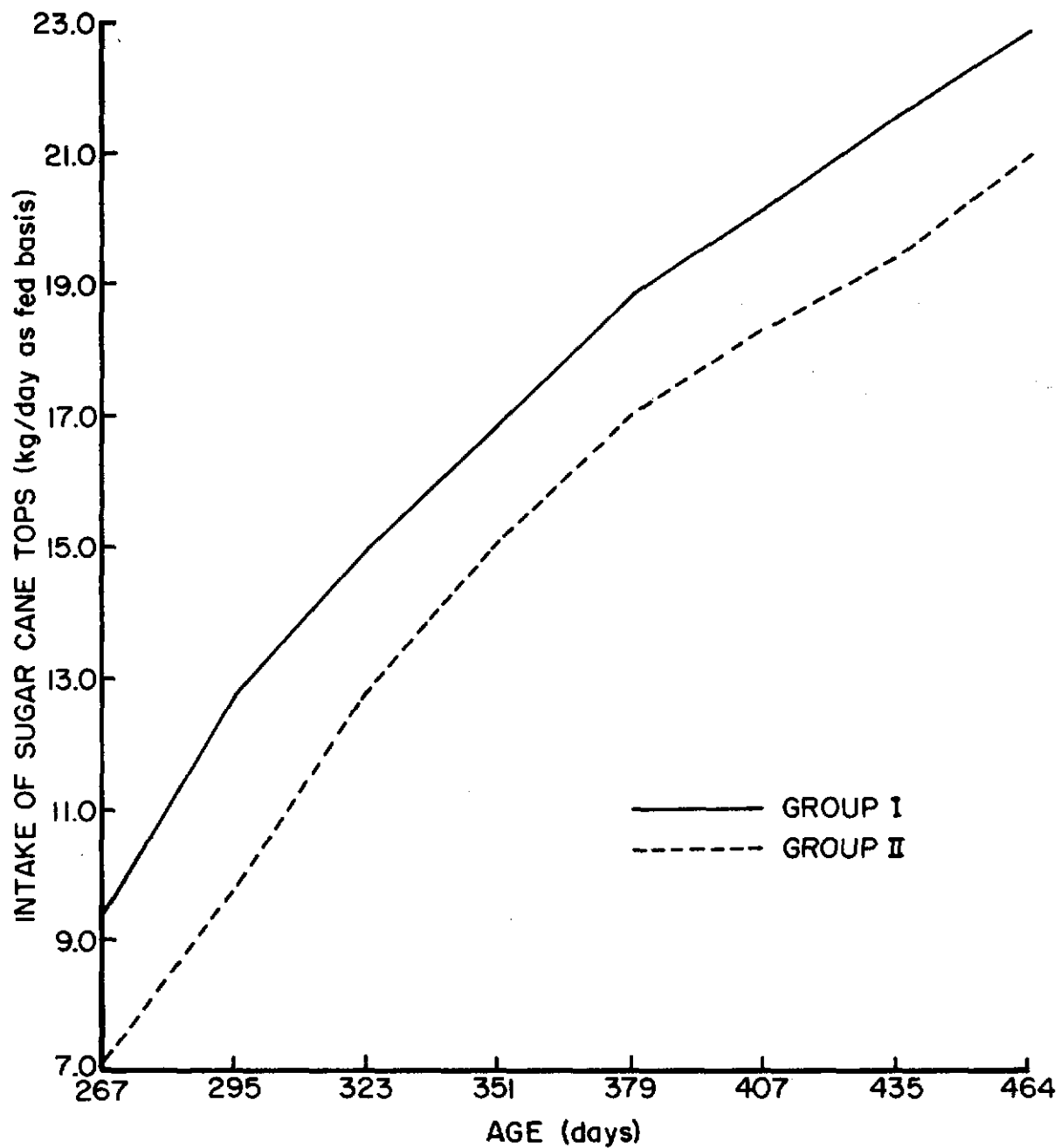


Figure 11. Average Daily Intake of Sugar Cane Tops.

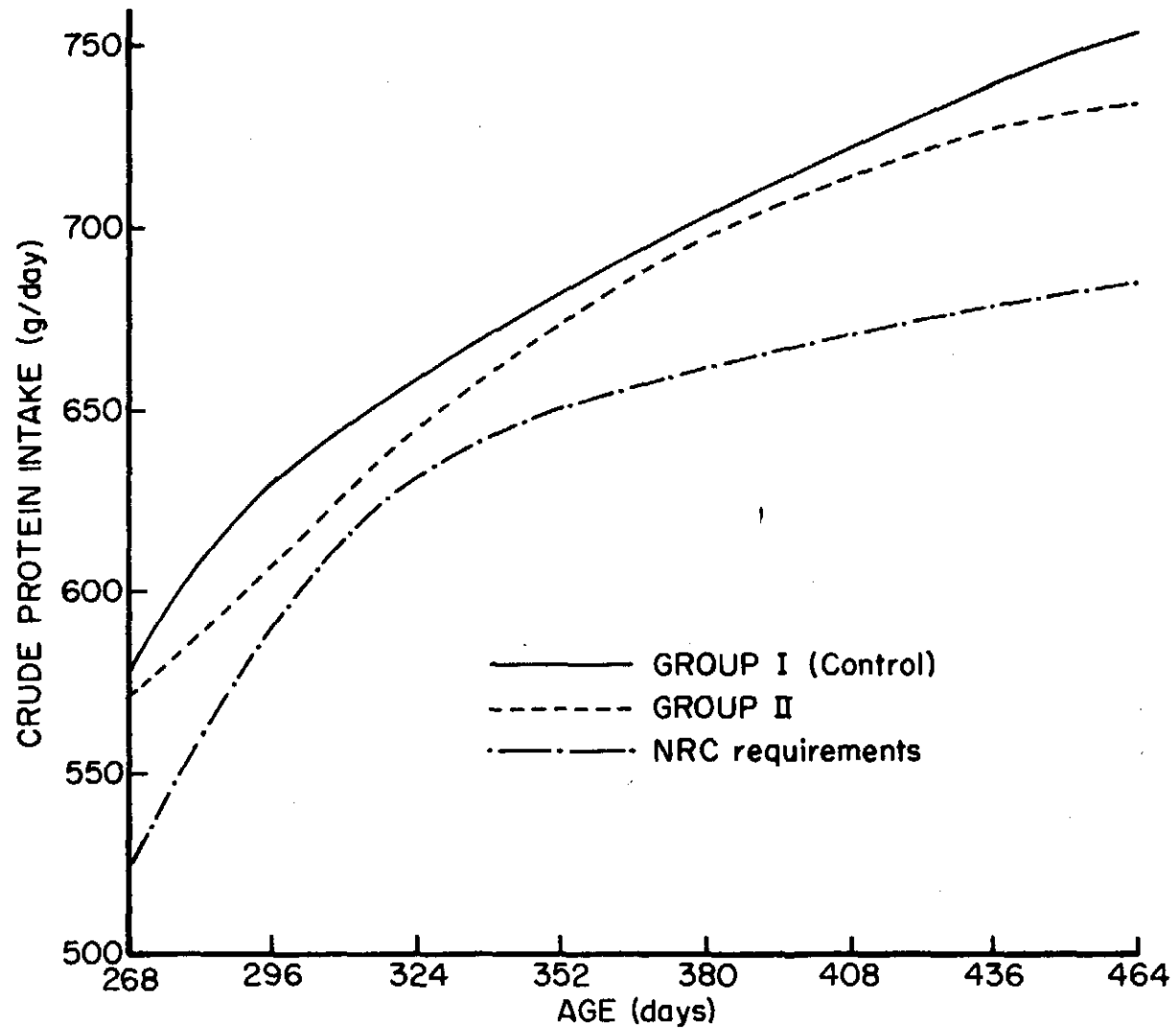


Figure 12. Average Daily Protein Intake of Animals Related to Body Weight and Compared to NAS-NRC Allowances.

three heifers were recently bred and no diagnosis of pregnancy was made.

Table 10. Average Chemical Composition of the Feeds Used During the Experiment.^{1/}

Item	Sugar Cane Tops	Yucca	Control Concentrate	Exp. Concentrate
Dry matter, %	28.00	35.00	88.00	88.00
Crude protein, %	4.36	3.77	18.10	40.00
Crude fiber, %	31.48	4.68	5.80	9.90
Ether extract, %	1.61	.90	3.20	2.70
Ash, %	7.87	3.69	4.20	5.80
Nitrogen-free extract, %	54.68	86.96	68.70	37.62

^{1/} Dry matter basis.

Table 11. Average Daily Feed Intakes and Weight Gains of Heifers.

Item	Group	
	I (Control)	II (Experimental)
Number of animals	10	10
Initial body weight, kg	191.8	190.6
Final body weight, kg	366.8	377.3*
Body weight gains, kg	175.0	186.7*
Average daily gain, kg	.781	.833*
Dry matter intakes from:		
Sugar cane tops, kg/day	4.82	4.17
Concentrate, kg/day	2.64	1.08
Yucca, kg/day	--	1.56
Total, kg/day	7.46	6.81
Protein intake gm/day	667	672

*Significantly different ($P < .05$).

Table 12. Sexual Maturity and Reproductive Performance of Heifers.

	Group	
	I (Control)	II (Experimental)
Number of animals	10	10
Average age at first detected heat, months	11.1	11.3
Average age at first breeding, months	15	14.5
Average body weight at first breeding, kg	352.9	355.9
Animals diagnosed pregnant, no.	8	9 ^{1/}
Services per conception, no.	1.88	1.77

^{1/}The remaining heifers were recently bred for the first time.

GENERAL SUMMARY

Two experiments were conducted in Colombia, South America: 1) to determine the effects of urea on production and reproductive performance of dairy cows when incorporated, as a source of protein, in the concentrate grain mixture; and 2) to evaluate the substitution of yucca (Manihot Esculenta) for corn as a source of energy for growing dairy heifers.

On the urea experiment, twenty-four Holstein dairy cows were assigned at random to three treatments; I) control, II) 33 percent of the supplementary protein from urea, and III) 66 percent of the supplementary protein from urea. Corn silage was fed as the sole forage. The experiment was initiated about one month prepartum and continued through one lactation to 140 days into the second lactation.

Statistically significant differences ($P < .05$) were found in overall concentrate intake during the first 305-day lactation period between the control and the experimental groups. Differences in intake were not significant during the second lactation period. Concentrate intakes were 1869.4, 1548.5 and 1619.4 kg, respectively, for cows in groups I, II and III during the first lactation period. Intakes of urea averaged 0, 118 and 216 g. for cows in the respective 3 groups.

Milk yields were 5457.9, 4915.9 and 5120.7 kg, respectively, for cows in groups I, II and III during the first 305-day lactation. Highly significant differences ($P < .01$) in percent milk fat were found between the groups during both lactations. Average milk fat percentages were 3.45, 3.54 and 3.74 for the first lactation and 3.44, 3.61 and 3.70 for the second lactation for groups I, II and III, respectively. No significant differences were found in fat-corrected milk produced.

Statistically significant differences between groups were found in blood serum levels of Ca, P, K and urea, particularly, immediately after parturition. Animals in the high urea group (Group III) consistently had the lowest levels of Ca, P and K, and the highest levels of blood urea nitrogen (BUN). BUN increased as dietary levels of urea increased. No significant differences were found in blood serum Mg.

Number of services required per conception were 1.50, 2.75 and 3.66 for the first period and 1.57, 2.71 and 2.25 for the second period, for groups I, II and III, respectively. In group I, one cow aborted, was rebred and had a normal second parturition on experiment. All animals in this group conceived after the second parturition on experiment.

In group II, one cow aborted, 7 calved a second time and all 7 were diagnosed pregnant after the second parturition

on experiment. In group III, 2 cows aborted, 2 did not conceive after 5 and 6 inseminations, respectively, and 1 cow died at time of second parturition. Only 3 cows entered a second lactation. The 3 mentioned cows and one of the animals that aborted were diagnosed pregnant a second time.

On the energy experiment, 20 eight-month-old Holstein heifers were assigned at random to two treatments: Group I, corn grain as the main supplementary energy source; and group II, yucca (Manihot Esculenta), substituted for corn on a dry matter basis. Sugar cane tops were used as the sole forage in both groups.

Statistically significant differences ($P < .05$) were found in body weight gains in favor of the yucca-fed heifers between 8 and 16 months of age (224 days). Average daily weight gains were .781 and .833 kg, respectively, for groups I and II. Feed intakes, on a dry matter basis, were similar in both groups.

Average age for the first breeding was 15 and 14.5 months and average services per conception were 1.88 and 1.77 for groups I and II, respectively.

BIBLIOGRAPHY

BIBLIOGRAPHY

- Alba, J. 1954. Nutritive Value of Cocoa Hulls for Milk Production as Compared to Ground Corn and Cassava Meal. *Turrialba*. 4:29.
- Altman, P. L. 1961. Blood and Other Body Fluids. Biological Handbook. Ed. D. S. Dittmer. p. 27.
- Archibald, J. G. 1943. Feeding Urea to Dairy Cows. *Mass. Agr. Exp. Sta. Res. Bull.* 406.
- Association of Official Analytical Chemists. 1965. Official Methods of Analysis. 10th Ed. Ass. Offic. Anal. Chemists. Washington D.C.
- Beeson, W. M. 1969. Urea in the Ration: How Much Can We Safely Add? *J. Am. Vet. Med. Assoc.* 154:1220.
- Brown, G. W. and D. R. Jacobson. 1966. Utilization of Urea by Growing Dairy Heifers. *J. Dairy Sci.* 49:450 (Abst.).
- Bryant, M. P. and I. M. Robinson. 1962. Some Nutritional Characteristics of Predominant Culturable Ruminant Bacteria. *J. Bacteriol.* 85:605.
- Chalupa, W. V. 1968. Problems in Feeding Urea to Ruminants. *J. Animal Sci.* 27:207.
- Chaney, A. L. and E. P. Marbach. 1962. Estimation of Urea Nitrogen in Blood Serum. *Clinical Chem.* 8:130.
- Clifford, A. J. and A. D. Tillman. 1968. Urea and Isolated Soybean Protein in Sheep Purified Diets. *J. Animal Sci.* 27:484.
- Colenbrander, V.F., L. D. Muller, T. G. Martin and W. W. Carlton. 1968. The Effects of Feeding all Supplemental Nitrogen as Urea to Dairy Steers. *J. Dairy Sci.* 51:979 (Abst.).
- Colom, J. L. 1939. Cassava, Its Cultivation and Utility. *Agriculture*. 16:593.

- Colombian Institute of Agriculture, (ICA). 1968. Dairy Science National Program. Annual Report. p. 10.
- Colombian Institute of Agriculture, (ICA). 1969. Averages of Feedstuffs Analysis Performed During 1967 and 1968. Nutr. Lab. Files. Bogota, Colombia.
- Colovos, N.F., H. A. Kenner, H. A. Davis, B. S. Reddy and P. P. Reddy. 1963. Nutritive Value of the Dairy Cattle Ration as Affected by Different Levels of Urea and Quality of Ingredients. J. Dairy Sci. 46:696.
- Colovos, N. F., J. B. Holter, J. B. Davis and W. E. Urban Jr. 1967. Urea for Lactating Dairy Cattle. II. Effect of Various Levels of Concentrate Urea on Nutritive Value of the Ration. J. Dairy Sci. 50:523.
- Conrad, H. R. 1966. Symposium on Factors Influencing the Voluntary Intake of Herbage by Ruminants: Physiological and Physical Factors Limiting Feed Intake. J. Animal Sci. 25:227.
- Conrad, H. R. and J. W. Hibbs. 1968. Nitrogen Utilization by the Ruminants. An Appreciation of Its Nutritive Value. J. Dairy Sci. 51:276.
- Chrichton, J. A., J. N. Aitken, and A. W. Boyne. 1959. The Effect of Plane of Nutrition During Rearing on Growth, Production, Reproduction, and Health of Dairy Cattle. I. Growth to 24 Months. Animal Prod. 1:145.
- Dinning, J. S., H. M. Briggs, W. D. Gallup, H. W. Orr and R. Butler. 1948. Effect of Orally Administered Urea on the Ammonia and Urea Concentration in the Blood of Cattle and Sheep with Observations on Blood Ammonia Levels Associated with Symptoms of Alkalosis. Am. J. of Physiol. 153:41.
- Donaldson, L. E. and W. Hansel. 1965. Prolongation of the Life-Span of the Bovine Corpus Luteum by Single Injection of the Bovine Luteinizing Hormone. J. Dairy Sci. 48:903.
- Donker, J. D., S. Harbanks and H. W. Mohrenweiser. 1968. Forage Evaluation. I. Performance of Holstein Heifers Fed Only Early-Cut or Late-Cut alfalfa Hay on a Free Choice Basis. J. Dairy Sci. 51:362
- Downie, N. M. and R. W. Heath. 1965. Basic Statistical Methods. Harper and Row, Publishers. p. 181.
- Dunn, T. G., J. E. Ingalls, D. R. Zimmerman and J. N. Wiltbank. 1969. Reproductive Performance of 2-year-old Hereford and Angus Heifers as Influenced by Pre- and Post-Calving Energy Intake. J. Animal Sci. 29:719

- Estrada, N. and L. A. Varon. 1970. The Cultivation of Cassava. Colombian Institute of Agriculture. Mimeograph.
- Feoktislov, S. I. 1966. Effect of Urea in Feed on Reproduction in Cows. Zivoknovodstvo. 8:90 (Nutr. Abst. Rev. 38. No. 1340).
- Gorskova, R. N. 1967. Morphology of Organs of Ruminants Fattened on Maize and Straw Silage with Added Urea. Izdat. Moscow. p. 124. (Nutr. Abst. Rev. 38. No. 1341).
- Hansson, A. 1956. Influence of Rearing Intensity on Body Development and Milk Production. Proc. British Soc. Animal Prod. 51:176.
- Harris, L. E. and H. H. Mitchell. 1941. The Value of Urea in the Synthesis of Protein in the Paunch of the Ruminant. II. In Growth. J. Nutrition. 22:183.
- Harris, W. D. and P. Popat. 1954. Determination of Inorganic Phosphorus in Biological Materials. Am. Oil Chem. Soc. J. 31:124.
- Helmer, L. G., E. E. Bartley and C. W. Deyoe. 1970. Feed Processing. VI. Comparison of Starea, Urea and Soybean Meal as Protein Sources for Lactating Dairy Cows. J. Dairy Sci. 53:883.
- Hill, J. R. Jr., D. R. Lamond, D. M. Herricks, J. F. Dickey and G. D. Niswender. 1970. The Effects of Undernutrition on Ovarian Function and Fertility in Beef Heifers. Biol. Reprod. 2:78.
- Holter, J.B., N. F. Colovos, H. A. Davis and W. E. Urban Jr. 1968. Urea for Lactating dairy Cattle. III. Nutritive Value of Rations of Corn Silage Plus Concentrate Containing Various Levels of Urea. J. Dairy Sci. 51:1243.
- Huber, J. T. and R. A. Sandy. 1965. Response of Dairy Cows Fed Unlimited Corn Silage to Three Levels of Urea and Grain. J. Animal Sci. 24:887 (Abst.).
- Huber, J. T., R. A. Sandy and C. E. Polan. 1967. Varying Levels of Urea for Dairy Cows Fed Corn Silage as the Only Forage. J. Dairy Sci. 50:1241
- Joubert, D. M. 1954. The Influence of Winter Nutritional Depressions on the Growth, Reproduction and Production of Cattle. J. Agric. Sci. 44:5.

- Joubert, D. M. 1954. The Influence of High and Low Nutritional Planes on the Oestrus Cycle and Conception Rate of Heifers. *J. Agric. Sci.* 45:164.
- Kendall, K. A., K. E. Harshbarger, R. L. Hays and E. E. Ormiston. 1968. Blood Mineral Levels Associated with Prepartum Milking. *J. Animal Sci.* 27:1769 (Abst.).
- Lane, A. G., and J. R. Campbell. 1966. Blood Urea Nitrogen in Jersey Cattle. *J. Dairy Sci.* 49:193.
- Lassiter, C. A. 1967. The Use of Corn Silage and Urea in Dietary Rations. *Proc. Dist. Feed Res. Council. Conf.* 22:64.
- Leathem, J. H. 1966. Nutritional Effects on Hormone Production. *J. Animal Sci.* 25:68 (Suppl.).
- Littledike, E. T., S. C. Whipp, D. A. Witzel and A. L. Baetz. 1970. Insulin Corticoids and Parturient Paresis. In book *Parturient Hypocalcemia*. Ed. J. J. B. Anderson. Academic Press.
- Lizal, F. 1967. Suitability of Large Amounts of Urea, Molasses and Straw for Rearing Heifers. *Nutr. Abst. Rev.* 38. No. 1599.
- Lomba, F., R. Paquay, V. Bienfet and A. Lousse. 1969. Statistical Research on the Fate of Dietary Mineral Elements in Dry and Lactating Cows. III. Phosphorus. *J. Agric. Sci.* 73:215.
- Loskutou, A. N. and V. I. Berkovic. 1964. Prolongued Feeding of Urea and Ammonia Solutions. *Veterinarija.* 41:46. (*Nutr. Abst. Rev.* 35. 518.).
- Maner, J. H., J. Buitrago and J. T. Gallo. 1970. Protein Sources for Supplementation of Fresh Cassava (*Manihot Esculenta*) Rations for Growing-finishing Swine. *J. Animal Sci.* 31:208 (Abst.).
- Matthews, C. A. and M. H. Fohrman. 1954. Beltsville Growth Standards for Holstein Cattle. U.S. Dept. of Agric. Tech. Bull. 1099. Washington D.C.
- Maynard, L. A., and J. K. Loosli. 1962. Animal Nutrition. 5th ed. McGraw-Hill Book Company Inc. p. 127.
- Mejia, R. 1946. The Cultivation of Cassava and Its Industrial Utilization. *Tropical Agric.* 2:14.

Mejia, R. 1960. Comparative Value of Cassava and Corn in Swine Feeding. Nat. Agronomy Faculty Bull. 22:135. Colombia.

Miller, R. H., N. W. Hooven Jr. and M. E. Creegan. 1969. Weight Changes in Lactating Holstein Cows. J. Dairy Sci. 52:90.

Montejo, O. A. 1940. Considerations on the Cultivation of Cassava in Brasil and on the Manufacturing of Alcohol, Starch Meals and Their Possibilities in Colombia. Nat. Agric. Bull. 35:135. Colombia.

Morrow, D. A. 1969. Estrous Behavior and Ovarian Activity in Prepuberal and Postpuberal Dairy Heifers. I. Dairy Sci. 52:224.

Nelson, A. B., L. R. Kuhlman, G. R. Waller and W. D. Campbell. 1961. Urea in Protein Supplements for Wintering Steer Calves Grazing Native Grass. Okla. Agr. Exp. Stat. Misc. Pub. 64:76.

Nelson, A. B. and G. R. Waller. 1962. Urea in Winter Supplements for Range Beef Cattle. J. Animal Sci. 21:387 (Abst.).

NOPCO Chemical Division. 1965. Feed Ingredient Analysis Table for Ruminants. Feed Ingrid. Anal. Table.

Oltjen, R. R. and P. A. Putman. 1967. NPN as the Primary Nitrogen Source for Cattle. Proc. Cornell Nutr. Conf. Feed Manuf. Ithaca, New York, p. 48.

Ospina, A. 1960. Cassava: A Valuable Resource. Rice. 9:19. Colombia.

Oyenuga, V. A. 1955. The Composition and Nutritive Value of Certain Feeding Stuffs in Nigeria. I. Roots, Tubers and Green Leaves. Emp. J. Exp. Agric. 23:81.

Patton, R. S. 1970. Conception Rate and Luteal Function of Holstein Heifers Fed a Ration with 45 Percent of the Nitrogen from Urea. M. S. Thesis. Purdue University., Lafayette, Ind.

Paquay, R., F. Lomba, A. Lousse and V. Bienfet. 1969. Statistical Research on the Fate of Dietary Mineral Elements in Dry and Lactating Cows. V. Potassium. J. Agric. Sci. 73:445.

Perkin-Elmer. 1966. Analytical Methods for Atomic Absorption Spectrophotometry. Calcium in Blood Serum, Tissue and Other Biological Materials. Part 990-9581.

Perkin-Elmer. 1965. Analytical Methods for Atomic Absorption Spectrophotometry. Determination of Magnesium in Biological Materials. Part 990-9461.

Perkin-Elmer. 1966. Analytical Methods for Atomic Absorption Spectrophotometry. Determination of Potassium in Blood Serum. Part 990-9559.

Pieterse, P. J. 1967. Urea in Winter Ration for Cattle. In book Urea as a Protein Supplement. Ed. M. H. Briggs Pergamon Press, New York.

Prior, R. L., A. J. Clifford, D. E. Hogue and W. J. Wisek. 1970. Enzymes and Metabolites of Intermediary Metabolism in Urea-fed Sheep. J. Nutr. 100:438.

Purser, D. B. 1970. Nitrogen Metabolism in the Rumen: Microorganisms as a Source of Protein for the Ruminant Animal. J. Animal Sci. 30:988.

Ragsdale, A. C. 1934. Growth Standards for Dairy Cattle. Mo. Agr. Expt. Sta., Bull. 336.

Raleigh, R. J. and J. D. Wallace. 1963. Effect of Urea at Different Nitrogen Levels on Digestibility and on Performance of Growing Steers Fed Low Quality Flood Meadow Forage. J. Animal Sci. 22:330.

Reid, J. T. 1960. Effects of Energy Intake upon Reproduction in Farm Animals. J. Dairy Sci. 43:103 (Suppl).

Reid, J. T., J. K. Loosli, G. W. Trimberger, and K. L. Turk. 1964. Causes and Prevention of Reproductive Failures in Dairy Cattle. IV. Effect of Plane of Nutrition During Early Life on Growth, Reproduction, Production, Health and Longevity of Holstein Cows. I. Birth to Fifth Calving. Cornell Expt. Sta., Bull. 987.

Rogers, D. J. 1965. Some Botanical and Ethnological Considerations on Manihot Esculenta. Economy Botany. 19:369.

Rumsey, T. S., J. Bond and R. R. Oltjen. 1969. Growth and Reproductive Performance of Bulls and Heifers Fed Purified and Natural Diets. II. Effect of Diet and Urea on Electrocardiograph and Respiratory Patterns. J. Animal Sci. 28:659.

- Rupel, I. W., G. Bohstedt and E. B. Hart. 1943. The Comparative Value of Urea and Linseed Meal for Milk Production. *J. Dairy Sci.* 26:647.
- Schultz, L. H. 1969. Relationship of Rearing Rate of Dairy Heifers to Mature Performance. *J. Dairy Sci.* 52:1321.
- Steel, R. G. D. and J. H. Torrie. 1960. Principles and Procedures of Statistics with Special Reference to the Biological Sciences. Pub. McGraw-Hill Book Company, Inc. p. 108.
- Swanson, E. W. 1967. Optimum Growth Patterns for Dairy Cattle. *J. Dairy Sci.* 50:244.
- Swanson, E. W. and S. A. Hinton. 1964. Effect of Seriously Restricted Growth upon Lactation. *J. Dairy Sci.* 47:267.
- Tillman, A. D. and K. S. Sidhu. 1969. Nitrogen Metabolism in Ruminants: Rate of Ruminal Ammonia Production and Nitrogen Utilization by Ruminants. *J. Animal Sci.* 28:689.
- Udo-Aka, M. U. 1970. Influence of dietary Urea on Urinary Estrogen Excretion Rates of Holstein Heifers after Breeding. M.S. Thesis. Purdue University., Lafayette, Ind.
- Van-Horn, H. H., Foreman, C. F. and J. E. Rodriguez. 1967. Effect of High Urea Supplementation on Feed Intake and Milk Production of Dairy Cows. *J. Dairy Sci.* 50:709.
- Virtanen, A. I. 1966. Milk Production of Cows on Protein-free Feed. *Science.* 153:1603.
- Virtanen, A. I. 1969. On Nitrogen Metabolism in Milking Cows. *Fed. Proc.* 28:232.
- Visek, W. J. 1968. Some Aspects of Ammonia Toxicity in Animal Cells. *J. Dairy Sci.* 51:286.
- Visutakul, P., E. T. Bell, J. A. Loraine and R. B. Fischer. 1966. The Effect of Urea on the Biological Activity of Pituitary Gonadotrophins. *J. Endocrinol.* 36:15.
- Visutakul, P., E. T. Bell, J. A. Loraine and R. B. Fischer. 1966. The Effect of Urea on the Biological Activity of Gonadotrophins of Placental, Endometrial and Urinary Origin. *J. Endocrinol.* 36:23.
- Waite, R., M. E. Castle, J. N. Watson and A. D. Drisdale. 1968. Biuret and Urea in Concentrates for Milking Cows. *J. Dairy Res.* 35:191.

Waldo, D. R. 1968. Nitrogen Utilization by the Ruminant. J. Dairy Sci. 51:265.

Word, J. D., L. C. Martin and D. L. Williams. 1969. Urea Toxicity Studies in the Bovine. J. An. Sci. 29:786.

APPENDIX

Table 13. Blood Serum Calcium Levels of Animals in Group I At Different Stages of Lactation (mg/100 ml).

Animal Number	Initial Sample	Days after Parturition											
		2	28	56	84	112	140	168	196	224	252	280	308
<u>First Lactation</u>													
6600	10.02	9.55	10.05	10.01	9.98	9.36	10.63	11.00	11.01	10.89	10.70	11.37	11.06
6249	9.86	9.00	9.60	9.87	9.81	9.83	10.70	10.68	10.93	11.00	10.47	10.78	10.04
6511	10.30	9.40	9.71	10.06	9.94	10.00	11.01	11.33	11.02	10.48	10.66	10.91	10.73
62120	9.71	8.71	9.40	9.54	9.83	9.81	10.36	10.39	10.90	10.26	10.07	10.60	10.59
6214	9.91	8.95	9.41	9.73	9.86	9.92	9.60	9.87	10.91	11.02	10.87	9.94	10.06
62156	10.01	9.30	9.67	10.31	10.40	10.31	10.47	10.27	10.33	9.86	10.01	10.46	10.39
62163	9.87	8.75	9.31	9.52	9.87	9.84	9.79	9.63	10.43	9.61	9.54	10.00	9.86
6063	9.60	8.42	8.85	8.80	9.11	9.41	9.04	9.15	10.15	9.36	9.50	9.95	9.87
Ave.	9.91	9.01	9.50	9.73	9.85	9.81	10.20	10.49	10.71	10.31	10.22	10.50	10.40
<u>Second Lactation</u>													
6600													
6249		9.20	9.48	10.00	10.16	10.25	10.36						
6511		9.43	9.63	10.02	10.03	10.20	10.29						
62120		9.31	9.47	9.85	9.96	10.05	10.21						
6214		9.42	9.36	10.05	10.20	10.35	10.51						
62156		9.40	9.50	9.90	9.91	10.15	10.28						
62163		9.39	9.45	10.01	10.30	10.30	10.39						
6063		10.35	9.60	9.47	10.49	10.45	10.41						
Ave.		9.51	9.50	9.90	10.15	10.25	10.35						

Table 14. Blood Serum Calcium Levels of Animals in Group II at Different Stages of Lactation (mg/100 ml).

Animal Number	Initial Sample	Days after Parturition											
		2	28	56	84	112	140	168	196	224	252	280	308
<u>First Lactation</u>													
6509	9.31	8.86	9.01	9.46	9.53	9.89	10.00	10.46	10.40	10.06	10.20	10.29	9.80
6611	10.30	9.05	9.00	9.95	9.97	10.02	9.98	10.02	10.36	10.40	10.32	10.26	10.05
6419	10.34	9.83	9.77	9.76	10.31	10.48	10.40	10.37	10.65	10.61	10.41	10.30	10.40
6521	9.96	8.71	8.96	8.49	9.63	9.88	10.02	9.97	10.00	9.87	9.66	9.86	9.77
6466	8.94	8.04	8.43	9.20	9.72	10.00	9.80	10.00	9.99	9.30	9.69	10.00	9.94
6455	10.33	9.35	9.20	10.00	10.46	10.45	10.33	10.29	10.71	10.33	10.52	10.34	10.15
6605	10.41	8.60	8.94	9.77	9.98	9.79	9.92	10.04	10.52	9.89	9.76	9.96	9.33
6671	8.89	8.13	8.77	9.37	10.00	9.58	9.56	10.61	10.97	9.95	9.28	9.79	9.94
Ave.	9.81	8.82	9.01	9.50	9.95	10.01	10.00	10.22	10.45	10.05	9.98	10.10	9.92
<u>Second Lactation</u>													
6509		9.41	9.61	9.80	10.06	10.00	10.35						
6611		10.01	9.98	9.91	9.86	9.98	9.71						
6419		9.33	9.46	10.00	9.75	10.12	9.67						
6521		9.06	9.55	9.69	9.89	9.90	10.31						
6466		9.37	9.76	9.86	9.91	10.02	10.06						
6455		9.56	9.45	9.63	10.21	10.15	10.22						
6605													
6671		9.06	10.09	9.37	9.62	9.91	9.07						
Ave.		9.40	9.70	9.75	9.90	10.01	10.00						

Table 15. Blood Serum Calcium Levels of Animals in Group III at Different Stages of Lactation (mg/100 ml).

Animal Number	Initial Sample	Days after Parturition											
		2	28	56	84	112	140	168	196	224	252	280	308
<u>First Lactation</u>													
6621	10.01	9.19	9.15	9.46	10.00	10.01	10.54	10.21	10.11	9.91	10.22	9.55	9.89
6528	9.86	8.54	8.96	9.21	9.48	9.40	9.85	10.30	9.95	10.00	9.91	9.81	9.60
6601	9.53	8.47	8.78	8.86	9.36	9.54	9.60	9.91	10.00	10.26	9.89	9.83	9.41
6149	10.20	9.15	9.00	9.77	10.03	10.15	10.09	10.12	10.36	10.04	10.12	9.95	10.05
6647	9.38	8.70	8.95	9.17	9.28	9.51	9.61	9.89	9.87	9.51	9.89	9.76	9.76
6437	9.76	8.67	8.69	8.96	9.35	9.70	9.83	9.76	9.96	10.15	9.78	9.90	9.58
6584	9.66	8.66	9.06	9.31	9.60	9.81	9.69	9.84	9.44	9.79	9.71	9.68	9.50
6612	9.44	8.40	8.85	9.66	9.62	9.47	9.68	9.72	9.91	9.57	9.93	10.00	9.80
Ave.	9.73	8.72	8.93	9.30	9.59	9.70	9.86	9.97	9.95	9.90	9.93	9.81	9.70
<u>Second Lactation</u>													
6621		9.11	9.52	9.50	9.70	9.77	10.00						
6528													
6601													
6149		8.94	9.33	9.31	9.43	9.63	9.71						
6647													
6437													
6584													
6612		9.18	9.35	9.55	9.69	9.73	9.82						
Ave.		9.08	9.40	9.45	9.60	9.71	9.85						

Table 16. Blood Serum Phosphorus Levels of Animals in Group I at Different Stages of Lactation (mg/100 ml).

Animal Number	Initial Sample	Days after Parturition											
		2	28	56	84	112	140	168	196	224	252	280	308
<u>First Lactation</u>													
6600	6.30	4.41	4.67	4.12	3.88	4.21	4.96	4.49	4.56	4.89	5.12	5.00	5.12
6249	4.85	3.96	4.32	4.52	4.86	4.78	3.98	4.01	4.30	4.81	4.93	4.70	4.69
6511	4.96	4.13	5.01	4.99	5.46	6.03	5.12	4.36	4.57	5.40	5.20	4.24	4.53
62120	5.26	4.10	5.41	5.31	5.37	6.31	7.02	6.48	5.63	4.93	4.78	4.36	5.04
6214	5.31	3.96	4.32	4.43	4.64	4.89	5.01	4.80	4.63	4.88	4.66	4.93	4.88
62156	4.83	4.29	4.01	4.46	4.57	4.47	4.40	4.64	4.36	4.38	4.50	4.40	4.51
62163	3.95	3.80	3.90	4.39	5.36	5.16	5.00	5.15	4.83	4.90	4.91	4.76	4.66
6063	5.51	3.75	4.44	5.37	4.98	4.96	4.58	4.63	4.40	3.83	4.29	4.01	4.98
Ave.	5.12	4.05	4.51	4.70	4.89	5.10	5.01	4.82	4.66	4.75	4.80	4.55	4.80
<u>Second Lactation</u>													
6600													
6249		4.35	4.40	4.53	5.13	5.17	5.03						
6511		3.93	4.51	4.90	4.86	4.88	4.76						
62120		3.99	4.20	4.34	4.53	4.63	4.52						
6214		4.06	4.87	4.81	4.60	4.61	4.63						
62156		4.43	4.70	4.12	4.79	4.70	4.58						
62163		4.05	4.33	4.36	5.00	4.99	5.04						
6063		4.42	4.98	5.49	4.70	5.04	4.27						
Ave.		4.16	4.60	4.65	4.80	4.86	4.69						

Table 17. Blood Serum Phosphorus Levels of Animals in Group II at Different Stages of Lactation (mg/100 ml).

Animal Number	Initial Sample	Days after Parturition											
		2	28	56	84	112	140	168	196	224	252	280	308
<u>First Lactation</u>													
6509	6.03	4.36	4.37	4.29	5.21	4.86	3.71	3.89	3.70	3.66	4.36	3.99	4.31
6611	5.30	3.80	4.06	4.17	3.99	4.20	5.02	5.12	5.46	4.51	5.20	4.86	5.20
6419	4.96	4.01	4.00	4.16	4.21	4.16	4.19	4.36	4.86	4.20	3.86	4.17	4.36
6521	4.87	3.79	3.95	4.12	3.86	4.12	4.61	4.49	5.04	5.03	4.70	4.65	5.05
6466	5.20	3.99	4.15	4.31	4.20	3.98	3.98	4.12	4.43	3.96	4.31	4.07	3.90
6455	3.99	3.71	3.89	4.45	4.37	4.30	3.88	4.36	4.74	4.06	4.00	4.12	4.36
6605	4.86	4.02	4.15	4.10	4.16	4.13	4.03	4.89	5.00	5.82	4.70	4.63	3.00
6671	6.80	3.92	4.31	4.73	4.79	5.36	6.43	4.77	4.75	4.51	4.96	4.63	5.03
Ave.	5.25	3.95	4.11	4.29	4.35	4.39	4.48	4.50	4.75	4.47	4.51	4.39	4.40
<u>Second Lactation</u>													
6509		4.12	4.36	4.30	4.67	4.63	4.31						
6611		3.36	4.60	5.02	6.10	5.93	4.79						
6419		3.50	4.01	4.23	4.08	4.13	4.00						
6521		3.47	3.99	4.18	3.99	4.06	4.33						
6466		3.52	4.70	4.68	4.46	4.39	4.76						
6455		3.70	4.43	4.40	4.32	4.05	5.13						
6605													
6671		2.90	5.34	4.06	3.19	3.74	4.19						
Ave.		3.51	4.49	4.41	4.40	4.42	4.50						

Table 18. Blood Serum Phosphorus Levels of Animals in Group III at Different Stages of Lactation (mg/100 ml).

Animal Number	Initial Sample	Days after Parturition											
		2	28	56	84	112	140	168	196	224	252	280	308
<u>First Lactation</u>													
6621	5.21	3.23	4.17	5.16	5.03	4.86	5.74	5.17	4.36	5.43	5.08	4.93	5.00
6528	4.66	3.43	3.54	3.99	4.16	4.06	4.12	4.31	4.16	4.12	4.37	4.26	4.19
6601	4.03	3.51	3.58	3.87	3.81	3.96	4.03	3.99	4.10	4.00	3.98	4.12	4.15
6149	5.46	3.86	4.03	4.28	4.13	3.99	4.16	4.20	3.97	4.05	3.97	3.96	4.21
6647	4.77	3.54	3.55	3.81	4.05	4.31	4.22	3.26	3.83	4.23	4.28	4.19	4.06
6437	4.84	3.46	3.69	3.94	3.86	3.97	4.03	4.20	4.06	4.00	3.81	3.87	3.80
6584	5.06	3.63	3.70	4.16	3.65	4.00	3.88	4.05	3.97	3.86	4.03	4.13	4.33
6612	4.35	3.75	3.83	3.67	3.30	3.24	3.89	3.95	3.56	3.98	4.08	4.55	3.96
Ave.	4.80	3.55	3.76	4.11	4.00	4.05	4.26	4.14	4.00	4.21	4.20	4.25	4.21
<u>Second Lactation</u>													
6621		3.15	3.46	4.00	4.12	4.33	4.20						
6528													
6601													
6149		3.61	3.87	3.89	3.95	3.90	4.00						
6647													
6437													
6584													
6612		3.00	3.32	3.62	3.91	3.91	3.64						
Ave.		3.25	3.55	3.84	3.99	4.05	3.95						

Table 19. Blood Serum Magnesium Levels of Animals in Group I at Different Stages of Lactation (mg/100 ml).

Animal Number	Initial Sample	Days after Parturition											
		2	28	56	84	112	140	168	196	224	252	280	308
<u>First Lactation</u>													
6600	1.85	1.91	1.96	2.02	2.00	1.96	1.99	2.08	2.05	2.00	1.98	2.13	2.12
6249	2.01	2.03	2.00	2.12	1.98	2.07	1.86	2.09	1.94	1.90	2.06	2.08	2.06
6511	1.93	1.99	1.99	1.97	2.02	2.06	1.85	2.13	1.96	1.93	2.11	1.99	2.01
62120	1.90	1.87	2.19	1.94	1.87	1.94	1.93	2.15	2.03	1.96	1.97	2.15	2.16
6214	2.05	1.92	2.01	2.11	2.11	2.09	2.06	2.10	2.08	1.95	2.06	2.10	2.09
62156	2.06	1.96	2.06	2.06	2.01	2.05	1.90	2.09	1.94	2.03	2.10	2.18	2.12
62163	2.05	2.00	2.10	2.11	1.96	1.96	1.89	2.14	1.94	2.00	2.04	2.14	2.12
6063	2.15	2.00	2.01	2.46	2.04	2.11	1.81	2.17	2.07	1.75	2.09	2.10	2.11
Ave.	2.00	1.96	2.04	2.10	2.00	2.03	1.91	2.12	2.00	1.94	2.05	2.11	2.10
<u>Second Lactation</u>													
6600													
6249		1.98	1.90	2.06	2.03	2.08	2.03						
6511		2.00	1.93	2.03	1.94	2.05	2.01						
62120		2.05	1.91	1.98	1.96	1.98	2.00						
6214		1.94	1.90	1.96	1.96	1.98	1.99						
62156		1.99	1.98	2.10	2.01	2.00	1.97						
62163		2.01	1.95	2.04	1.97	2.08	2.05						
6063		1.93	2.03	2.06	1.99	2.12	2.01						
Ave.		1.99	1.95	2.04	1.98	2.04	2.01						

Table 20. Blood Serum Magnesium Levels of Animals in Group II at Different Stages of Lactation (mg/100 ml).

Animal Number	Initial Sample	Days after Parturition											
		2	28	56	84	112	140	168	196	224	252	280	308
<u>First Lactation</u>													
6509	2.11	2.10	2.03	2.05	2.11	2.12	2.07	2.03	2.07	2.13	2.11	2.08	2.03
6511	2.10	2.08	1.95	2.00	2.09	2.09	2.05	2.10	2.08	2.05	2.01	2.00	1.95
6419	1.98	2.00	1.99	2.02	2.14	2.15	2.05	2.07	2.01	1.96	1.98	2.01	1.97
6521	2.11	1.99	1.99	1.98	2.05	2.06	2.09	2.04	2.06	1.99	2.03	1.95	1.93
6466	2.10	2.09	2.01	2.00	2.09	2.09	2.10	2.10	2.13	2.04	2.09	2.07	1.92
6455	2.11	2.06	2.05	2.03	2.13	2.12	2.02	2.05	2.06	2.01	2.07	2.01	2.02
6605	2.07	1.93	1.98	1.99	2.08	2.10	2.04	1.99	2.11	2.05	2.00	1.99	2.03
6671	2.13	2.13	2.00	2.08	2.11	2.14	2.13	2.09	2.05	2.06	2.10	1.98	2.00
Ave.	2.09	2.05	2.00	2.02	2.10	2.11	2.07	2.06	2.07	2.04	2.05	2.01	1.98
<u>Second Lactation</u>													
6509		1.95	2.05	2.08	2.09	2.10	2.13						
6511		1.98	2.05	2.04	2.07	2.12	2.11						
6419		2.00	2.10	2.04	2.04	2.09	2.07						
6521		1.91	2.11	1.99	2.02	2.06	2.09						
6466		1.93	2.03	2.08	2.07	2.13	2.12						
6455		1.90	2.10	2.07	2.06	2.05	2.10						
6605													
6671		1.97	2.06	2.05	2.05	2.14	2.16						
Ave.		1.95	2.07	2.05	2.06	2.10	2.11						

Table 21. Blood Serum Magnesium Levels of Animals in Group III at Different Stages of Lactation (mg/100 ml).

Animal Number	Initial Sample	Days after Parturition											
		2	28	56	84	112	140	168	196	224	252	280	308
<u>First Lactation</u>													
6621	2.12	2.04	2.11	2.00	1.99	1.95	1.90	1.89	1.81	1.80	1.85	1.80	1.79
6528	2.06	2.01	2.07	1.91	1.90	1.91	1.96	1.96	1.90	1.90	2.01	1.98	2.01
6601	2.09	2.04	2.08	1.88	1.89	1.94	1.89	1.95	1.91	1.83	1.93	1.89	1.88
6149	2.10	1.99	2.05	1.89	1.80	1.86	1.88	1.93	1.90	1.80	1.82	1.88	2.00
6647	1.96	1.95	2.07	1.86	1.81	1.83	1.84	1.83	1.83	1.75	1.84	1.80	1.95
6437	1.98	1.96	2.10	2.01	1.82	1.81	1.85	1.84	1.81	1.79	1.96	1.84	1.86
6584	2.06	2.00	2.10	1.85	1.81	1.91	1.86	1.89	1.90	1.90	1.86	1.80	1.85
6612	2.04	1.99	2.15	1.88	1.80	1.89	1.86	2.02	1.85	1.88	1.97	1.88	2.00
Ave.	2.05	2.00	2.09	1.91	1.85	1.89	1.88	1.91	1.86	1.83	1.90	1.86	1.92
<u>Second Lactation</u>													
6621		1.82	1.83	2.00	1.80	1.95	1.93						
6528													
6601													
6149		1.80	1.85	1.88	1.83	1.89	1.80						
6647													
6437													
6584													
6612		1.80	1.92	1.94	1.80	1.80	1.79						
Ave.		1.80	1.86	1.94	1.81	1.88	1.84						

Table 22. Blood Serum Potassium Levels of Animals in Group I at Different Stages of Lactation (mg/100 ml).

Animal Number	Initial Sample	Days after Parturition											
		2	28	56	84	112	140	168	196	224	252	280	308
<u>First Lactation</u>													
6600	19.35	19.86	20.07	20.20	20.19	19.95	20.21	19.98	20.15	20.26	19.96	19.80	19.03
6249	20.15	19.95	19.87	20.03	20.15	20.30	20.16	19.76	20.22	20.03	19.38	19.12	19.70
6511	19.30	18.40	18.36	18.40	19.30	19.03	19.00	18.88	18.79	19.43	19.67	19.28	18.87
62120	19.35	19.05	19.40	19.86	19.67	19.86	19.96	20.00	19.50	18.70	18.50	18.01	19.04
6214	17.89	18.50	18.81	18.96	19.39	18.90	19.01	19.19	19.43	19.67	19.40	18.90	18.63
62156	20.17	19.50	19.08	20.15	19.50	19.67	19.30	19.46	19.04	19.00	19.15	19.04	19.00
62163	18.91	18.64	18.55	19.00	18.84	19.06	19.41	19.21	19.40	18.71	18.96	18.70	17.99
6063	20.10	19.00	18.11	19.78	20.06	19.30	18.78	18.30	19.77	20.23	19.05	19.40	19.04
Ave.	19.40	19.11	19.03	19.55	19.64	19.51	19.60	19.35	19.41	19.50	19.26	19.03	18.91
<u>Second Lactation</u>													
6600													
6249		18.60	19.00	20.15	20.18	20.25	20.01						
6511		19.03	19.15	19.20	19.76	19.86	19.70						
62120		18.14	18.00	19.03	19.30	19.37	19.00						
6214		18.67	18.50	18.99	19.05	19.00	18.66						
62156		18.04	18.36	18.95	18.87	19.01	19.40						
62163		19.00	18.55	19.50	19.30	19.47	19.03						
6063		19.12	19.98	19.62	19.41	19.54	20.22						
Ave.		18.75	18.90	19.35	19.41	19.50	19.43						

Table 23. Blood Serum Potassium Levels of Animals in Group II at Different Stages of Lactation (mg/100 ml).

Animal Number	Initial Sample	Days after Parturition											
		2	28	56	84	112	140	168	196	224	252	280	308
<u>First Lactation</u>													
6509	20.12	20.03	19.95	20.15	19.86	18.66	18.00	18.47	18.60	19.00	18.90	19.15	18.99
6511	18.63	18.50	18.30	18.76	19.03	18.50	19.01	17.86	18.04	18.01	18.09	18.19	18.00
6419	17.99	18.15	17.90	18.50	19.67	19.15	19.30	19.46	18.77	19.40	19.12	19.95	19.50
6521	20.15	19.67	19.95	20.20	20.11	19.55	19.36	19.67	19.50	19.04	18.87	18.30	18.02
6466	19.67	19.55	19.30	19.50	19.41	19.11	18.67	19.00	19.33	18.43	17.89	18.15	17.86
6455	19.53	19.04	19.60	19.50	18.87	18.85	18.86	18.40	18.00	17.79	17.60	18.00	17.87
6605	19.98	18.01	17.86	18.40	18.90	18.03	19.12	18.66	18.15	19.15	18.50	18.77	18.40
6671	19.88	18.66	18.44	19.39	19.10	19.34	19.31	18.06	18.10	17.99	18.88	17.79	18.49
Ave.	19.50	18.95	18.91	19.30	19.37	18.90	18.95	18.70	18.56	18.60	18.48	18.54	18.39
<u>Second Lactation</u>													
6509		17.95	18.60	18.10	17.90	19.20	18.73						
6511		17.95	18.00	18.20	18.20	18.70	19.40						
6419		19.35	19.40	19.60	19.80	18.00	18.66						
6521		18.50	19.00	19.04	19.40	18.03	19.00						
6466		19.06	18.70	18.70	18.70	19.06	18.40						
6455		18.00	18.50	18.61	18.50	18.80	18.06						
6605													
6671		17.99	17.63	17.95	18.00	19.46	19.05						
Ave.		18.40	18.55	18.60	18.64	18.75	18.76						

Table 24. Blood Serum Potassium Levels of Animals in Group III at Different Stages of Lactation (mg/100 ml).

Animal Number	Initial Sample	Days after Parturition											
		2	28	56	84	112	140	168	196	224	252	280	308
<u>First Lactation</u>													
6621	20.12	19.73	20.10	20.00	19.37	19.03	19.15	19.47	19.66	18.01	18.40	18.03	17.98
6528	20.03	19.05	19.66	19.75	19.56	18.99	18.50	18.36	18.50	18.33	17.99	17.70	17.80
6601	19.35	18.40	18.77	19.03	18.50	18.67	18.35	17.98	18.00	18.13	18.06	18.12	17.96
6149	17.99	17.81	18.00	17.95	18.33	18.01	17.80	18.35	18.43	17.71	17.70	18.00	17.75
6647	18.05	17.66	18.13	18.56	18.35	17.99	18.00	18.66	18.37	17.65	17.87	17.66	17.71
6437	20.01	19.70	19.13	19.04	18.00	18.25	18.12	17.89	18.15	17.60	17.79	17.69	17.60
6584	17.86	17.67	18.22	18.11	18.00	18.51	18.21	18.01	18.40	18.23	17.96	18.00	17.87
6612	19.54	19.48	18.02	17.66	17.75	17.74	17.87	17.51	17.78	17.52	17.58	17.59	17.75
Ave.	19.12	18.69	18.75	18.76	18.48	18.40	18.25	18.28	18.41	17.90	17.92	17.85	17.80
<u>Second Lactation</u>													
6621		17.81	17.83	18.55	18.67	19.11	18.98						
6528													
6601													
6149		17.99	18.01	18.21	18.20	18.01	18.25						
6647													
6437													
6584													
6612		17.78	18.11	18.09	18.06	18.22	18.02						
Ave.		17.86	18.15	18.28	18.31	18.45	18.42						

Table 25. Blood Serum Urea Levels of Animals in Group I at Different Stages of Lactation (mg/100 ml).

Animal Number	Initial Sample	Days after Parturition											
		2	28	56	84	112	140	168	196	224	252	280	308
<u>First Lactation</u>													
6600	17.00	18.20	21.03	23.18	22.16	19.37	20.08	20.20	17.23	18.15	16.33	15.05	16.20
6249	14.95	16.36	17.15	16.94	18.41	18.06	17.96	18.00	17.90	17.03	14.67	13.81	13.90
6511	17.06	19.14	16.27	18.61	18.33	17.63	18.15	18.07	17.84	16.30	13.91	13.00	12.97
62120	13.20	15.66	18.87	15.96	17.16	15.98	17.63	17.96	18.31	16.93	15.68	15.65	15.03
6214	12.65	14.37	15.30	16.07	19.57	18.66	19.90	18.90	17.95	15.67	14.63	15.20	14.95
62156	16.70	19.21	19.00	20.15	22.33	19.95	20.15	21.30	18.51	19.98	17.81	16.03	15.55
62163	15.85	14.36	16.54	15.33	18.41	18.26	18.55	19.00	18.33	17.01	14.50	14.97	14.46
6063	16.59	18.79	19.67	13.81	22.82	16.19	21.97	18.65	17.91	16.98	14.97	16.23	17.05
Ave.	15.50	17.01	17.98	17.50	19.90	18.00	19.30	19.01	18.00	17.25	15.21	14.99	15.01
<u>Second Lactation</u>													
6600													
6249		13.01	12.20	14.97	13.85	14.00	16.33						
6511		10.56	11.65	13.50	14.01	13.70	14.13						
62120		17.86	14.90	16.84	15.00	14.56	16.89						
6214		15.25	14.33	15.69	13.89	14.25	15.06						
62156		12.67	12.80	13.70	14.12	12.89	14.75						
62163		14.00	12.60	14.88	14.10	15.12	15.79						
6063		15.71	10.71	15.75	16.53	13.42	18.90						
Ave.		14.20	13.02	15.04	14.50	13.99	15.98						

Table 26. Blood Serum Urea Levels of Animals in Group II at Different Stages of Lactation (mg/100 ml).

Animal Number	Initial Sample	Days after Parturition											
		2	28	56	84	112	140	168	196	224	252	280	308
<u>First Lactation</u>													
6509	19.30	23.01	22.51	20.50	21.56	20.71	19.30	29.66	27.18	22.36	23.01	20.15	20.96
6611	13.95	17.30	19.73	21.17	22.30	22.66	23.55	25.10	23.95	19.81	20.50	18.63	19.30
6419	17.64	20.50	21.33	22.50	30.17	31.20	26.66	26.79	24.31	23.60	21.39	20.46	21.55
6521	14.36	18.76	19.95	19.86	18.71	19.95	21.36	22.00	25.08	22.66	23.07	21.17	21.03
6466	16.06	20.37	20.06	18.95	21.50	23.30	22.60	23.06	24.10	19.93	20.00	17.16	19.50
6455	19.26	22.80	23.15	26.00	23.40	23.07	22.75	23.87	23.55	21.11	20.76	19.38	18.95
6605	13.70	17.65	19.65	18.04	20.56	19.75	21.04	21.76	23.11	17.96	19.45	17.30	22.98
6671	14.62	15.71	22.51	20.73	25.05	25.34	18.78	22.15	26.66	21.36	21.59	21.66	23.48
Ave.	16.11	19.50	21.11	20.97	23.03	23.25	22.00	24.30	24.74	21.10	21.22	19.49	20.97
<u>Second Lactation</u>													
6509		23.12	25.06	24.31	23.79	23.15	24.86						
6611		20.17	19.68	20.20	22.20	20.66	20.04						
6419		17.86	18.31	19.68	21.07	19.04	21.36						
6521		21.30	20.70	21.46	21.00	19.30	21.77						
6466		19.96	21.04	22.55	23.79	20.03	21.16						
6455		21.20	20.66	21.37	21.03	19.76	21.40						
6605													
6671		16.59	21.50	24.58	26.34	18.46	23.56						
Ave.		20.03	21.00	22.02	22.75	21.49	22.01						

Table 27. Blood Serum Urea Levels of Animals in Group III at Different Stages of Lactation (mg/100 ml).

Animal Number	Initial Sample	Days after Parturition											
		2	28	56	84	112	140	168	196	224	252	280	308
<u>First Lactation</u>													
6621	12.31	21.74	23.89	24.16	19.77	21.31	24.66	23.67	22.91	23.45	26.38	24.86	25.20
6528	10.15	18.63	22.33	24.71	26.16	25.84	28.07	27.86	20.40	22.33	22.66	21.15	22.50
6601	18.67	23.55	25.51	25.50	24.90	23.63	25.17	27.61	28.08	26.17	26.13	26.80	25.53
6149	15.34	20.05	24.67	22.04	23.71	21.63	27.09	29.00	30.28	25.61	31.23	26.81	28.90
6647	17.77	21.81	23.13	24.01	22.03	21.74	24.61	23.16	25.44	23.00	24.46	23.87	23.00
6437	15.96	19.46	20.00	22.67	24.55	26.15	27.10	28.04	26.18	27.60	29.30	28.55	29.33
6584	20.47	28.64	30.15	31.33	29.87	28.41	31.15	32.91	33.40	31.69	31.30	28.47	29.14
6612	23.27	31.72	34.41	35.67	30.61	27.36	30.47	31.60	29.47	27.27	28.63	29.56	25.35
Ave.	16.74	23.20	25.51	26.25	25.20	24.50	27.29	27.98	27.02	25.89	27.51	26.26	26.12
<u>Second Lactation</u>													
6621		26.03	24.31	30.66	28.46	27.62	27.00						
6528													
6601													
6149		22.16	22.17	27.71	26.30	25.44	23.81						
6647													
6437													
6584													
6612		26.51	27.11	26.52	26.30	27.19	27.09						
Ave.		24.90	24.53	28.30	27.00	26.75	25.97						

Table 28. Body Weights of Animals in Group I Recorded Every 28 Days (kg).

Animal Number	Birth Weight	Days of Age								
		240	268	296	324	352	380	408	436	464
6909	44	188	208	230	251	273	295	318	338	354
6911	36	192	213	232	255	276	298	320	341	366
6920	43	214	236	256	278	300	321	340	361	380
6924	32	194	213	234	255	274	300	323	344	365
6929	38	180	201	222	243	262	283	304	332	359
6934	40	200	218	236	256	275	299	318	335	354
6937	34	182	200	228	252	275	301	324	349	365
6946	30	168	186	208	229	251	274	300	322	346
6948	36	212	236	259	280	302	327	350	374	395
6950	36	188	208	230	252	275	301	328	354	384
Ave.	36.9	191.8	211.9	233.5	255.1	276.3	299.9	322.5	345.0	366.8

Table 29. Body Weights of Animals in Group II Recorded Every 28 Days (kg).

Animal Number	Birth Weight	Days of Age								
		240	268	296	324	352	380	408	436	464
6906	36	204	224	248	273	300	325	351	372	392
6907	30	188	209	235	260	280	304	324	342	362
6915	36	184	214	238	261	285	310	329	347	360
6916	27	186	211	240	267	290	311	331	350	366
6927	44	190	216	241	268	291	317	338	358	375
6928	36	188	212	245	266	290	315	342	360	383
6933	30	176	203	231	252	277	297	319	341	362
6935	32	208	234	265	290	316	341	367	389	409
6942	34	184	209	235	259	288	314	339	363	386
6943	35	198	221	244	270	295	317	337	358	378
Ave.	34.0	190.6	215.3	242.2	266.6	291.2	315.1	337.7	358.0	377.3

Table 30. Individual Daily Consumption of Sugar Cane Tops by Animals in Group I, Control (kg on as fed basis).

Animal Number	Days of Age							
	240 to 267	268 to 295	296 to 323	324 to 351	352 to 379	380 to 407	408 to 435	436 to 463
6909	6.93	6.75	10.47	14.08	14.54	16.60	19.31	19.00
6911	7.48	8.68	12.47	14.23	15.79	17.04	19.31	18.49
6920	7.65	11.58	15.20	16.02	18.18	19.91	19.28	23.53
6924	7.85	13.74	15.00	18.02	19.75	19.30	20.72	23.70
6929	7.98	13.34	13.20	14.70	17.60	18.16	22.34	24.37
6934	11.05	10.97	12.76	16.74	16.64	19.98	22.52	24.27
6937	9.12	12.72	17.42	19.49	18.50	22.33	24.12	24.52
6946	9.34	13.35	15.51	15.90	21.25	20.59	19.95	21.42
6948	13.24	18.81	19.57	19.02	23.60	23.99	24.41	24.78
6950	12.54	17.34	17.77	20.39	22.79	23.57	24.10	24.20
Ave. Daily Intake	9.32	12.72	14.93	16.86	18.86	20.14	21.60	22.82

Table 31. Individual Daily Consumption of Sugar Cane Tops by Animals in Group II, Experimental (kg on as fed basis).

Animal Number	Days of Age							
	240 to 267	268 to 295	296 to 323	324 to 351	352 to 379	380 to 407	408 to 435	436 to 463
6906	6.10	8.61	11.36	14.96	15.03	18.11	21.32	20.85
6907	5.89	7.71	11.03	16.50	17.00	18.68	19.25	18.57
6915	5.43	6.89	13.78	14.71	16.54	17.32	17.28	20.50
6916	5.89	8.43	13.46	13.86	15.96	16.50	15.18	17.10
6927	6.60	10.67	12.14	14.46	17.64	15.75	19.18	19.67
6928	7.14	11.29	12.21	14.50	16.36	15.07	19.60	19.64
6933	8.57	9.93	12.46	14.86	14.71	20.03	19.36	19.64
6935	9.39	10.93	14.53	17.14	17.68	19.75	19.68	19.93
6942	8.29	10.71	14.07	17.29	23.07	22.75	23.54	23.82
6943	7.39	11.93	13.10	12.50	16.25	19.14	19.57	19.57
Ave. Daily Intake	7.06	9.71	12.81	15.08	17.02	18.31	19.40	19.93

Table 32. Body Weight Changes and Daily Feed Consumption of Dairy Heifers According To Age

	Days of Age							
	268	296	324	352	380	408	436	464
<u>Group I</u>								
Average body weight, kg	212	234	255	276	300	323	345	367
Average daily gain, kg	.718	.771	.771	.757	.843	.807	.804	.782
Dry matter intake, kg	5.25	6.19	6.82	7.36	7.92	8.28	8.69	9.03
Dry matter intake from sugar cane tops, kg	2.61	3.55	4.18	4.72	5.28	5.64	6.05	6.39
Dry matter/100 bw/day	1.23	1.50	1.63	1.70	1.76	1.75	1.75	1.74
Dry matter intake from concentrate, kg	2.64	2.64	2.64	2.64	2.64	2.64	2.64	2.64
Dry matter intake from yucca, kg								
<u>Group II</u>								
Average body weight, kg	215	242	267	291	315	338	358	377
Average daily gain, kg	.882	.960	.871	.905	.853	.807	.725	.693
Dry matter intake, kg	4.50	5.31	6.19	6.84	7.39	7.75	8.08	8.22
Dry matter intake from sugar cane tops, kg	1.98	2.72	3.59	4.22	4.77	5.13	5.44	5.58
Dry matter/100 bw/day	.92	1.12	1.34	1.45	1.51	1.52	1.52	1.48
Dry matter intake from concentrate, kg	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08
Dry matter intake from yucca, kg	1.44	1.51	1.52	1.54	1.54	1.54	1.56	1.56

Table 33. Dry Matter Consumption According to Body Weight Changes as Compared to NAS-NRC Allowances (1966).

	Days of Age							
	268	296	324	352	380	408	436	464
Ave. body weight of control animals, kg	212	234	255	276	300	323	345	367
Ave. body weight of exptl. animals, kg	215	242	267	291	315	338	358	377
Dry matter intake of control animals, kg/day	5.3	6.2	6.8	7.3	7.9	8.2	8.6	9.0
Dry matter intake of exptl. animals, kg/day	4.5	5.3	6.2	6.8	7.3	7.8	8.0	8.2
NAS-NRC dry matter allowances, kg/day ^{1/}	5.3	5.8	6.4	6.7	7.2	7.8	8.0	8.3
Protein intake of control animals, gm/day	579	630	657	681	705	721	739	754
Protein intake of exptl. animals, gm/day	572	608	645	674	698	714	728	734
Protein requirements, ^{1/}	522	590	630	650	661	668	680	684

^{1/}Based on NAS-NRC Dairy, 1966.

Table 34. Summary of Individual Reproductive Performance of the Experimental Animals.

Animal Number	First Lactation			Interval Between Calvings	Second Lactation		
	Total Days in Milk	Number of Services per Conception	Dry Period		Total Days in Milk	Number of Services per Conception	Pregnancy Diagnosis
<u>Treatment I</u>							
6600 ^{1/}	560	2	66	626	56	--	--
6249	364	1	58	422	221	1	Pregnant
6511	392	3	68	460	219	1	Pregnant
62120	305	1	91	396	245	3	Pregnant
6214	305	1	16	321	265	1	Pregnant
62156	305	1	46	351	171	2	Pregnant
62163	305	2	53	358	145	2	Pregnant
6063	305	1	34	339	136	1	Pregnant
Ave.	355	1.5	54	409	182	1.57	
<u>Treatment II</u>							
6509	392	4	60	452	192	2	Pregnant
6611 ^{2/}	476	4	78	554	124	4	--
6419	392	3	78	470	216	4	Pregnant
6521	336	4	101	437	199	3	Pregnant
6466	336	3	62	398	225	3	Pregnant
6455	305	1	61	366	225	1	Pregnant
6605 ^{3/}	530	2	--	--	--	2	Pregnant
6671	305	1	60	365	188	1	Pregnant
Ave.	384	2.75	71	434	196	2.71	

Table 34, cont.

Animal Number	First Lactation				Second Lactation		
	Total Days in Milk	Number of Services per Conception	Dry Period	Interval Between Calvings	Total Days in Milk	Number of Services per Conception	Pregnancy Diagnosis
<u>Treatment III</u>							
6621	305	1	46	351	309	2	Pregnant
6528 ^{4/}	663	3	--	--	--	2	Pregnant
6601 ^{5/}	364	4	--	--	--	--	--
6149	305	2	84	389	196	3	Pregnant
6647 ^{6/}	504	2	--	--	--	--	--
6437 ^{7/}	364	1	79	443	--	--	--
6584 ^{8/}	392	6	--	--	--	--	--
6612 ^{9/}	305	3	77	382	122	1	Pregnant
Ave.	400	3.66	72	391	209	2.0	

^{1/} Aborted at 194 days of first pregnancy, bred and settled, calved normally, not yet bred again.

^{2/} Not pregnant, left ovaric cyst.

^{3/} Aborted at 149 days of first pregnancy, continued milking.

^{4/} Aborted at 180 days of first pregnancy, continued milking, 162 days pregnant.

^{5/} Could not be settled, no heat after 4 services, pyometra diagnosed.

^{6/} Aborted at 73 days of first pregnancy, bred, pyometra diagnosed.

^{7/} Died at second calving, parturient paresis.

^{8/} After 6 services, could not be settled, diagnosed bilateral ovaric cysts, sold.

^{9/} Calf dead, 65 days of second pregnancy on exp.

Table 35. Individual Feed Intakes, Milk Yields and Fat Test During 305-day Lactation.

Animal Number	Grain consumed, kg	Silage dry matter, kg	Milk yield, kg	Fat test, %	4% FCM, kg
<u>Group I</u>					
6600	1499.0	2715	4486.1	3.50	4149.6
6249	1580.0	3100	4714.5	3.42	4303.8
6511	1879.5	3269	5615.0	3.50	5193.8
62120	2215.5	2891	6673.8	3.45	6123.2
6214	1720.1	3057	5165.0	3.48	4762.1
62156	1829.4	2700	5441.9	3.41	4960.3
62163	2165.0	3202	5516.3	3.44	5052.9
6063	2067.2	3260	6050.8	3.40	5506.2
Ave.	1869.0	3024	5582.9	3.44	5006.5
<u>Group II</u>					
6509	1269.4	2822	4506.5	3.61	4242.8
6611	1757.9	2624	5745.5	3.59	5392.5
6419	1534.3	3519	4981.2	3.60	4682.3
6521	1778.8	2926	5843.4	3.55	5448.0
6466	1608.3	3093	5013.9	3.54	4667.9
6455	1432.6	3337	4429.9	3.48	4084.3
6605	1605.3	2667	4803.8	3.50	4443.4
6671	1402.0	2173	4003.0	3.48	3690.7
Ave.	1548.5	2895	4915.9	3.55	4581.5

Table 35. cont.

Animal Number	Grain consumed, kg	Silage dry matter, kg	Milk yield, kg	Fat test, %	4% FCM, kg
<u>Group III</u>					
6621	1273.9	2711	4084.3	3.73	3918.8
6528	1783.4	3035	5428.5	3.76	5233.0
6601	1507.3	2469	4533.8	3.77	4317.3
6149	1562.2	3020	5139.2	3.70	4907.9
6647	1625.3	2481	5276.0	3.66	5007.0
6437	1819.1	2692	5672.7	3.82	5519.3
6584	1886.5	2837	6261.3	3.68	5960.6
6612	1497.2	2425	4570.2	3.80	4432.9
Ave.	1619.4	2709	5120.7	3.74	4912.1

VITA

VITA

Jaime E. Pineda Morales was born on the eighth of July, 1936 at Libano, Tolima. He is a citizen of the Republic of Colombia. He received his elementary education in the public school system, Libano, Tolima. His Bachillerate diploma was received from the Instituto Isidro Parra, Libano, Tolima, in November 1957. In November 1962 he received the degree, Doctor of Veterinary Medicine from the National University of Colombia at Bogota'.

Dr. Pineda began his graduate studies at Purdue University in September, 1965, under the direction of Dr. Carl H. Noller. He received the degree of Master of Science in June 1967.

After completion of his course work toward his Ph.D. degree, he returned to Colombia where he conducted a two-year research project whose results are presented as a thesis.

Doctor Pineda is a member of the Latin-American Society of Animal Production and, at the present time, is National Director of the Dairy Program of the Colombian Institute of Agriculture (ICA).

He was married to the former Ligia Silva Orozco on May 11, 1959.