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I am submitting herewith a thesis written by Bobby E. Jones entitled "Utilization of Maltlage in Complete Rations for Lactating Cows and Replacement Dairy Heifers." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Science.

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UTILIZATION OF MALTLAGE IN COMPLETE RATIONS FOR LACTATING COWS AND REPLACEMENT DAIRY HEIFERS

A Thesis

Presented for the

Master of Science

Degree

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Bobby E. Jones

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ABSTRACT

To evaluate the intake and milk production response of lactating cows fed complete rations containing Maltlage,* 38 Holstein cows were randomly assigned to the following dietary treatments at calving: 1) 3:1 as fed ratio of corn silage to concentrate plus soybean meal, 2) 1:1 as fed ratio of corn silage to Maltlage. All cows were fed five pounds of alfalfa hay per day to prevent milkfat depression, and six pounds of concentrate per head daily in the milking parlor. Daily dry matter intake (lb.) per 100 pounds of body weight, daily milk production (lb.), fat (percent), and 4 percent fat corrected milk (lb.), for two treatments were: 1) 2.69, 66.2, 3.03, 56.1; 2) 2.21, 63.0, 2.93, 52.3.

The differences in the production variables for milk, milkfat, and 4 percent fat corrected milk were not significant ($P<.05$). Treatment had a significant effect ($P<.01$) on daily dry matter intake. Cows fed the 1:1 ratio of corn silage to Maltlage consumed less dry matter than cows fed the 3:1 ratio of corn silage to concentrate.

The data suggest that acceptable lactation performance can be produced by complete rations containing a 1:1 ratio of corn silage to Maltlage

*Maltlage is a registered trademark of Murphy Products Company, Inc., and denotes a mixture containing wet brewers grains, corn and mineral-vitamin supplement. Average composition of Maltlage used in this study is in Table 1.

To determine the growth performance of calves fed complete feeds containing corn silage and Maltlage, forty Holstein heifer calves were individually fed the following rations: 1) 3:1 ratio of corn silage to grain plus soybean meal, 2) 1:1 ratio of corn silage to Maltlage, 3) ad libitum intake of corn silage plus Maltlage fed separately at the rate of two pounds per 100 pounds of body weight. These rations were fed from birth to 30 weeks of age. Milk replacer or unsaleable whole milk was fed up to six weeks of age. Cumulative average daily gain (lb.), length (in.), height (in.), paunch circumference (in.) and dry matter intake per 100 pounds of body weight for each treatment at 30 weeks were:

1. 1.62, 32.4, 43.8, 64.2, 3.12;
2. 1.52, 31.9, 42.7, 63.5, 2.62; and,
3. 1.15, 29.6, 40.2, 59.4, 2.62.

Significant treatment differences were found in average daily gain body weight, length, height, paunch circumference, and dry matter intake per 100 pounds of body weight. Feeding Maltlage separately at two pounds per 100 body weight (Treatment 3) produced less acceptable performance than the complete rations, (Treatment 1 and 2). This data suggests that Holstein calves may be raised successfully on complete rations containing a 1:1 ratio of corn silage to Maltlage.

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CHAPTER I

INTRODUCTION

Feed and labor costs constitute the major production expenses in a dairy enterprise. Therefore, feeding systems that emphasize minimum labor requirements, maximum mechanization, and reduced ration ingredient costs are of great importance. The feeding of complete rations, quantitative blends of all diet ingredients, is a means of utilizing less expensive forages in a system which permits increased mechanization and a reduction in labor costs.

A growing world-wide population has increased the competition for high protein feedstuffs, and this competition is expected to increase. Thus, commodity by-products of other industries will assume an even more important role in supplying nutrients for livestock diets. Dried and wet brewer's grains, products of the production of beer and ale, have served as a source of nutrients in livestock feeds for many years.

The objectives of this study were to determine the intake and milk production response of lactating cows fed complete rations containing Maltlage (a commercial source of wet brewer's grains) plus corn silage, and to determine whether complete feeds containing Maltlage and corn silage could produce acceptable growth in young calves.

CHAPTER II

REVIEW OF LITERATURE

Feeding Systems

Several methods or feeding systems are employed to meet the nutrient requirements of dairy cattle. The objective of feeding is to obtain efficient utilization of nutrients and maximum economic returns. Spahr (88) defines an optimum ration as "mixtures of forage and concentrates fed in proportion necessary to achieve maximum income above feed cost over the productive life of the cow."

The traditional system of feeding lactating cows has been to offer forages free choice and to supplement with concentrates (grain) to meet the individual cow's needs (86). Amounts of grain fed were based on age, production level, gestation, stage of lactation, body weight, and milk fat percent. Generally, feeding all of the grain in the milking barn was a preferred system since dairymen could adjust the grain intake to production level.

The traditional system has several disadvantages (86): 1) inability to accurately predict forage intake of individual cows, 2) when two or more forages are fed, it is impossible to predict which forage is consumed in preference by individual cows, 3) automation of milking parlors does not permit high producing cows sufficient time to consume their grain requirement.

Concentration of dairy cattle in larger herds has caused a major emphasis to be placed upon automated feeding systems. As herds become larger the feeding of growing heifers and cows requires more labor and/or automation.

Various feeding systems have been utilized to solve the above problems. To reduce labor and maximize automation, some feed manufacturers and dairymen are blending the concentrate, forage and other supplements to form a complete blended ration. Coppock (19) defines a complete ration as "a quantative blend of all diet ingredients mixed thoroughly enough to prevent separation and sorting, formulated in specific nutrient levels and offered ad libitum." Complete feeds can be offered to cows in self-feeders or mechanical feeding devices. The relative amounts of different rations consumed can be controlled without the management difficulties encountered when concentrates and roughages are provided separately.

Reviews by Coppock (18) and Rakes (78) reported several advantages and disadvantages of complete rations. Included among the advantages are:

1. Cows are not permitted an expression of choice since each bite is a uniform, nutritionally complete diet.
2. Free choice of mineral supplements was unnecessary.
3. Complete rations result in few digestive upsets early in lactation as cows are changed from a high forage to a high concentrate diet.
4. By using a specific and obligatory ratio of forage to concentrate milk fat depression can be prevented by insuring a minimal fiber level.

5. The percentage of crude protein desired in the total ration can be controlled.

6. Total diet of the cow can be quantitatively formulated.

Included among the disadvantages are:

1. Mixer wagons are an expensive investment.

2. This system is not economical for small herds and herds on pasture; especially during the pasture season.

3. More calculations are necessary on the farm to implement the use of complete rations.

Protein level of complete feeds which will give maximum production has been investigated by several workers. Rakes (78), in a review of complete feeds, indicates that a 13-14 percent crude protein level will support milk production similiar to that achieved with conventional rations. Hawkins (37) concluded on the basis of the requirements proposed by Reid et al. (80) that a blended ration (65 percent TDN) containing 14 to 15 percent crude protein would meet the requirements of most cows. Rusoff et al (83) suggest a crude protein content of 14 to 16 percent. An increase in TDN content of the ration, an intake below that necessary to meet the cow's energy requirement, or a change in protein digestibility would alter these recommendations (37).

McCoy et al (56), Olson (67), and Rakes (78) indicate that complete feeds should contain at least 30 percent forage to prevent milk fat depression and prevent digestive disturbances. Kesler and Spahr (46) concluded from a review that a dietary fiber level of 13 to 14 percent is necessary to maintain good health in dairy cows. Rusoff et al (83) and

Spahr (89) recommend a dietary fiber level of approximately 16 percent in complete feeds to prevent milk fat depression.

Special consideration should be given to vitamin and mineral supplementation when formulating complete rations. Rusoff et al (83) recommend the following levels in the complete feed: 0.7% Ca, 0.5% P, 0.5% salt, and 1500 to 3,000 IU vitamin A/lb of complete feed.

Numerous materials can be used as roughage sources in complete rations for dairy cattle. Some of the sources include: hay (14, 32, 35, 64), pineapple hay and bran (48), corn cobs (14, 55), cottonseed hulls (14, 15, 55), straw (28), silage (16, 22, 29, 38, 42, 69), haylage (32, 68), waste paper (47), sugar cane bagasse (54), citrus pulp (15), and brewers grains (11, 22, 33, 45, 51, 79). Use of a specific roughage source is dependent upon availability, economics, and nutritional composition.

Utilization of Complete Rations

Complete rations have been used successfully in dairy operations for several years. Early research conducted by Harshberger (35) established the potential usefulness of complete blended rations, and reported that the ad libitum feeding of a mixture of 70 percent coarsely ground hay and 30 percent concentrate produced a fat corrected milk yield (FCM) and milk fat percent similar to that produced by other groups of cattle fed this ration plus corn silage or long hay.

One of the primary concerns in research with complete rations has been the establishment of an optimum forage-to-concentrate ratio for

efficient milk production without depressing milk fat. As previously reported, complete feeds should contain at least 30 percent forage to prevent milk fat depression. McCoy et al (56) found that a complete feed containing 30 percent forage and 70 percent concentrate was readily eaten and supported adequate levels of milk and milk fat production.

Ronning and Laben (82) compared four milled diets in which lactating cows were fed the following hay to concentrate ratios, 90:10, 60:40, 30:70, and 0:100. Depressed milk yield was noted on the 90:10 diet and overconditioning resulted in the two higher concentrate groups.

Lactating cows were group fed corn silage containing 100, 50 and 0 percent concentrate portions, as reported by Muller et al (63). The remaining portion of the concentrate for the latter two groups was fed in the milking parlor. The method of feeding had no significant effect upon daily FCM yields. A significantly smaller weight gain was observed for cows consuming all their concentrate in the parlor, when compared to cows consuming 100 percent of their concentrate in a complete feed.

In a study by Marshall and Voight (53), comparisons of complete feeds of corn silage and concentrate with forage to concentrate ratios of 40:60, 30:70 and 20:80 were made. As the concentrate portion increased, stepwise increases in milk production and body weight gains were produced, but milk fat test was reduced.

Spahr and Harshbarger (90) report that complete feeds of corn silage and concentrate, with forage to concentrate ratios of 55:45 or 50:50 were sufficient to maintain production of up to 30 kg per day when fed ad libitum.

Montgomery and Bearden (61) studied another feeding regime utilizing complete feeds. Cows were divided into two treatment groups with three production levels, (high, medium and low) in each group. One treatment group received a constant forage to concentrate ratio of 60:40, regardless of production level. The other treatment group received a forage to concentrate ratio per production level as follows: high, 60:40; medium, 75:25; low, 80:20. The constant ratio resulted in slightly higher milk production, but no statistical difference was reported.

Everson et al (27) compared feeding one group of cows a constant 60:40 forage to concentrate complete feed while feeding another group a variable ratio of 50:50 for the first 21 weeks of lactation, a 65:35 ratio for the next 23 weeks, and an 85:15 ratio during the 8 week dry period. These researchers reported no significant differences between actual or FCM production for the two year lactation study.

According to Van Dijk (96), it appears that a forage to concentrate ratio of 50:50 to 60:40 would be optimum if a constant ratio complete feed must be offered throughout a lactation.

As previously mentioned, several roughage sources have been used in complete rations. Villavicencio et al (100) compared the effects of feeding three different complete feed roughages (alfalfa, cottonseed hulls, or native grass hay) with a conventional system of feeding roughage and concentrate separately. No significant differences were observed in milk production, FCM, milk constituents, gross feed efficiencies, or body weight changes.

Frequency of feeding complete rations was studied by Smith et al (87). Once versus twice daily feeding had no effect on dry matter intake or milk production, with a complete ration of 45 percent forage and 55 percent concentrate (as fed basis).

Performance of ensiled complete feeds was compared to that of complete feeds mixed just prior to feeding (42, 52, 69, 70). Similiar results were produced by the two methods of preparation.

Escano et al (26) compared the production responses of three different energy levels in a complete ration. As the energy density was increased from 22.8 to 28.5 to 33.1 Mcal ENE intake, FCM increased stepwise As the energy of the ration was increased, the efficiency of FCM production per unit of ENE intake decreased.

The addition of limestone buffers to complete rations of corn silage and concentrate improves efficiency by increasing intestinal pH which provides a more favorable pH for pancreatic alpha amylase activity (79). Cows fed complete feeds containing 2.76 percent limestone consumed 7.36 percent less DM than cows fed a ration with .11 percent added limestone, with no effect on milk production. In a subsequent trial, cows fed a complete ration with 2.71 percent limestone had similiar feed intakes and milk production but gained more weight than cows fed a ration with 0.01 percent limestone.

With the onset of the use of complete feeds for feeding dairy cows, interest has increased in the use of complete feeds for dairy calves. A feeding system utilizing complete rations would permit group feeding of calves with more automation and less labor.

According to Swanson and Harris (92), calves begin rumination at an early age, approximately 50 percent of the calves in this experiment were ruminating effectively at two weeks of age. These results indicate that calves should be able to utilize complete rations at an early age.

The Iowa Experiment Station (44) concluded that silage is desirable for calves as early as the calves will consume the silage. Silage gave increased weight gains and more thrifty calves, than rations without silage. To prevent problems with silage feeding, care should be taken not to feed any moldy or frozen silage, and to remove any uneaten silage from the manger daily.

Grieve et al (32) compared corn silage, corn silage - wilted hay silage, and blended corn silage - chopped hay fed to Holstein heifers from three weeks to 18 months of age. No differences were observed in forage intake, total dry matter intake, growth measurements, age to first breeding, or conception rates. Calves fed corn silage as the only forage had slightly higher weights which were probably caused by the higher energy content of the corn silage.

Porter and Kesler (73) report that good grass silage can be used as the sole source of roughage for young Holstein calves from birth to 16 weeks of age. However, Conrad and Hibbs (16) found grass silage to be inferior to a pelleted alfalfa meal - alfalfa hay ration for dairy calves up to 12 weeks of age.

Gardner (29) fed alfalfa hay, alfalfa silage, and corn silage to new born calves through 16 weeks of age. When the effects of birth differences were considered, the differences in gains were non-significant.

High, roughage feeding systems for calves have been studied by Hibbs et al (39, 40). Acceptable growth was achieved with hay to grain ratios of 2:1, 3:2 and 4:1. The addition of molasses or penicillin to the diet did not produce a significant benefit (39).

Complete rations can produce adequate growth in young calves. Van Horn et al (97) successfully reared calves from approximately three to 12 weeks on a complete ration containing cottonseed hulls and/or citrus pulp as roughage sources. Clifton and Fowler (15) fed Holstein and Jersey heifers from eight weeks to six months either hay and grain or an all-in-one ration ad libitum. The all-in-one mixture contained 50 percent grain mix and 50 percent bulky, fibrous mix composed of equal parts citrus pulp, soybean hulls, Coastal Bermudagrass pellets and cottonseed hulls. The Holstein and Jersey heifers fed the hay and grain diet gained 92 and 70 percent of the Beltsville standards (94, 95), respectively, whereas those fed the all-in-one ration gained 112.5 and 103 percent of the standards, respectively.

Clifton and Fowler (14) fed Holstein and Jersey heifer calves four complete rations from birth to 16 weeks. The rations contained concentrate and either ground Coastal Bermudagrass, cottonseed hulls, pelleted corn cobs, or a combination of these ingredients. Differences

in weight gains among the groups approached significance, but total feed consumption did not vary significantly among treatments.

From 16 to 26 weeks of age, Holstein calves were fed complete rations containing corn silage or alfalfa silage as the forage versus concentrate and alfalfa hay fed separately (38). Mean body weight gains of 0.96 kg/day were observed for the complete rations mixed at feeding, whereas the alfalfa hay concentrate diet produced gains of 0.97 kg/day.

In a two year study, Nease (64) fed Holstein and Jersey heifers the following complete rations, from two weeks to six months of age: (a) 1:1 ratio of hay and 16 percent crude protein grain mix, (2) 2:1 ratio of corn silage and grain mix plus soybean meal, (c) 4:1 ratio of corn silage and grain mix plus soybean meal. All complete ration treatments contained approximately 16 percent crude protein. Average daily gains (lbs) for the Jerseys and Holsteins on each treatment for the first trial were: (a) 1.06, 1.73; (b) 1.12, 1.82, and (c) 1.02, 1.74 and for the second trial were: (a) 1.06, 1.60; (b) 0.95, 1.63; and (c) 0.97, 1.53. There were no significant differences in height at withers, length, and paunch circumference in either year. Nease also determined the digestibility and retention of the above complete feeds at four, 17, and 29 weeks of age. Within an age group, no significant differences were observed in digestibility of dry matter, acid detergent fiber, acid detergent lignin, and nitrogen; phosphorus and nitrogen retention were also similiar. It was concluded that Holstein and Jersey calves can be raised successfully on complete rations containing corn silage.

Miller et al (58) investigated the effect of adding fiber (10 percent cottonseed hulls) to simplified and to complex calf starters, as the only dry feed offered dairy calves from one to nine weeks of age. Additions of fiber to both the simplified and the complex starters resulted in increased feed consumption and weight gains. Estimated net energy requirements per unit of gain were similar. Results of this research suggest that when a starter is used as a complete feed for young calves, too low a fiber level can reduce weight gains.

Heifers fed a complete ration containing 2.4 percent magnesium limestone, as a buffer, gained 0.49 kg/day more than heifers fed a similiar ration without the buffer (103).

Use of Brewers' Grains in Animal Feeds

By-products of many industries have been used in feed formulation. A growing world-wide population has increased the competition for high protein feedstuffs, and this competition is expected to increase. The growing population will also increase the demand for animal protein products for human consumption, thus commodity by-products of other industries will assume an even more important role in supplying nutrients for animal feeds.

Typical of the by-products from other industries is brewers' grains, a by-product of the production of beer and ale. Brewers grains have served as a source of nutrients in livestock feeds for many years. Rakes and Davenport (79) state that a need exists for current information

on the feeding value of brewers grains. They suggest that data from the early feeding studies may not be applicable due to changes in grain composition and alterations in brewery operations. Field trials with animals fed brewers grains indicate that the nutrient values listed in tables of feed composition underestimate the actual feeding value of the product now available.

Currently, two general types of brewers grains are commercially available: dried brewers' grain (DBG), and wet brewers' grain (WBG). The American Association of Feed Control Officials defines these products as follows: DBG "is the dried extracted residue of barley malt alone or in mixture with other cereal grain or grain products resulting from the manufacture of wort or beer and may contain pulverized spent hops in an amount not to exceed 3 percent, evenly distributed;" WBG "is the extracted residue resulting from the manufacture of wort from barley malt alone or in mixture with other cereal grains or grain products. The guaranteed analysis shall include the maximum moisture" (9).

The utilization of brewers grains has been examined in several species: dogs (101, 102), poultry (21, 25), swine (34, 49), sheep and horses (9), and cattle (36, 45, 74, 75, 77).

Even though brewers grains have been widely used in ruminant rations, only limited research data is available to estimate their feeding value. Some of the earlier work in the United States was reported by Hills (41). When compared to distillers grain, DBG produced 5 percent less milk, but DBG was consumed more readily. Brewers dried grains

produced results similiar to a mixture of cottonseed meal and linseed meal supplements.

Many feeds are overheated in processing and protein solubility may be altered (30, 31), with a possible decrease in animal performance. Unavailable protein is a problem in DBG (99), possibly due to overheating during the drying process.

The potassium content of brewers grains is low and should be considered in ration formulation, especially when fed with corn silage (11, 43).

Hatch et al (36) evaluated the effects of adding DBG with yeast to a semi-purified, high urea ration fed to beef steers. Inclusion of 5 percent DBG with yeast significantly increased nitrogen retention and decreased rumen ammonia and plasma urea concentrations. The results indicate increased urea utilization and conversion to animal protein.

A study of the energy value of brewers grains for growing and finishing cattle was conducted by Preston et al (77). Beef steer calves, average initial weight approximately 240 kg, were fed one of four complete rations composed of crimped corn mixed with: 1) 10 percent urea (control), 2) 25 percent DBG, 3) 25 percent DBG with 5 percent yeast, or 4) 50 percent DBG. Feeding either 25or 50 percent DBG significantly increased daily gains compared to the control ration. DBG in the ration completely eliminated the rumen keratosis and liver abscesses that were associated with the high concentrate control diet. DBG can provide a roughage function in the rumen, which probably accounts for the improved

performance of the DBG groups. Net energy values of DBG determined in this experiment were in the following range: NE_m = 2.01-2.55 Kcal/g DM, NE gain = 1.20-1.51 Kcal/g DM. It was concluded that DBG, when fed at less than 50 percent of the ration, have a feeding value approximately equal to corn for gain in cattle.

Johnson et al (45) conducted a five-year study to evaluate DBG as a feed source in beef cattle rations. All rations used in this study were mixed in a mixer wagon and fed as complete rations. Nitrogen retention of DBG was approximately equal to soybean meal. The roughage component of DBG was as efficient as ground cobs or oat hulls, and was effective in reduction of digestive disturbances and liver abscesses when included at 5, 10, 15, 30, 45 or 75 percent of rations containing ground shelled corn and minerals. The efficiency of high concentrate rations was increased when DBG was added as the roughage source. With the addition of supplemental potassium to rations containing 10 to 45 percent DBG, the energy values of DBG were approximately equal to corn. Palatability of the ration was decreased when DBG constituted more than 50 percent of the ration without added minerals. Generally, acceptable gains were produced from rations with low to medium levels of DBG, and no statistical differences in carcass traits were attributable to DBG. It was concluded that DBG can be a single economical source of protein, energy and roughage for beef cattle.

Loosi and Warner (51) compared lactation response produced by concentrate mixtures containing 40 percent DBG, 40 percent corn distillers

dried grains, or urea as protein supplements. The urea diet was not as effective as the other protein sources, and DBG appeared to be less valuable than corn distillers dried grains.

Dairy cows readily consumed mixed diets containing DBG, while dairy heifers tended to refuse diets with more than 50 percent DBG when fed with poor quality hay (33). Positive nitrogen retention was maintained on diets high in DBG content, but calcium retention tended to decrease. Rumen fermentation of the DBG ration was of the high acetate type, and substitution of DBG for hay or silage exerted only a small effect on the pattern of rumen volatile fatty acid production. Mixed diets containing DBG supported milk production similiar to that produced by a good quality dairy diet.

Chase (11) reports that in recent years the combination of new breweries being built and increased energy costs associated with drying the wet brewers grains has renewed an interest in marketing of the grains wet rather than as dried brewers grains. As energy costs continue to increase, a larger proportion of the total production of brewers grains will probably be fed to animals as WBG. Wet brewers grains are bulky, succulent high moisture grains similiar to silages, and can be used to extend a limited supply of forage, as a concentrate or roughage source, and can supply a medium level of fiber in dairy rations (11, 66). Most of the carbohydrates have been digested out of WBG in the brewing process, thus they are similiar to direct cut forages, which have a low dry matter and low soluble carbohydrate content (1).

Dairymen have raised numerous questions concerning the feeding of wet brewers grains to dairy cattle. What level of this material can be fed to lactating cows without a reduction in nutrient intake and/or milk production? Does the feeding of wet brewers grains to cows for extended periods affect their health? Can wet brewers grain produce adequate growth and development of dairy heifers? A basic problem (11) which research must attack is the actual energy and protein value of WBG and DBG for high producing dairy cows.

Rakes and Davenport (79) calculated the following digestion coefficients for WBG obtained from a North Carolina brewery: crude protein, 77.38 percent; ether extract, 83.84 percent; crude fiber, 39.71 percent, nitrogen free extract, 74.46 percent; and energy, 69.30 percent. On a dry matter basis, the following feeding values were calculated for WBG: DE, 1,630.9 Kcal/lb; TDN, 77.3 percent; DP 25.5 percent; digestible ether extract, 4.5 percent; digestible crude fiber, 4.2 percent; digestible NFE, 37.3 percent; and dry matter content as fed was 33 percent.

Chase (11) reports that most research work has used 30 pounds or less WBG per cow daily. Ten to 15 pounds of dry matter from WBG could be satisfactorily used in most dairy rations, but a minimum of 1.25 percent of body weight as dry matter should be derived from some other forage source.

In an early report, Armsby (4) computed the digestible protein of WBG to be 3.87 pounds per 100 pounds. A later report (5), indicated

a net energy value of 14.53 therms and a crude protein content of 4.6 pounds per 100 pounds. When converted to a 100 percent dry matter basis WBG contained 60.29 therms per 100 pounds of dry matter, while DBG on the same basis contained between 55.5 and 57.7 therms.

Porter and Carter (74) compared DBG, WBG, dried distillers grains and solubles, and a combination of wheat bran and soybean meal as sources of supplemental protein for lactating dairy cows. Each by-product feed was added at 20 percent of the total dry matter, and ground shelled corn provided the remainder of the concentrate. The rations produced 4 percent FCM yields of 21.4, 21.6, 21.9, and 21.3 kg/day, respectively. Feed intake was similiar, but less day matter was consumed on the WBG rations. Feeding brewers grains in this study elevated plasma selenium values compared to the controls.

Porter et al (75) compared wet, dried, and rewetted brewers grains which represented 20 percent of the ration dry matter. Dry matter intake was depressed with both WBG and rewetted grains 17.9 and 16.7 kg/day, respectively versus 22.4 kg/day for the DBG ration. The reason for this depression is not certain, but is probably not due to moisture alone (8, 12, 93). Milk production was similiar for all three rations, but wet and rewetted grains were more efficient producers of milk per unit of dry matter intake. Porter et al (75) also compared the digestibility and nitrogen utilization of WBG and DBG when fed to dairy calves. Calves fed WBG had a significantly higher nitrogen retention and improved apparent nitrogen digestibility, and a slightly higher dry matter

digestibility than calves fed DBG. It was concluded that a major nutritional difference between DBG and WBG exists in the superior nitrogen utilization of WBG.

Maltlage Feeding

In Tennessee, processed WBG are also available in the form of Maltlage*, a silage-type ration made from a combination of pressed WBG, cereal grains and a mineral-vitamin supplement.

Barrick et al (7) investigated the value of Maltlage as a replacement for dry grain for pasture finishing of beef steers. Yearling steers, average 620 lb. initial weight, were fed either ground corn or Maltlage as a supplement to fescue pasture from April to September. Grain supplements were hand fed once daily, corn at 1 percent of body weight, and Maltlage at 1.9 percent of body weight, (to provide the same dry matter intake as obtained from the corn). The Maltlage fed steers gained an average of 56 lbs/head more weight than the corn fed steers, or a difference in average daily gain of 2.03 lb versus 1.70 lb. Since the dry matter intake per unit of body weight was essentially the same for both groups, the Maltlage apparently stimulated forage consumption or improved the utilization of feed consumed. Higher protein intake from the Maltlage may have been a factor in the superior performance of the Maltlage steers.

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*Maltlage is a registered trademark of Murphy Products Company, Inc., and denotes a mixture containing wet brewers grains, corn and mineral-vitamin supplement. Average composition of Maltlage used in this study is in Table 1.

Daniel and Arnold (22) compared the 10 week lactation response of cows fed Maltlage with sorghum silage or low grain content corn silage. Each group of cows was fed either corn silage or sorghum silage ad libitum, plus 30 lbs of Maltlage per cow daily. An 18 percent protein concentrate was fed at the rate of one pound to 3 pounds of milk with the Maltlage replacing the concentrate for the first 30 pounds of milk. No significant differences were observed in 3.5 percent FCM yields, or in dry matter intake of silage per 100 lbs of body weight. Since dairy animals usually consume more corn silage than sorghum silage, the absence of a difference in dry matter intake indicates that the Maltlage may have improved the acceptance of the sorghum silage.

The lactation response of Holstein cows fed Maltlage for an entire lactation was examined by Rakes and Davenport (79). Three complete ration treatments utilizing corn silage were used: I (control) 51 percent DM, no maltlage; II 49 percent DM approximately 40 percent Maltlage (medium); and III 45 percent DM, approximately 50 percent Maltlage (high). All cows received limited alfalfa hay to adjust the ration crude fiber and protein to 14-15 percent of the ration dry matter. Neither the total amount of complete ration nor hay consumed was significantly affected by feeding treatment (when expressed on an as fed basis). Dry matter consumption was lowered by the addition of Maltlage to the ration. Cows on treatment III ate more hay, possibly an attempt to compensate for their lower dry matter intake from the complete ration. Although differences in milk production were not significant, average

milk production decreased as Maltlage was added to the ration. Milk production for the different treatment groups followed a similiar trend to that of dry matter intake. It appears that treatment III containing no grain other than Maltlage may have limited milk production, especially during the first 8-12 weeks of lactation. Treatment III cows did not maintain their weight as well during early lactation, but exhibited a relatively consistent increase during the latter half. TDN consumption as mixed feed was lowered as more Maltlage was added. However, FCM produced per unit of TDN was higher for the Maltlage treatments. The following conclusions are based on the data and observations recorded during these studies with Maltlage. A satisfactory level of milk production was maintained throughout lactation by using Maltlage as a partial or complete substitute for a conventional concentrate mixture. The digestible energy of Maltlage was at least as efficiently utilized as that in conventional feeds used in these studies. No cow health or reproductive problems resulted from including Maltlage in the ration.

Montgomery et al (60) studied the performance of lactating cows fed Maltlage. Cows were assigned to one of the following complete rations: 1) a 3:1 ratio of corn silage to concentrate (16 percent CP), 2) a 3:1 ratio of corn silage to Maltlage, plus 1/2 part concentrate (16 percent CP), and 3) a 1.5:1 ratio of corn silage to Maltlage. All cows were fed five pounds of hay per head daily. No significant differences were recorded for milk, fat, FCM, or body weight change. Mean daily FCM yields (lb.) for the three rations were 51.08, 52.99 and 53.76, respectively.

To determine the relative feeding value of Maltlage for milk production in lcatating dairy cows, Culvahouse et al (20) fed Holstein and Jersey cows the following rations: 1) corn silage ad lib plus one pound concentrate per three pounds of FCM, 2) 60 percent corn silage and 40 percent Maltlage plus one pound of concentrate per three pounds of FCM in excess of 35 pounds daily, 3) 60 percent corn silage and 40 percent Maltlage and no concentrate. Mean milk yield (pounds), FCM (pounds) and dry matter intake as a percent of body weight for the three treatments were: 1) 43.0, 42.3, 3.05; 2) 43.4, 42.6, 3.07; 3) 36.8, 36.0, 2.64.

Storage of Wet Brewers Grains

A practical concern with WBG is their storage quality. Even though they can be successfully ensiled, some attempts to ensile have resulted in a poor quality product with offensive odors and high dry matter losses (1). Observations indicate that fresh WBG will maintain quality for 3 to 8 days depending on weather conditions (11). If they can be obtained at satisfactory prices, blending fresh WBG at feeding time may be preferable to ensiling with corn silage (43). Maltlage is ensiled prior to commercial shipment to enhance its storage qualities, aroma, and handling characteristics (85).

During periods of favorable prices and/or increased availability such as the peak spring and summer beer brewing season, it may be desirable to store or ensile WBG on the farm. Storage in the Southeast has mainly involved vertical silos, trench silos, and slabs. One method

which has been used to prolong keeping quality is to sprinkle on salt at the rate of 20 lbs per ton of WBG (62).

Research in Canada has examined the effect of additives upon storage quality of WBG. Allen et al (2) found that 0.20 percent and 0.40 percent formic acid or 0.40 percent proponic acid were effective in reduction of subsurface deterioriation of WBG stored in outdoor piles for two weeks. A mixture of formic and proponic acid (rate 0.40 percent) effectively reduced both surface spoilage and subsurface deterioriation in similar WBG piles. Allen and Steveson (1) reported that WBG can be more satisfactorily ensiled with additivies of 0.75 percent formic acid or a 0.75 percent mixture of formic and proponic acid.

A new innovation in WBG storage was reported by Deterling (24). The system involves the use of a press which packs WBG into a plastic bag. The bag is eight feet in diameter and can be cut to any length up to 95 feet and will hold one to two tons of feedstuff per linear foot. Field observations report a high quality storage is maintained with the system.

CHAPTER III

EXPERIMENTAL PROCEDURE

Objective

The objectives of this study were to compare the intake and milk production response of lactating cows fed complete rations containing either Maltlage or commercial pelleted concentrate with corn silage, and to determine the intake and growth measurements of replacement heifers fed complete rations containing Maltlage or commercial pelleted concentrate with corn silage.

I. Lactation Experiment

Thirty-eight high producing Holstein cows were used in a continuous type 18-week feeding trial to determine the production level of complete rations containing Maltlage or commercial pellets during early lactation. Cows used were in either first or second or later lactation (18 first lactation and 20 second or later lactation cows). Cows were assigned to the respective treatment group at random within age classification three days postpartum.

Ration Treatments

Treatment 1 consisted of a complete ration of three parts corn silage and one part pelleted dairy concentrate, (18 percent CP) on an as fed basis, fed continuously throughout the experiment. Soybean meal was

added to this 3:1 ration to make all diets approximately isonitrogenous.

Treatment 2 consisted of a complete ration of one part corn silage and one part Maltlage on an as fed basis, fed continuously throughout the experiment.

Both complete rations were formulated to contain approximately 14 percent CP and 70 percent TDN on a dry matter basis. Complete rations were mixed fresh just prior to feeding. In addition to complete rations which were fed three times daily, all cows received five pounds of alfalfa hay daily in an attempt to prevent milk fat depression, and three pounds 18 percent CP concentrate at each milking. Complete rations were offered ad libitum to provide approximately 10 percent refusals.

Data Collection

Body weights were obtained three days postpartum and at bi-weekly intervals thereafter. Cows were housed in a stanchion barn equipped for obtaining individual consumption data of rations. Cows were milked twice daily in a standard two-in-line walk-through parlor with daily milk yields recorded using stationary weigh jars. Cows received their only exercise at this time. Composite, morning and evening milk samples were collected bi-weekly for analysis of milk fat, total solids and protein.

Chemical Analyses

Weekly samples of ration ingredients and complete rations were collected and analyzed for dry matter content, crude protein,

acid-detergent fiber, calcium and phosphorus. The fresh samples were dried in a 60° C drying oven for three days to obtain air dry, dry matter content. Total dry matter was then determined by placing the samples in a 100° C oven overnight. Feeds were analyzed for nitrogen content by the Kjeldahl method (3). Acid-detergent fiber (ADF) was determined by the method of Van Soest (98). Calcium was determined by the method developed by Perkin and Elmer (81). Fiske and Subbarow (76) method was used for phosphorus determination. Milk fat was determined by the use of the Foss-Milk-O-Tester, Model Mark II.

Statistical Analysis

The data were analyzed statistically with programs prepared by Barr et al (6). Analyses of variance and multivariate analyses were used to determine if differences existed between treatments for milk, FCM, milkfat and dry matter consumption. If differences existed as determined by F test, then means were separated using Duncan's New Multiple Range Test (91), ($P \leq .05$).

The preliminary analysis of variance was performed using the following model with treatment, lactation, cow, and week as discrete variables:

$$Y_{ijk} = u + t_i + l_j + (t*l)_{ij} + w_k + c_{ij} + (t*w)_{ik} + (l*w)_{ik} + (t*l*w)_{ijk} + e_{ijk}.$$

where: $Y_{i\,j\,k}$ = the estimated value of the dependent production variables: milk, fat, FCM and dry matter consumption.

u = theoretical population mean.

t_i = treatment, i = 1-2.

l_j = lactation, j = 1 (first lactation) or 2 (second or later lactation).

w_k = week, k = 1-18.

c = cow within treatment and lactation

$e_{i\,j\,k}$ = random error.

The term cow within treatment-lactation, was used as the error term to test significance for the sources treatment, lactation and treatment* lactation.

Dependent production variables milk, milkfat, FCM and dry matter consumption were fitted to a non-linear regression on lactation week using the weekly observed values as a polynomial to describe the curve for each cow. The following equation was used:

$$\hat{Y}_i = a + b_1\,(\text{week}) + b_2\,(\text{week}^2) + b_3\,(\text{week}^3)$$

where: $\hat{Y}_i$ = the estimated value of the dependent production variable for each week.

a = the intercept value for each dependent variable at week 0.

week = the week number.

b_1, b_2, b_3 = the regression coefficients for each dependent variable on the independent variable = week, week^2, week^3.

Estimated values for the dependent production variables were generated for each cow from the above regression curves for weeks 4, 8, 12 and 16. This method of analysis is similiar to that used by Box (9) with growth curves. Multivariate analysis of these predicted values was performed using the following model with treatment and lactation as discrete variables:

$$\hat{Y}_{i\,j\,k} = u + t_i + l_j + (t*l)_{i\,j} + e_{i\,j\,k}.$$

where: $\hat{Y}_{i\,j\,k}$ = the estimated value for each dependent variable week: 4, 8, 12 and 16.

u = theoretical population mean.

t_i = treatment, i = 1-2

l_j = lactation, j = 1 (first lactation) or 2 (second or later lactation).

$e_{i\,j\,k}$ = random error.

Multivariate analysis of intercept and regression coefficients for each dependent production variable by cow was also performed using the above model.

In preliminary analysis, previous lifetime production was included in the above model as a covariate for second or later lactation cows with little improvement in R-square, therefore this term was not included in the model for final analysis.

II. Replacement Heifer Growth Experiment

A continuous type feeding trial was conducted with Holstein female calves from birth to 30 weeks of age. Calves were randomly assigned to

pens and rations based on birth order. Fourteen calves were assigned to treatments 1 and 2, and 12 calves were assigned to treatment 3.

Ration Treatments

Treatment 1 consisted of a complete ration of three parts corn silage and one part pelleted dairy concentrate (18 percent CP), on an as fed basis, fed ad libitum throughout the experiment. Soybean meal was added to this 3:1 ration to make diets approximately isonitrogenous.

Treatment 2 consisted of a complete ration of one part corn silage and one part Maltlage, on an as fed basis, fed ad libitum.

Treatment 3 consisted of an ad libitum intake of corn silage plus Maltlage fed separately at the rate of two pounds (as fed) per 100 pounds of body weight. Rates of Maltlage fed were adjusted weekly for each calf.

Both complete rations (Treatments 1 and 2) were formulated to contain approximately 14 percent CP and 70 percent TDN on a dry matter basis. Complete rations were mixed fresh just prior to feeding, and all ration treatments were fed twice daily. Complete rations (Treatments 1 and 2) and corn silage (Treatment 3) were offered ad libitum to provide approximately 10 percent refusals.

Management of Calves

Animals were housed in individual pens in a calf barn throughout the experiment. Calves remained with the dam for two or three days post-partum. Care was taken to insure that each calf received ample colostrum during the first few hours post-parturition.

Milk replacer (one pound/nine pounds water) or unsalable whole milk (from fresh or antibiotic treated cows) was fed to each calf individually at the rate of 10 percent of body weight for six weeks. All calves were weaned at six weeks. The three experimental rations were offered to each calf during the second week. Individual feed consumption data were collected beginning with the third week.

Data Collection

Body weights were taken at birth and at weekly intervals for the remainder of the experiment. Beginning of one week of age and each week thereafter through 30 weeks of age, wither height, body length and paunch circumference were determined for each animal. The individual feed weights of rations fed and refused were recorded daily.

Chemical Analyses

Chemical analyses of weekly samples of ration ingredients and complete rations was conducted as previously described for the lactation experiment.

Statistical Analysis

The data were analyzed statistically with programs prepared by Barr et al (6). Analyses of variance and multivariate analyses were used to determine if differences existed between treatments for body weight, average daily gain (ADG), wither height, body length, paunch circumference, and dry matter intake per hundred pounds of body weight. If differences

existed, as determined by F test ($P<.05$), then means were separated using Duncan's New Multiple Range Test (91), ($P<.05$).

The preliminary analysis of variance was performed using the following model with treatment, week and calf as discrete variables:

$$Y_{i\ j\ k} = u + t_i + w_j + c_i + (t * w)_{i\ j} + e_{i\ j\ k}$$

where:

$Y_{i\ j\ k}$ = the dependent variables: weight, ADG, length, wither height, paunch circumference, and dry matter intake per hundred weight.

u = theoretical population mean.

t_i = treatment, $i = 1\text{-}3$.

w_j = week, $j = 1\text{-}30$.

c = calf within treatment.

$e_{i\ j\ k}$ = random error.

Dependent variables: weight, length, wither height, paunch circumference and dry matter intake per hundred weight were fitted to a non-linear regression on age using weekly observed values as a polynominal to describe the response curve for each calf. The following equation was used:

$$\hat{Y}_i = a + b_1\ (\text{week}) + b_2\ (\text{week}^2) + b_3\ (\text{week}^3).$$

where:

$\hat{Y}_1$ = the estimated value of the dependent variable.

a = the intercept value for each dependent variable at week 0.

week = age of calf in week(s).

b_1, b_2, b_3 = the regression coefficients for each dependent variable = week, $week^2$, $week^3$.

Multivariate analysis of the regression coefficients, b values, (generated in the previous model for each dependent production variable by calf) was performed using the following model, with treatment as a discrete variable:

$$\hat{Y}_{ij} = u + t_i + e_{ij}$$

where:

$\hat{Y}_{ij}$ = the estimated intercept value and the regression coefficient for each dependent variable on the independent variable week.

u = theoretical population mean.

t_i = treatment, i = 1-3.

e_{ij} = random error.

III Storage of Maltlage

In October 1977, approximately 60 tons of Maltlage were stored in a plastic bag as described by Deterling (24). Maltlage was removed daily through June 1978 for use in experimental rations.

To study the storage quality of Maltlage via the above system, weekly samples were collected and chemical analyses conducted as previously described for the lactation experiment. Fresh Maltlage samples were selected at random for pH determination.

CHAPTER IV

RESULTS AND DISCUSSION

I Lactation Experiment. The chemical composition of the feeds is reported in Table 1. Corn silage had a dry matter content of 28.9 percent and crude protein content of 9.6 percent. Maltlage had a dry matter content of 48.0 percent and crude protein content of 18.5 percent.

Dry matter content of complete rations was 42.3 percent for Treatment 1 and 37.7 percent for Treatment 2. In Treatment 1, corn silage provided 48 percent of the dry matter and concentrate provided 52 percent of the dry matter. In Treatment 2, corn silage provided 37 percent of the dry matter and Maltlage provided 63 percent of the dry matter. Acid detergent fiber (ADF) content of Treatment 1 was slightly higher than Treatment 2. Rations were made isonitrogenous by adding soybean meal to Treatment 1. Crude protein content of complete ration 1 was 14.3 percent and ration 2 was 14.8 percent. Treatment 2 was higher in calcium content than Treatment 1.

Consumption data are reported in Table 2. On both an as fed basis and a dry-matter basis the intake was significantly ($P<.05$) lower for Treatment 2 than Treatment 1. The reduction in dry matter intake of the Maltlage (WBG) diet is in agreement with other research (20, 74, 75, 79). Rakes and Davenport (79) suggest that the reduction in dry matter intake of complete rations of corn silage and Maltlage may be due

TABLE 1

MEANS AND STANDARD DEVIATIONS OF CONSTITUENTS OF COMPLETE FEEDS AND INGREDIENTS OF COMPLETE FEEDS FED TO HOLSTEIN COWS AND HEIFERS

Lactation Trail	Complete Ration Treatment[a] I	Complete Ration Treatment[a] II	Corn Silage	Maltlage	Concentrate (18% CP)	Hay
Dry matter (%)	42.3 ± 1.86[b]	37.7 ± .92	28.9 ± 1.57	48.0 ± .87	89.1 ± .87	86.2 ± .48
Crude Protein (%) DMB[c]	14.3 ± .14	14.8 ± .64	9.6 ± .31	18.5 ± 1.11	19.1 ± .77	20.2 ± .27
Acid detergent fiber (%) DMB	22.4 ± 1.04	21.4 ± .82	29.3 ± .93	14.1 ± .88	12.2 ± .88	37.1 ± .01
Calcium (%) DMB	.61 ± .05	.92 ± .12	.37 ± .07	1.19 ± .18	.94 ± .14	1.59 ± .14
Phosphorus (%) DMB	.41 ± .02	.46 ± .03	.23 ± .01	.60 ± .09	.58 ± .06	.25 ± .06

Growth Trial	Complete Ration/Treatment[a] I	Complete Ration/Treatment[a] II	III Corn Silage	III Maltlage	Concentrate (18% CP)
Dry matter (%)	42.6 ± 1.72	37.9 ± .95	28.5 ± 1.75	48.5 ± 1.28	89.3 ± .83
Crude Protein (%) DMB	14.3 ± .17	14.6 ± .67	9.7 ± .30	18.4 ± 1.14	19.1 ± .77
Acid degergent fiber (%) DMB	22.4 ± .93	21.0 ± 1.05	29.4 ± .82	13.9 ± .95	11.9 ± .95
Calcium (%) DMB	.61 ± .07	.97 ± .16	.37 ± .06	1.26 ± .24	.96 ± .13
Phosphorus (%) DMB	.42 ± .02	.49 ± .07	.23 ± .01	.60 ± .09	.59 ± .07

[a]Treatment I = 3 parts corn silage: 1 part concentrate (18% CP).
Treatment II = 1 part corn silage: 1 part Maltlage.
Treatment III = ad libitum corn silage plus Maltlage fed separately at the rate of two lbs./100 lbs. of body weight.

[b]Standard deviation

[c]DMB = Dry matter basis

TABLE 2

DAILY CONSUMPTION DATA OF HOLSTEIN COWS

	Treatment	
	I	II
Ration (lb), $\bar{x}$	58.6[a] ± 13.3[c]	45.9[b] ± 15.1
Lactation 1	47.9 ± 8.1	40.3 ± 12.0
Lactation 2	68.2 ± 8.9	50.9 ± 16.4
% Dry matter	42	38
Ration dry matter (lb), $\bar{x}$	24.9[a] ± 5.8	17.5[b] ± 5.7
Lactation 1	20.3[a] ± 3.5	15.4[b] ± 4.6
Lactation 2	29.1[a] ± 4.1	19.4[b] ± 6.2
Concentrate dry matter (lb)	5.4	5.4
Hay dry matter (lb)	4.5	4.5
Total dry matter (lb), $\bar{x}$	34.8 ± 5.9	27.4 ± 5.7
DM/cwt, $\bar{x}$	2.70 ± 2.9	2.21 ± .35

Treatment I = 3 parts corn silage: 1 part concentrate (18% CP).

Treatment II = 1 part corn silage: 1 part Maltlage.

Lactation 1 = first lactation
Lactation 2 = second or later lactation

[a,b] = Means on a line with different superscripts were tested and differ significantly (P<,05).

[c] = Standard deviation.

to the low dry matter content of the ration. Porter et al (75) suggest that depressed dry matter intake of WBG rations is not due to moisture alone. Treatment 2 cows did not compensate for the reduced dry matter content of the ration by increasing intake.

Since the intakes of hay and parlor fed concentrate were controlled, the difference in total dry matter intake between treatments is due to differences in consumption of the complete rations. Total overall dry matter consumption as a percent of body weight was 2.70 for Treatment 1 and 2.21 for Treatment 2. Consumption was less than expected and less than was found at other Tennessee experiment stations (60). Total dry matter consumption as a percent of body weight has also been found to be low at this location in previous experiments (60, 96). Researchers (60, 88) have found that cattle can consume dry matter up to 3.5 percent of body weight, thus cows in this experiment were not consuming feed to their potential. The relationship between stage of lactation and dry matter intake is shown in Figures 1, 2, 3 and 4. The period of maximum voluntary intake occurred approximately 12-14 weeks postpartum. Cows in second or later lactation assigned to Treatment 2 containing Maltlage consumed considerably less complete ration dry matter than similiar cows on Treatment 1, 19.4 versus 29.1 pounds per day, respectively.

Average production values for milk, milk fat and FCM are shown in Table 3. Milk fat test was depressed on both treatments. The average daily milk production started lower and continued lower for the Maltlage (Figure 5) compared to Treatment 1, but no statistical differences ($P<.05$)

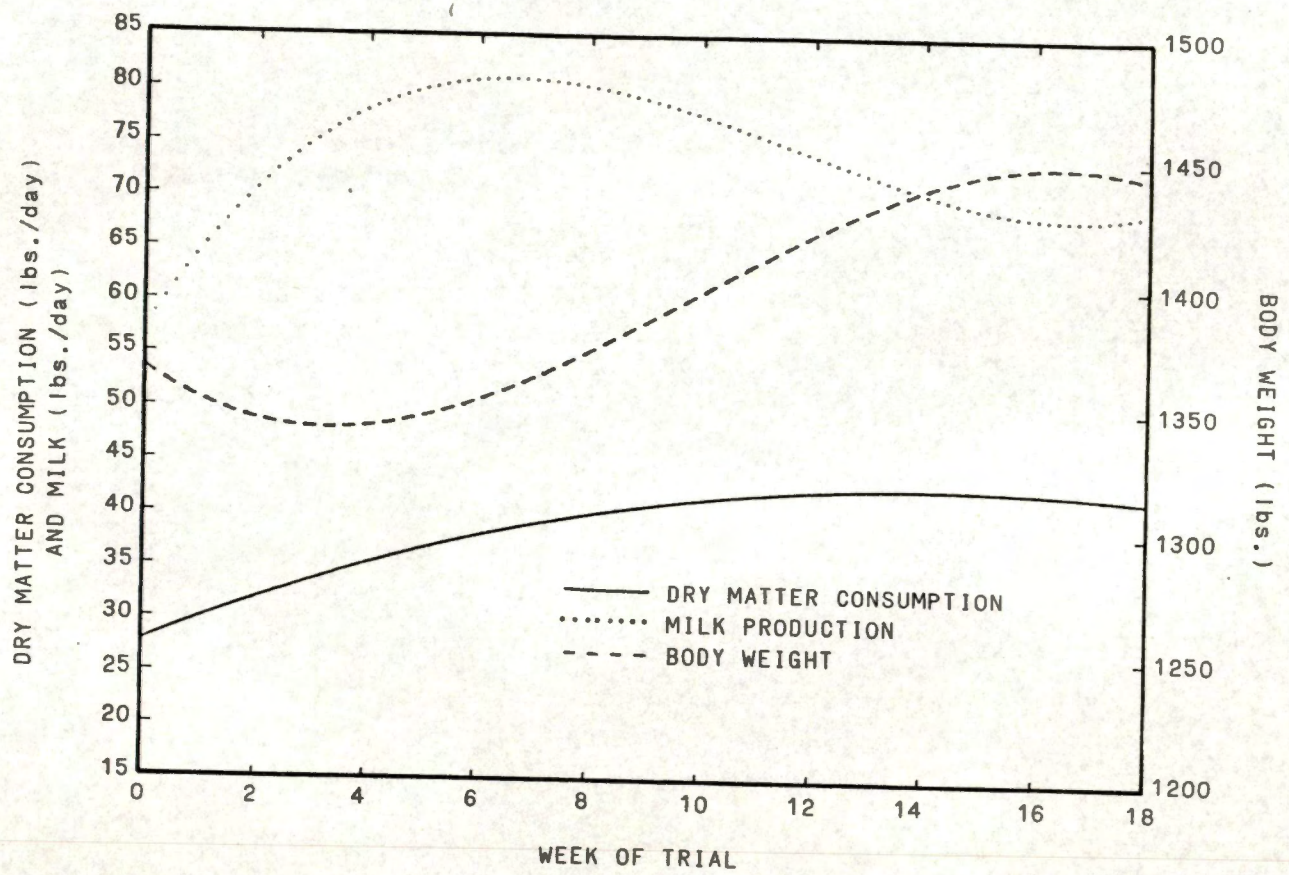


Figure 1. Trinomial regression curves for body weight, daily dry matter intake, and daily milk production for Treatment I, Lactation 2 cows.

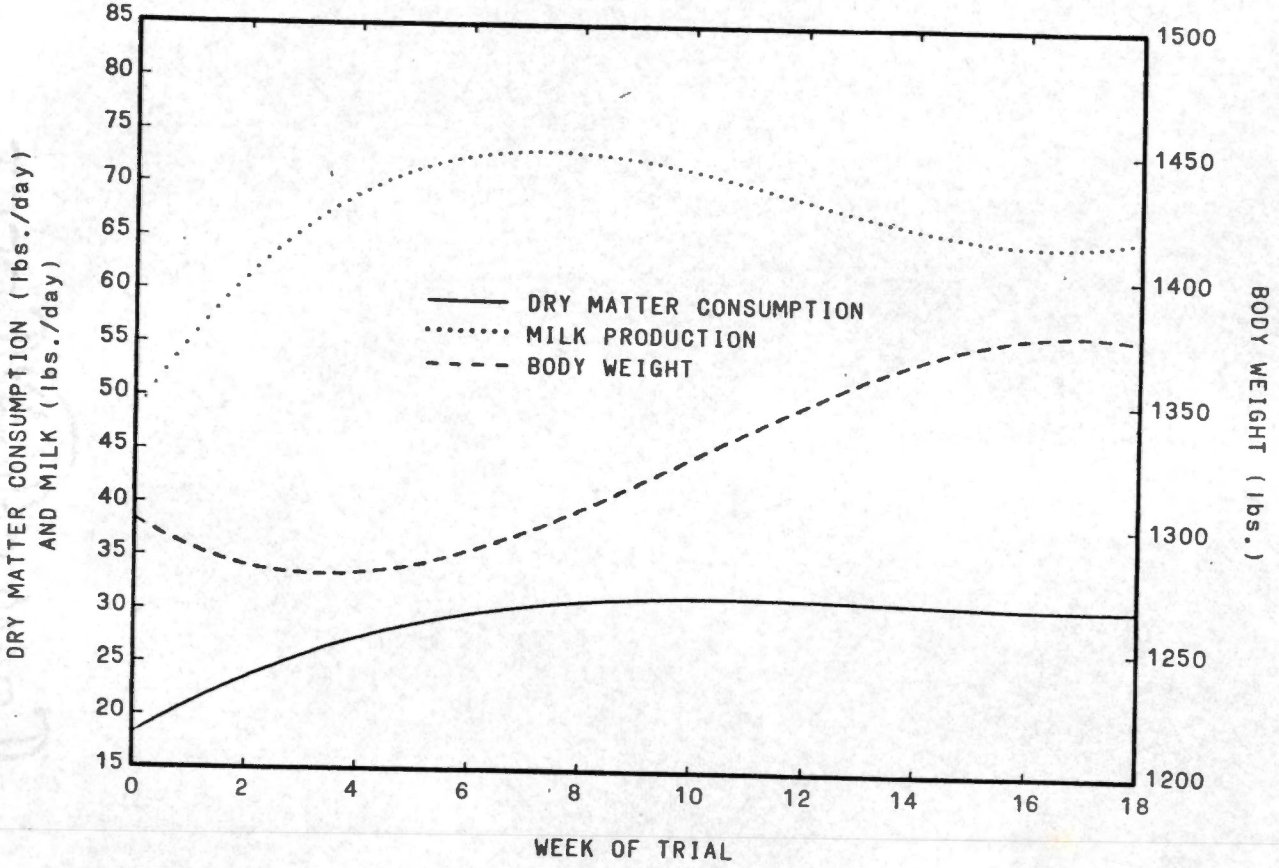


Figure 2. Trinomial regression curves for body weight, daily dry matter intake, and daily milk production for Treatment II, Lactation 2 cows.

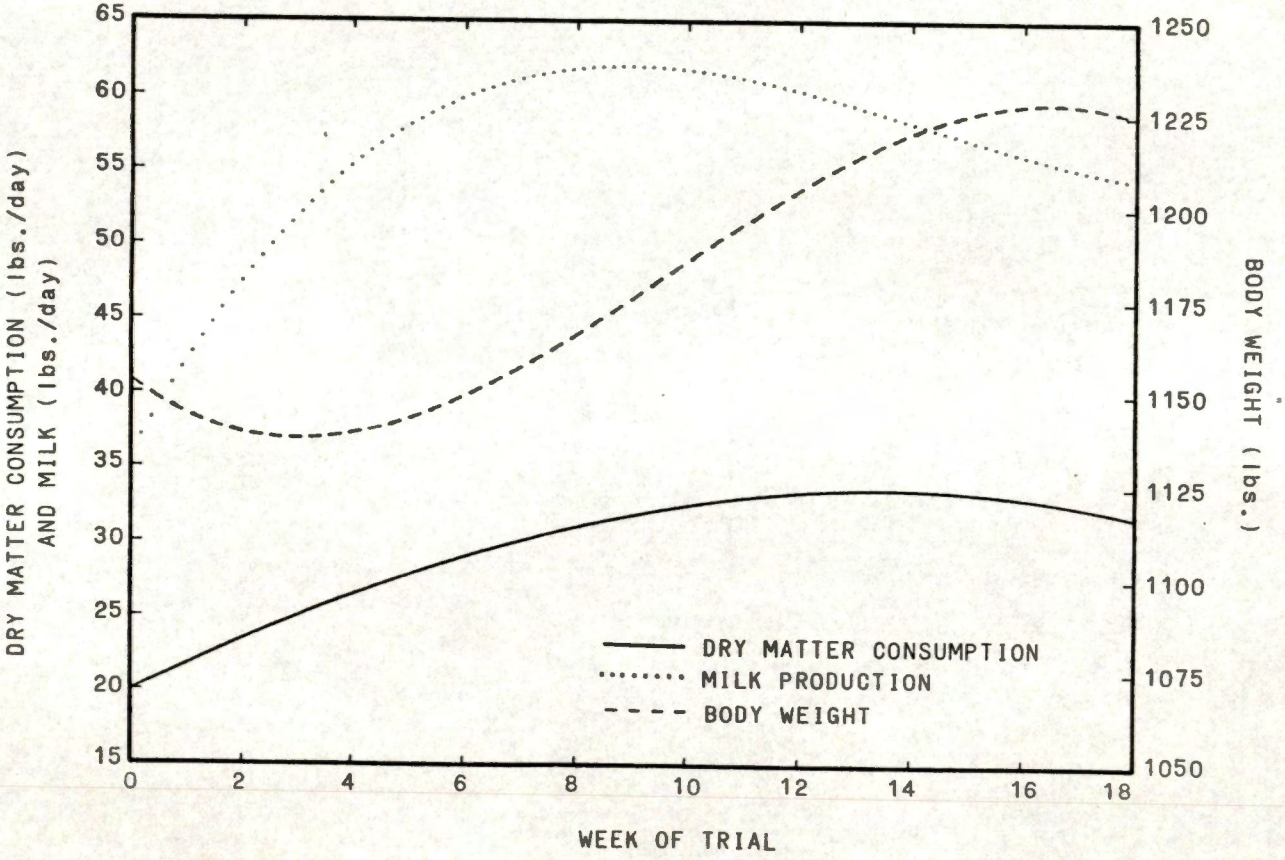


Figure 3. Trinomial regression curves for body weight, daily dry matter intake, and daily milk production for Treatment I, Lactation 1 cows.

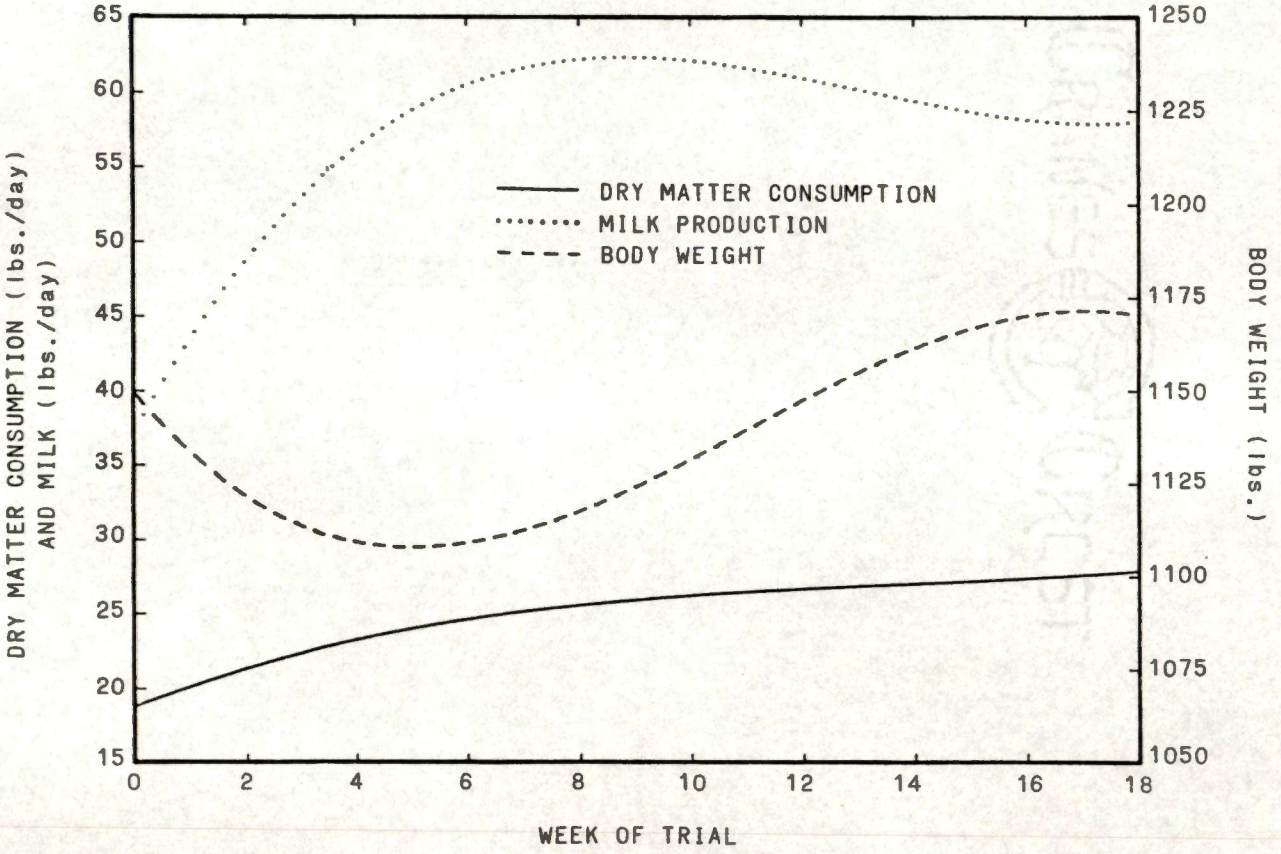


Figure 4. Trinomial regression curves for body weight, daily dry matter intake, and daily milk production for Treatment II, Lactation 2 cows.

TABLE 3

DAILY PRODUCTION DATA OF HOLSTEIN COWS

Production variable	Treatment I	Treatment II
Actual milk (lb), $\bar{x}$	66.3[a] ± 15.2[b]	63.1[a] ± 10.6
Lactation 1	57.4[a] ± 11.3	57.9[a] ± 11.1
Lactation 2	74.3[a] ± 14.1	67.6[a] ± 8.0
% Fat, $\bar{x}$	3.03[a] ± .38	2.92[a] ± .43
Lactation 1	2.95[a] ± .30	2.82[a] ± .45
Lactation 2	3.09[a] ± .44	3.00[a] ± .42
FCM (lb), $\bar{x}$	56.1[a] ± 12.2	52.3[a] ± 8.9
Lactation 1	47.9[a] ± 9.4	47.05[a] ± 7.3
Lactation 2	63.5[a] ± 9.7	57.0[a] ± 7.5
Milk solids (%)	11.8[a] ± .66	11.5[a] ± .63
Milk protein (%)	3.1[a] ± .20	3.0[a] ± .22

Treatment I = 3 parts corn silage: 1 part concentrate (18% CP).

Treatment II = 1 part corn silage: 1 part Maltlage.

Lactation 1 = first lactation
Lactation 2 = second or later lactation

[a] = Means on a line with different superscripts differ significantly ($P < .05$).

[b] = Standard deviation.

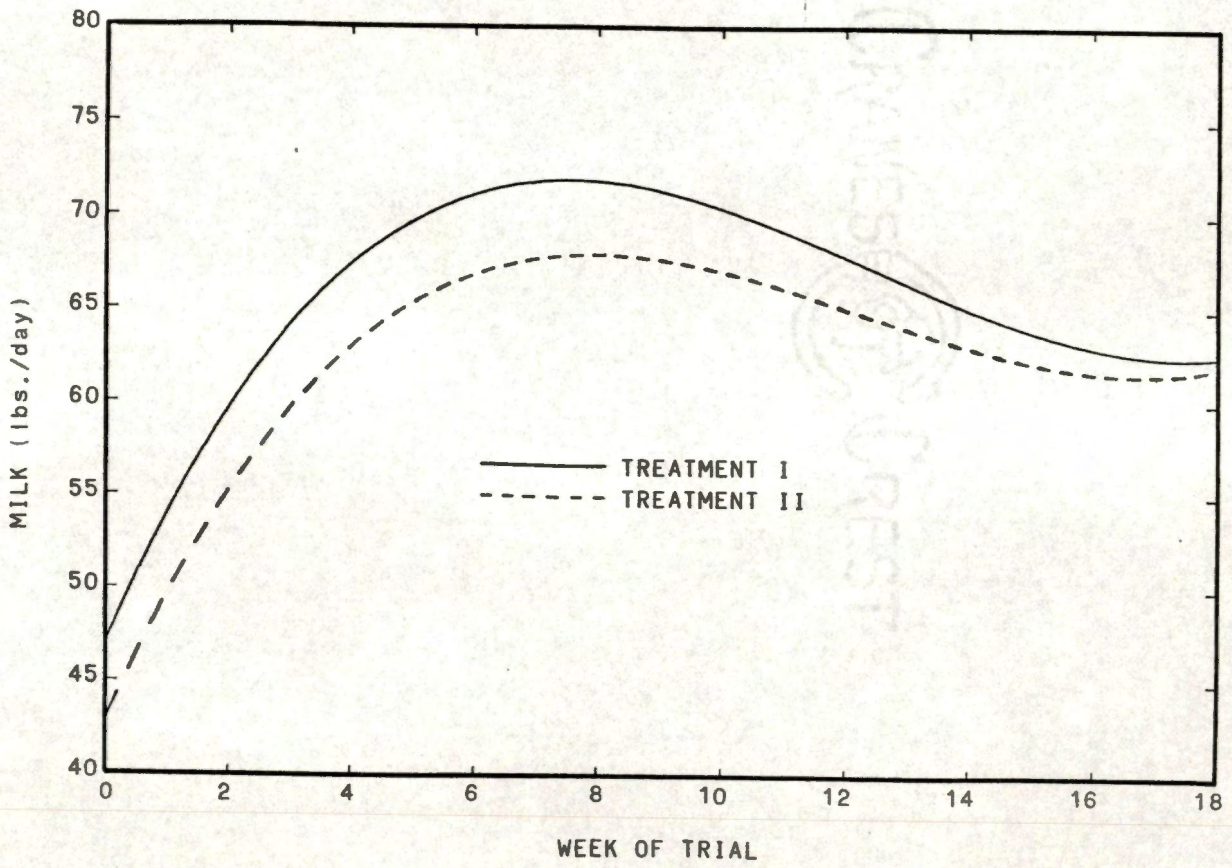


Figure 5. Trinomial regression curves for daily milk production.

were found by analysis of variance. First lactation cows assigned to Treatments 1 and 2 had very similiar average daily milk yields, 57.4 and 57.9 pounds, respectively. Cows in second or later lactation produced an average of 74.3 pounds of milk daily on Treatment 1 and 67.6 pounds daily on Treatment 2. Although these differences were not statistically different ($P>.05$), it appears that Treatment 2 containing Maltlage may have limited milk production during the first eight to ten weeks of lactation. Milk production of cows in second or later lactation followed a similiar trend to that of dry matter intake of the respective treatment ration, (Figures 1 and 2, pages 37 and 38). Since the ration crude protein and acid detergent fiber contents were essentially equal for both treatment groups, the milk yield of Treatment 2 second or later lactation cows was likely related to the decreased dry matter percentage of the complete ration containing Maltlage and the resultant lower total dry matter intake, (Tables 1 and 2, pages 34 and 35). The dry matter content of silage used in both treatments was also low, Table 1, page 34. Corn silage with a higher dry matter content could have increased the dry matter intake of both rations.

Rakes and Davenport (79) reported similiar non-significant reductions in milk production as Maltlage replaced shelled corn in complete rations containing corn silage, and suggested that complete rations of Maltlage and corn silage without additional concentrate may limit milk production during the first eight to twelve weeks of lactation.

Montgomery et al (60) observed no significant differences in milk, milk fat and FCM when corn silage-Maltlage complete rations were compared

to corn silage-concentrate rations. However, Culvahouse et al (20) observed a reduction in milk for cows fed a 60 percent corn silage - 40 percent Maltlage ration, when compared to a corn silage plus concentrate ration or a 60 percent corn silage - 40 percent Maltlage ration plus one pound of concentrate per three pounds of FCM in excess of 35 pounds daily.

Regression coefficients for milk, milk fat and FCM are in Table A1. As determined by multivariate analysis, there were no overall treatment effects on the regression coefficients for milk and FCM curves which are illustrated in Figure 5, page 42 and Figure 6.

Multivariate analysis of treatment effects on predicted values for the production variables milk, milk fat and FCM for weeks four, eight, twelve and sixteen was non-significant ($P>.05$).

Regression coefficients for dry matter consumption are in Table A2. Multivariate analysis of treatment effects on predicted values for dry matter consumption for weeks four, eight, twelve and sixteen was significant ($P<.01$).

Treatment had no significant effect on the regression coefficients for body weight. Table A3 contains the regression coefficients for body weight, and body weight curves are shown in Figures 1, 2, 3 and 4, pages 37-40. Multivariate analysis of treatment effects on predicted values for body weight for weeks four, eight and twelve and sixteen was non-significant ($P>.05$). Although these differences were non-significant, it appears that first lactation cows on Treatment 2 containing Maltlage did

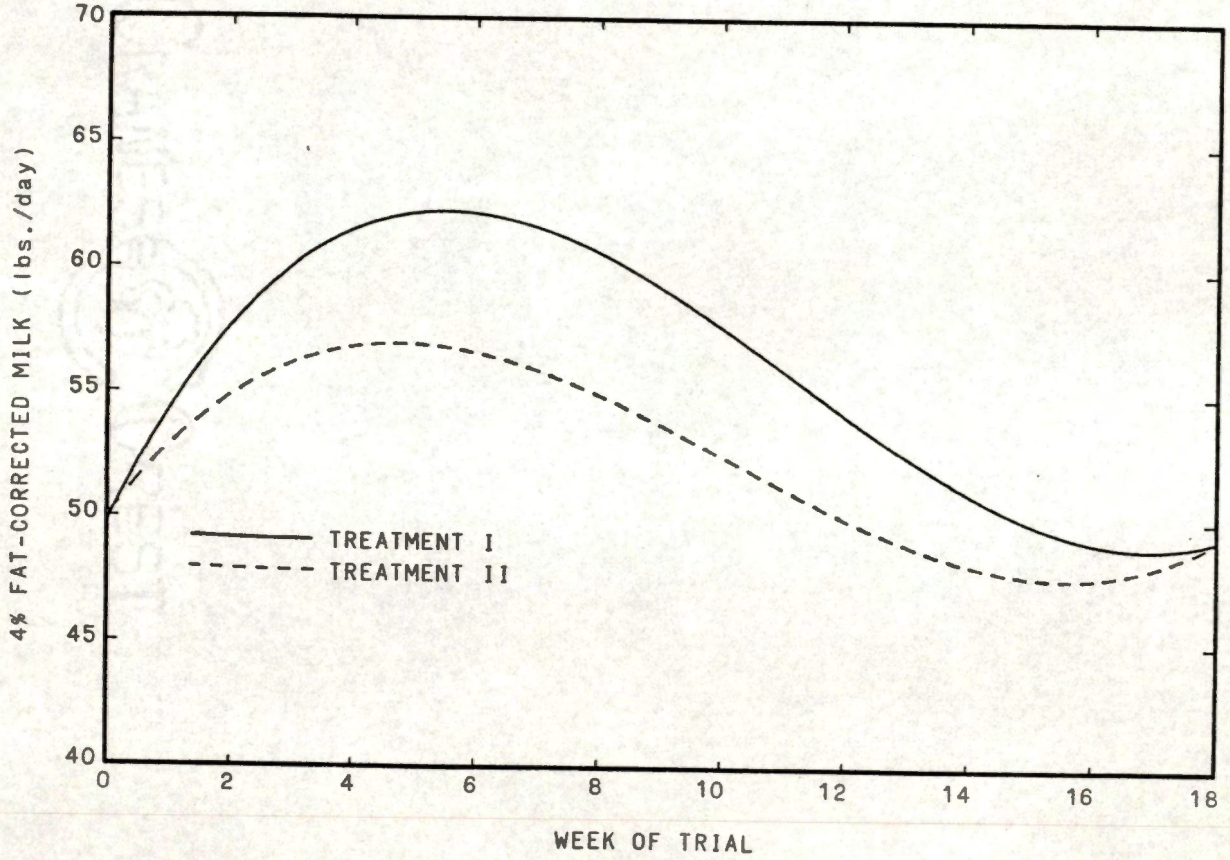


Figure 6. Trinomial regression curves for daily 4 percent fat-corrected milk production.

not maintain their weight as well as similiar cows on Treatment 1. The additional weight loss of the first lactation cows on Treatment 2 was probably due to a significant ($P<.05$) reduction in dry matter intake compared to similiar cows on Treatment 1. Rakes and Davenport (79) report similiar weight losses for cows consuming complete rations composed of a 1:1 ratio of corn silage to Maltlage. Montgomery et al (60) found no significant differences in body weight change of cows consuming corn silage-Maltlage diets compared to corn silage-concentrate diets.

The ratio of milk and FCM produced to dry matter consumed was significantly ($P<.05$) affected by treatment. Treatment 2 cows produced more milk and FCM per unit of dry matter intake than cows on Treatment 1. Porter et al (75) report that WBG produced milk more efficiently per unit of dry matter intake than DBG. Although cows on Treatment 2 produced milk more efficiently per unit of dry matter intake, these values are potentially confounded by possible differences in energy intake between the treatment groups.

Since energy is used with similiar degrees of efficiency for maintenance and milk production in lactating cows, a single net energy value of feeds is adequate to calculate rations for both maintenance and milk production, as reported by Moe et al (59). When compared to National Research Council (NRC) (65) net energy requirements, the net energy intake of Treatment 1 cows was deficient until approximately ten weeks of lactation. Similiarly, the net energy intake of cows assigned to Treatment 2 did not meet NRC net energy requirements at any time during

this study. Treatment 1 cows had an average net energy deficiency of 2.1 Mcal per head daily over the 18 week lactation trial compared to a deficiency of 6.7 Mcal per head daily for Treatment 2 cows. (Calculations were based on estimated net energy values for Maltlage and concentrate of 1.86 and 1.85 Mcal/kg, respectively.)

The apparent greater net energy deficiency of Treatment 2 cows helps to explain the trend for greater weight loss of first lactation cows assigned to Treatment 2.

The Maltlage ration produced milk and FCM more efficiently per unit of net energy intake, 3.0 and 2.5 pounds per Mcal, respectively compared to 2.4 and 2.0 pounds per Mcal for Treatment 1. The difference in efficiency is related to the differential rate of dry matter intake between the two treatments and their corresponding differences in energy intake and resultant body weight change.

No significant ($P>.05$) treatment differences were found in milk protein or milk solids, (Table 3, page 41).

II Growth Trial. The chemical composition of the feeds is reported in Table 1, page 34. Corn silage had a dry matter content of 28.5 percent and crude protein content of 9.7 percent. Maltlage had a dry matter content of 48.5 percent and crude protein content of 18.4 percent.

Dry matter content of complete rations was 42.6 percent for Treatment 1 and 37.9 percent for Treatment 2. In Treatment 1, corn silage provided 48 percent of the dry matter, and concentrate provided 52 percent of the dry matter. In Treatment 2, corn silage provided 37 percent

of the dry matter, and Maltlage provided 63 percent of the dry matter. Acid detergent fiber (ADF) content of Treatment 1 was slightly higher than Treatment 2. Soybean meal was added to Treatment 1 to make complete rations isonitrogenous; crude protein content was 14.3 and 14.6 percent for Treatments 1 and 2, respectively. Treatment 2 contained 9.67 mg calcium per gram of ration compared to 6.1 mg calcium per gram of ration for Treatment 1.

Daily dry matter consumption at weekly intervals is reported in Table 4. Heifers progressively consumed more dry matter with increasing age. Treatment significantly ($P<.01$) affected dry matter intake per hundred pounds of body weight. Average dry matter intake (pounds) per hundred pounds of body weight was 2.4 for Treatment 1, 2.2 for Treatment 2 and 2.0 for Treatment 3; each of the values was significantly ($P<.05$) different from the other two. Multivariate analysis of treatment effects on the regression coefficients for dry matter intake was significant ($P<.01$). Plots of the treatment regression curves of dry matter intake are illustrated in Figure 7.

The growth rate of heifers on each treatment increased weekly as shown in Table 5. Average daily gain (ADG) was significantly ($P<.05$) affected by treatment. Mean ADG for Treatment 1, 1.03 pounds, was higher ($P<.05$) than for Treatment 2, .85 pounds and Treatment 3, .75 pounds. Cumulative average daily gain (pounds) for Treatments 1, 2, and 3 at 30 weeks of age was 1.62, 1.52 and 1.15, respectively.

Table 6 lists the period average daily gain (PADG) which is the weight change difference between two consecutive weeks divided by seven

TABLE 4

DAILY DRY MATTER CONSUMPTION BY HOLSTEIN HEIFERS

Age (wk.)	Treatment[a]	Daily dry matter intake	Dry matter intake/CWT
		----------lb----------	
5	I	.8 ± .31[b]	.80 ± .33
	II	.5 ± .23	.55 ± .25
	III Corn Silage	.2 ± .16	.62 ± .27
	Maltlage	.4 ± .24	
10	I	4.0 ± .86	2.81 ± .46
	II	3.1 ± .72	2.32 ± .35
	III Corn Silage	1.8 ± .52	2.18 ± .32
	Maltlage	1.1 ± .25	
15	I	6.0 ± 1.19	3.03 ± .42
	II	5.4 ± 1.05	2.96 ± .41
	III Corn Silage	2.7 ± .83	2.43 ± .48
	Maltlage	1.3 ± .46	
20	I	8.0 ± 1.84	3.25 ± .57
	II	7.6 ± 1.81	3.11 ± .64
	III Corn Silage	3.7 ± .69	2.67 ± .27
	Maltlage	1.8 ± .33	
25	I	10.6 ± 1.59	3.14 ± .46
	II	8.8 ± 1.79	2.77 ± .47
	III Corn Silage	4.3 ± .76	2.50 ± .30
	Maltlage	2.1 ± .62	
30	I	12.9 ± 1.49	3.11 ± .39
	II	10.4 ± 1.73	2.62 ± .22
	III Corn Silage	5.5 ± 1.07	2.62 ± .21
	Maltlage	2.8 ± .51	

[a] = Treatment I = 3 parts corn silage: 1 part concentrate (18% CP).

Treatment II = 1 part corn silage: 1 part Maltlage.

Treatment III = Corn silage ad libitum plus Maltlage fed separately at the rate of two lbs./100 lbs, of body weight.

[b] = Standard Deviation

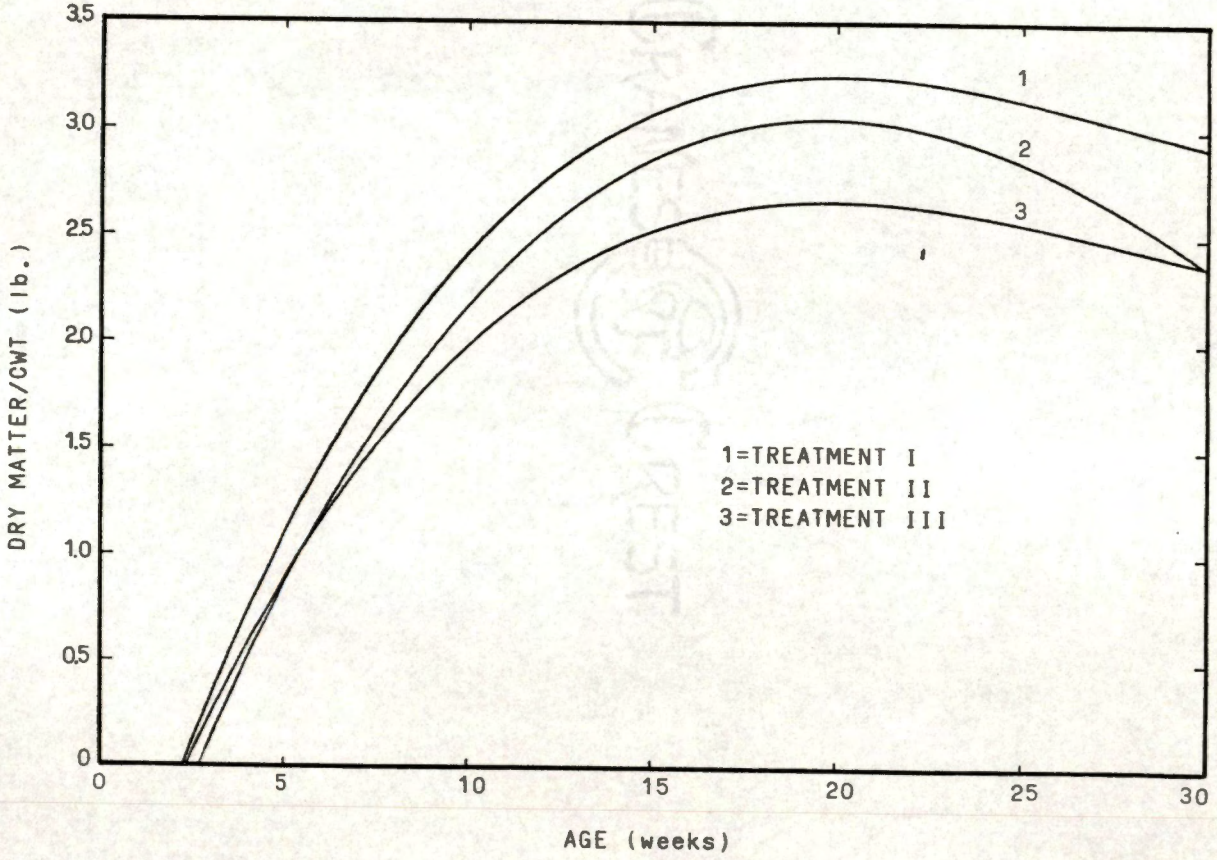


Figure 7. Trinomial regression curves for daily dry matter intake per hundred pounds of body weight of Holstein heifers.

TABLE 5

CUMULATIVE AVERAGE DAILY GAIN (ADG) OF HOLSTEIN HEIFERS

Age (wk)	Treatment[a]		
	I	II	III
	lb		
5	.70 ± .21[b]	.35 ± .20	.48 ± .18
10	.91 ± .19	.73 ± .24	.72 ± .20
15	1.14 ± .20	.96 ± .22	.81 ± .22
20	1.32 ± .19	1.17 ± .14	.91 ± .21
25	1.50 ± .16	1.35 ± .18	1.02 ± .21
30	1.62 ± .14	1.52 ± .18	1.15 ± .24

[a] = Treatment I = 3 parts corn silage: 1 part concentrate (18% CP).

Treatment II = 1 part corn silage: 1 part Maltlage.
Treatment III = Corn silage ad libitum plus Maltlage fed separately at the rate of two lbs./100 lbs. of body weight.

[b] = Standard deviation.

TABLE 6

PERIOD AVERAGE DAILY GAIN (PADG) OF HOLSTEIN HEIFERS

Age (wk)	Treatment[a]		
	I	II	III
	lb		
5	1.00 ± .72[b]	1.00 ± .63	1.27 ± .47
10	1.23 ± .50	1.17 ± .66	.99 ± .46
15	1.99 ± .52	1.62 ± .63	1.30 ± .60
20	1.76 ± .76	2.16 ± .93	1.04 ± .88
25	2.05 ± .83	1.96 ± .53	1.58 ± .82
30	2.27 ± 1.11	2.22 ± 1.09	1.61 ± .99

[a] = Treatment I = 3 parts corn silage: 1 part concentrate (18% CP).

Treatment II = Corn silage ad libitum plus Maltlage fed separately at the rate of two lbs./100 lbs. of body weight.

[b] = Standard deviation.

days. This permits one to examine the ADG within a certain period to determine the growth progress of the animal. With three exceptions, PADG increased for all treatments through 30 weeks of age.

Body weight of the heifers is reported in Table 7. All heifers progressively increased in weight each week. Treatment had a significant ($P<.01$) effect on body weight, and heifers on Treatment 3 had significantly lower average body weights (pounds) than heifers on Treatments 1 and 2, 177.6 versus 215.5 and 203.5, respectively. Average body weight (pounds) for Treatments 1, 2 and 3 at 30 weeks of age was 415.4, 396.3 and 319.4, respectively.

Regression coefficients for body weight are listed in Table A4. Multivariate analysis of the treatment effects on the regression coefficients for body weight was significant ($P<.01$). Plots of body weight curves by treatment are shown in Figure 8.

Wither height measurements by treatment are listed in Table 8. Significant ($P<.01$) treatment differences were observed for height measurements. Average wither height (inches) for Treatment 3, 34.4 was less ($P<.05$) than height of Treatment 1 and 2 heifers, 36.2 and 35.7, respectively. At 30 weeks of age the heifers had wither height measurements of 43.9, 42.7 and 40.2 inches for Treatments 1, 2, and 3 respectively.

Treatment had a significant ($P<.01$) effect on the regression coefficients for wither height when subjected to multivariate analysis. Regression coefficients for wither height measurements are listed in Table A4. Plots of wither height regression curves are illustrated in Figure 9.

TABLE 7

BODY WEIGHT OF HOLSTEIN HEIFERS

Age (wk)	Treatment[a]		
	I	II	III
	lb		
1	79.9 ± 7.50[b]	82.9 ± 11.09	82.0 ± 10.01
5	98.2 ± 10.02	96.5 ± 9.87	97.8 ± 12.28
10	142.4 ± 16.37	134.0 ± 16.99	130.5 ± 19.44
15	198.2 ± 24.67	182.7 ± 23.20	164.9 ± 29.30
20	262.3 ± 29.41	245.2 ± 24.58	207.3 ± 35.81
25	339.2 ± 32.38	315.8 ± 37.54	258.3 ± 42.78
30	415.4 ± 34.18	396.3 ± 45.21	319.4 ± 56.82

[a] = Treatment I = 3 parts corn silage: 1 part concentrate (18% CP).

Treatment II = 1 part corn silage: 1 part Maltlage.
Treatment III = Corn silage ad libitum plus Maltlage fed separately at the rate of two lbs./100 lbs. of body weight.

[b] = Standard deviation.

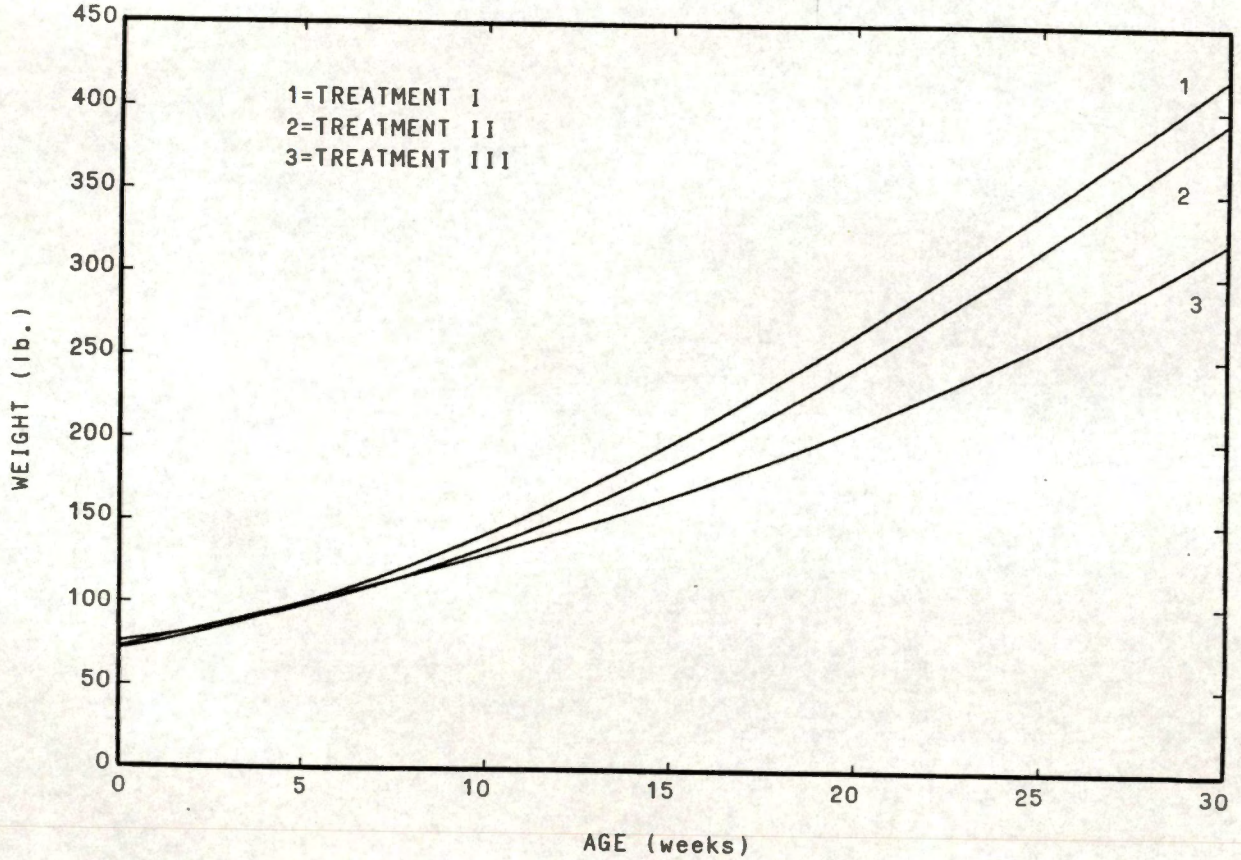


Figure 8. Trinomial regression curves for body weight of Holstein heifers.

TABLE 8

WITHER HEIGHT OF HOLSTEIN HEIFERS

Age (wk)	Treatment[a]		
	I	II	III
	lb		
5	31.3 ± 1.09[b]	31.6 ± 1.40	30.8 ± 1.12
10	33.1 ± 1.29	32.9 ± .79	32.3 ± 1.39
15	36.1 ± 1.61	35.4 ± 1.31	34.2 ± 1.50
20	38.4 ± 1.55	38.1 ± 1.18	35.7 ± 2.44
25	40.9 ± 1.16	40.1 ± 2.17	37.7 ± 1.68
30	43.9 ± 1.14	42.7 ± 1.39	40.2 ± 1.69

[a] = Treatment I = 3 parts corn silage: 1 part concentrate (18% CP).

Treatment II = 1 part corn silage: 1 part Maltlage.

Treatment III = Corn silage ad libitum plus Maltlage fed separately at the rate of two lbs./100 lbs. of body weight.

[b] = Standard deviation.

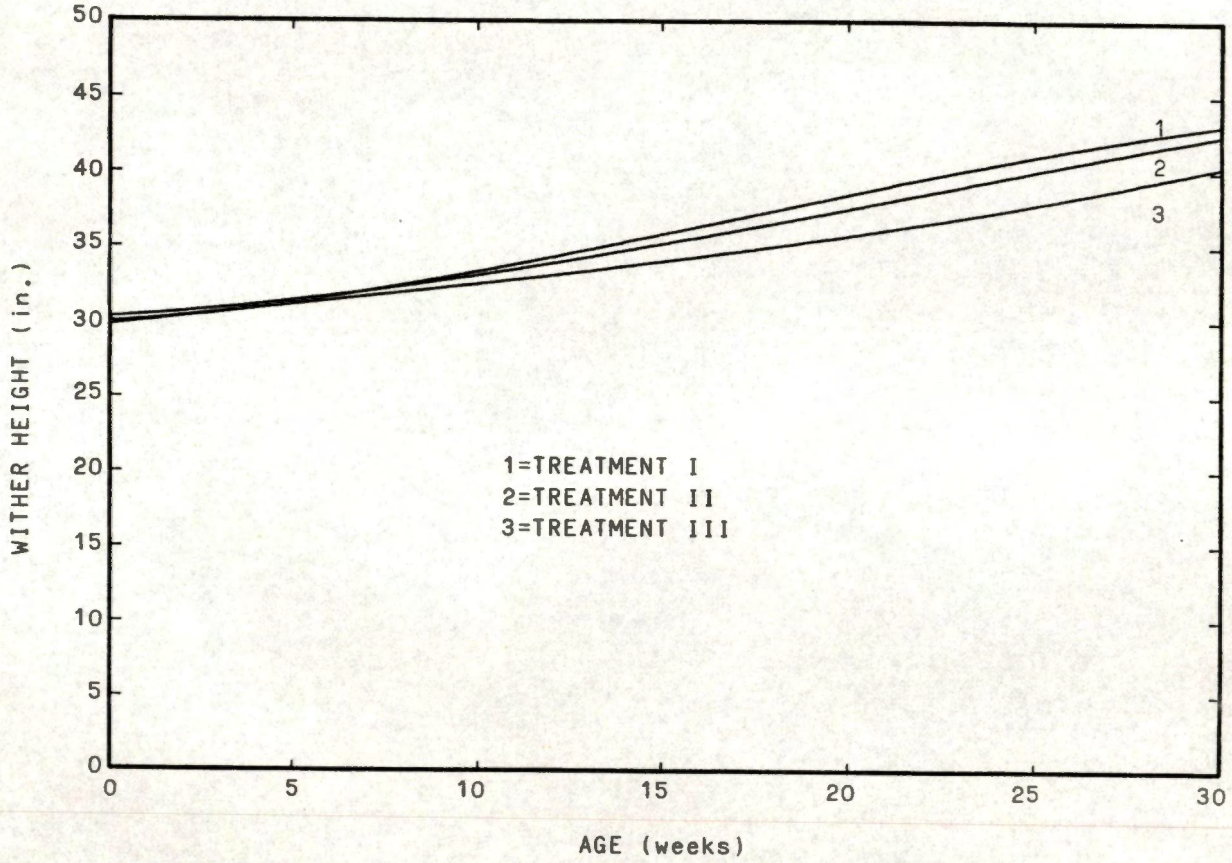


Figure 9. Trinomial regression curves for wither height of Holstein heifers.

A third measurement taken to determine growth was the length down the topline from the anterior of the shoulder blade to the first caudal vertebra. Body length measurements are reported in Table 9. At 30 weeks of age, the heifers had length measurements (inches) of 32.4, 31.9 and 29.6 for Treatment 1, 2 and 3, respectively. Average length of Treatment 3 heifers was shorter ($P<.05$) than the length of Treatments 1 and 2 heifers, 24.2 versus 25.3 and 25.1 inches, respectively.

Table A4 lists the regression coefficients for length measurements. Multivariate analysis of the treatment effects on length was significant ($P<.01$). Plots of the treatment regression curves for length are shown in Figure 10.

Paunch circumference was recorded to determine if complete rations containing corn silage would cause heifers to develop "pot belly." Measurements of paunch circumference (inches) at 30 weeks of age for Treatments 1, 2 and 3 were 64.2, 63.5 and 59.4, respectively, (Table 10). Treatment differences in paunch circumference approached significance ($P>.06$) as determined by univariate analysis.

Multivariate analysis of the paunch regression coefficients produced significant ($P<.01$) treatment differences. Table A4 lists the regression coefficients for paunch measurements and plots of the paunch regression curves are illustrated in Figure 11.

Nease (64) compared growth performance of Holstein heifers fed complete rations of corn silage and concentrate to a hay and concentrate

TABLE 9

LENGTH OF HOLSTEIN HEIFERS

Age (wk)	Treatment[a]		
	I	II	III
	----------lb----------		
5	21.1 ± 1.11[b]	21.3 ± 1.35	21.1 ± 1.12
10	22.2 ± 1.05	22.1 ± .95	22.0 ± .94
15	24.4 ± 1.08	24.3 ± 1.45	23.5 ± 1.50
20	27.1 ± .95	26.8 ± 1.15	25.3 ± 1.40
25	30.2 ± 1.20	28.8 ± 2.66	27.8 ± 1.65
30	32.4 ± 1.34	31.9 ± 1.85	29.6 ± 1.56

[a] = Treatment I = 3 parts corn silage: 1 part concentrate (18% CP).

Treatment II = 1 part corn silage: 1 part Maltlage.

Treatment III = Corn silage ad libitum plus Maltlage fed separately at the rate of two lbs./100 lbs. of body weight.

[b] = Standard deviation.

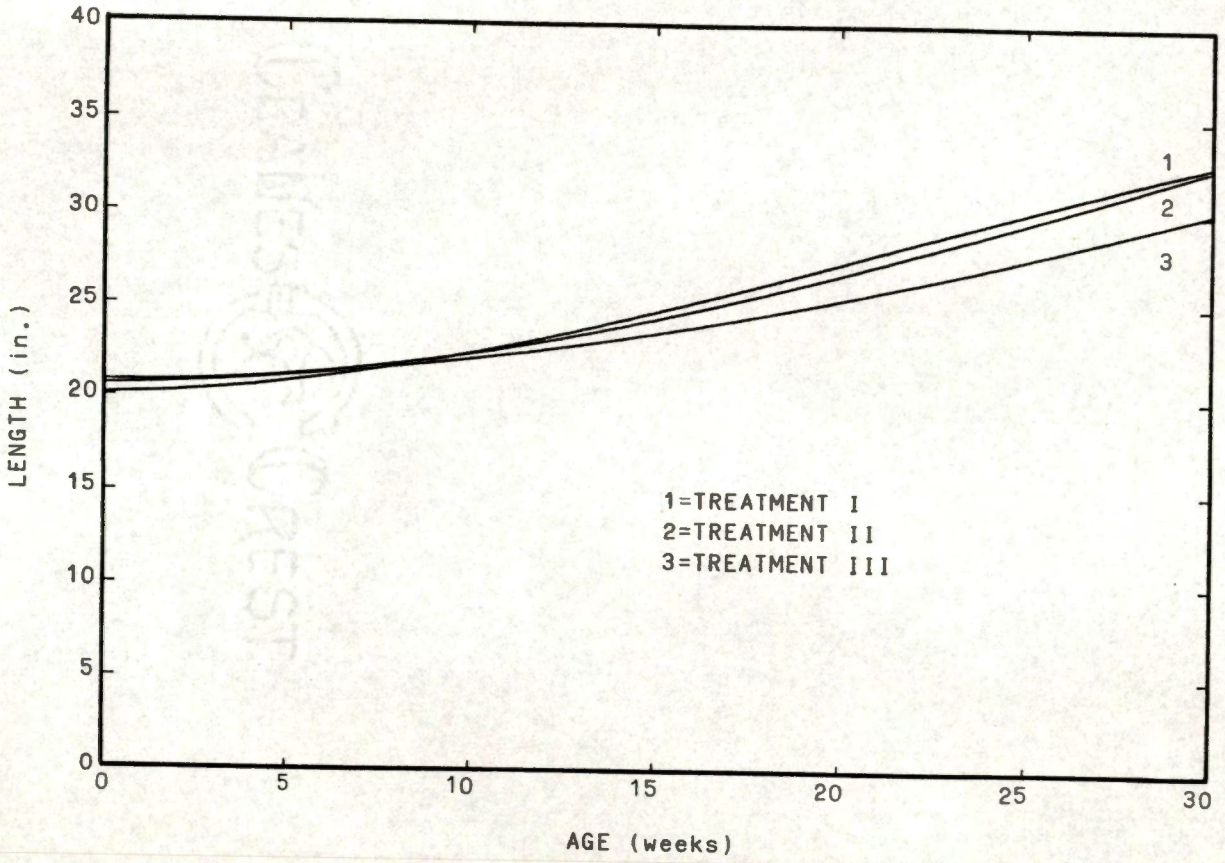


Figure 10. Trinomial regression curves for length of Holstein heifers.

TABLE 10

PAUNCH CIRCUMFERENCE OF HOLSTEIN HEIFERS

Age (wk)	Treatment[a] I	II	III
	---------- lb ----------		
5	35.4 ± 1.77[b]	34.3 ± 2.31	34.9 ± 2.18
10	45.0 ± 1.98	43.7 ± 3.00	43.6 ± 2.49
15	50.1 ± 2.84	48.5 ± 2.61	48.1 ± 3.63
20	54.4 ± 2.30	53.0 ± 2.33	51.7 ± 2.72
25	59.2 ± 2.33	57.5 ± 3.02	54.8 ± 4.11
30	64.2 ± 2.17	63.5 ± 3.31	59.4 ± 4.27

[a] = Treatment I = 3 parts corn silage: 1 part concentrate (18% CP).

Treatment II = 1 part corn silage: 1 part Maltlage.
Treatment III = Corn silage ad libitum plus Maltlage fed separately at the rate of two lbs./100 lbs. of body weight.

[b] = Standard deviation.

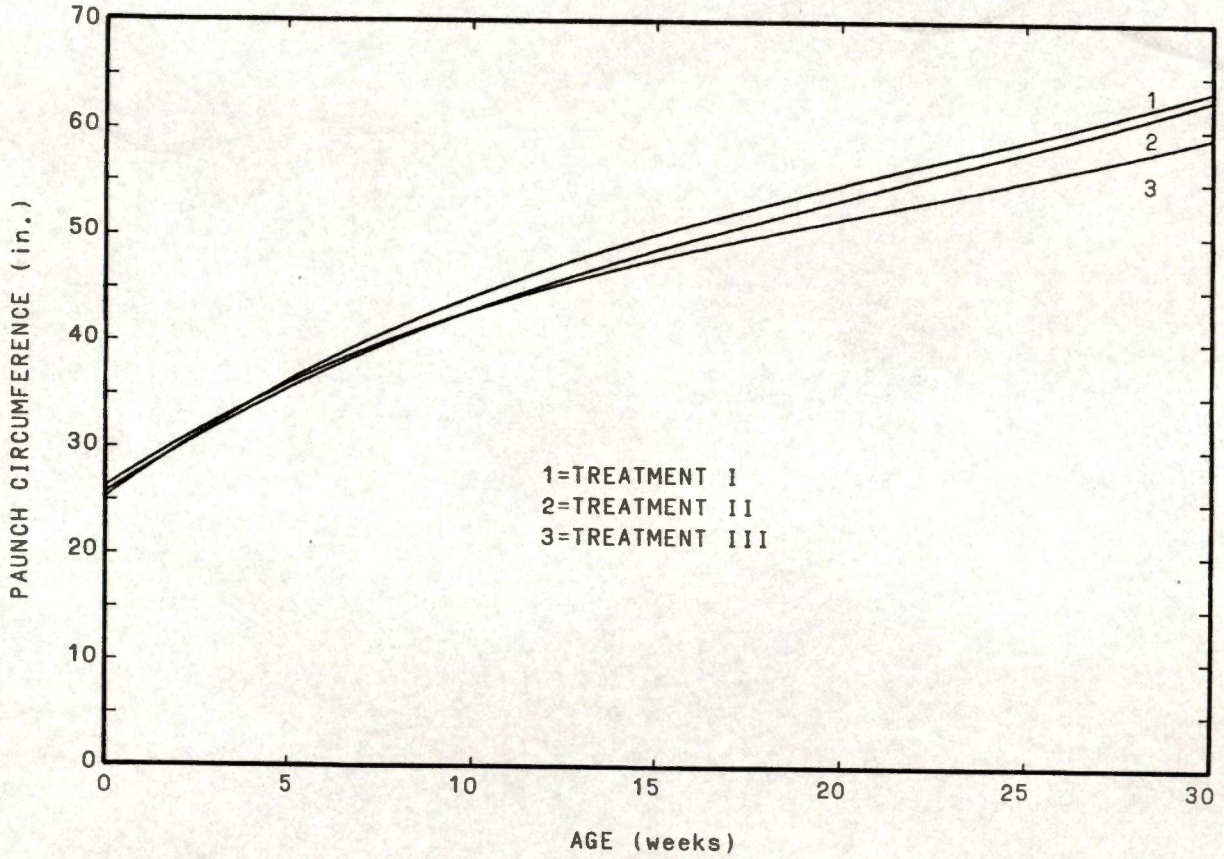


Figure 11. Trinomial regression curves for paunch circumference of Holstein heifers.

ration and reported no significant treatment differences for wither height, body length, paunch circumference and body weight. In the current study, performance of Holstein heifers fed Treatment 1 (3:1 ratio of corn silage to concentrate) compared favorably with the performance of Holstein heifers in the Nease study, which were fed complete rations of corn silage and concentrate in 2:1 and 4:1 ratios, respectively.

Performance of heifers on all rations was relatively similiar until approximately 10 weeks of age, at which time Treatment 3 heifers (ad libitum corn silage plus Maltlage at the rate of 2 percent of body weight) began to decline in growth compared to Treatments 1 and 2.

When compared to National Research Council (NRC) (65) crude protein requirements for large breed dairy heifers, gaining 1.6 pounds per day, the daily crude protein intake of heifers on all treatments in this study was deficient until approximately 14 weeks of age, Figure 12. From 14 to 30 weeks of age, heifers assigned to Treatments 1 and 2 had daily intakes of dry matter in quantities sufficient to approach or meet NRC crude protein requirements. Treatment 3 heifers did not meet NRC crude protein requirements at any time during this study. Average daily crude protein intake (pounds) for Treatments 1, 2 and 3 at 30 weeks of age was 1.8, 1.6 and 1.0, respectively. The restricted feeding of Maltlage dry matter at 1 percent of body weight plus ad libitum intake of corn silage (Treatment 3) did not provide sufficient crude protein for an acceptable rate of growth.

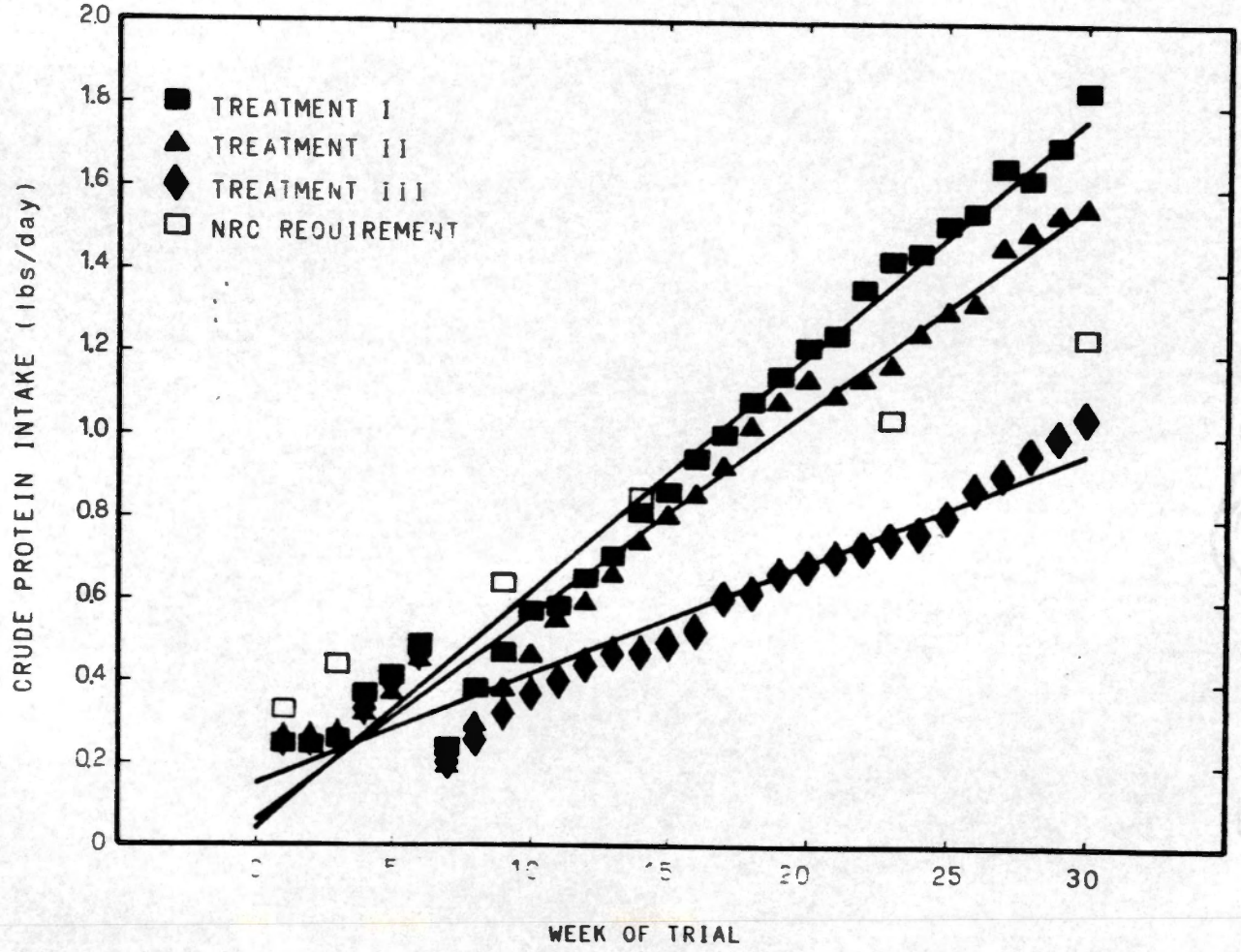


Figure 12. Average daily crude protein intake by treatment versus daily NRC crude protein requirements for Holstein heifers gaining 1.6 pounds per day.

Mean body weight at 30 weeks of age for heifers on Treatments 1 and 2, 415.4 and 396.3 pounds, respectively compares favorably with the suggested NRC body weight of 400 pounds at 32 weeks of age. The lower mean body weight (319.4 pounds) at 30 weeks of age for Treatment 3 heifers was probably due to crude protein deficiency.

Van Soest (99) has suggested that dried brewers grain may contain unavailable protein, however, Porter et al (74) report a superior utilization of the protein in wet brewers grain by dairy calves.

Chronic protein deficiency can reduce feed intake, which results in a combined deficiency of protein and energy (71, 72). When compared to NRC (65) metabolizable energy requirements for large breed dairy heifers, gaining 1.6 pounds per day, the daily metabolizable energy intake of heifers on all treatments in this study was deficient until approximately 14 weeks of age, Figure 13. From 14 to 30 weeks of age, heifers assigned to Treatments 1 and 2 consumed dry matter in quantities sufficient to approach or meet NRC metabolizable energy requirements. Treatment 3 heifers did not meet NRC metabolizable energy requirements at any time during this study. The reduction in metabolizable energy intake of Treatment 3 heifers was possibly due to the crude protein deficiency which reduced feed intake. (Metabolizable energy calculations were based on estimated metabolizable energy values for concentrate and Maltlage of 3.30 and 3.14 Mcal/kg, respectively.)

III Storage of Maltlage. The chemical composition of the Maltlage is listed in Table 1, page 34. The plastic bag maintained an acceptable

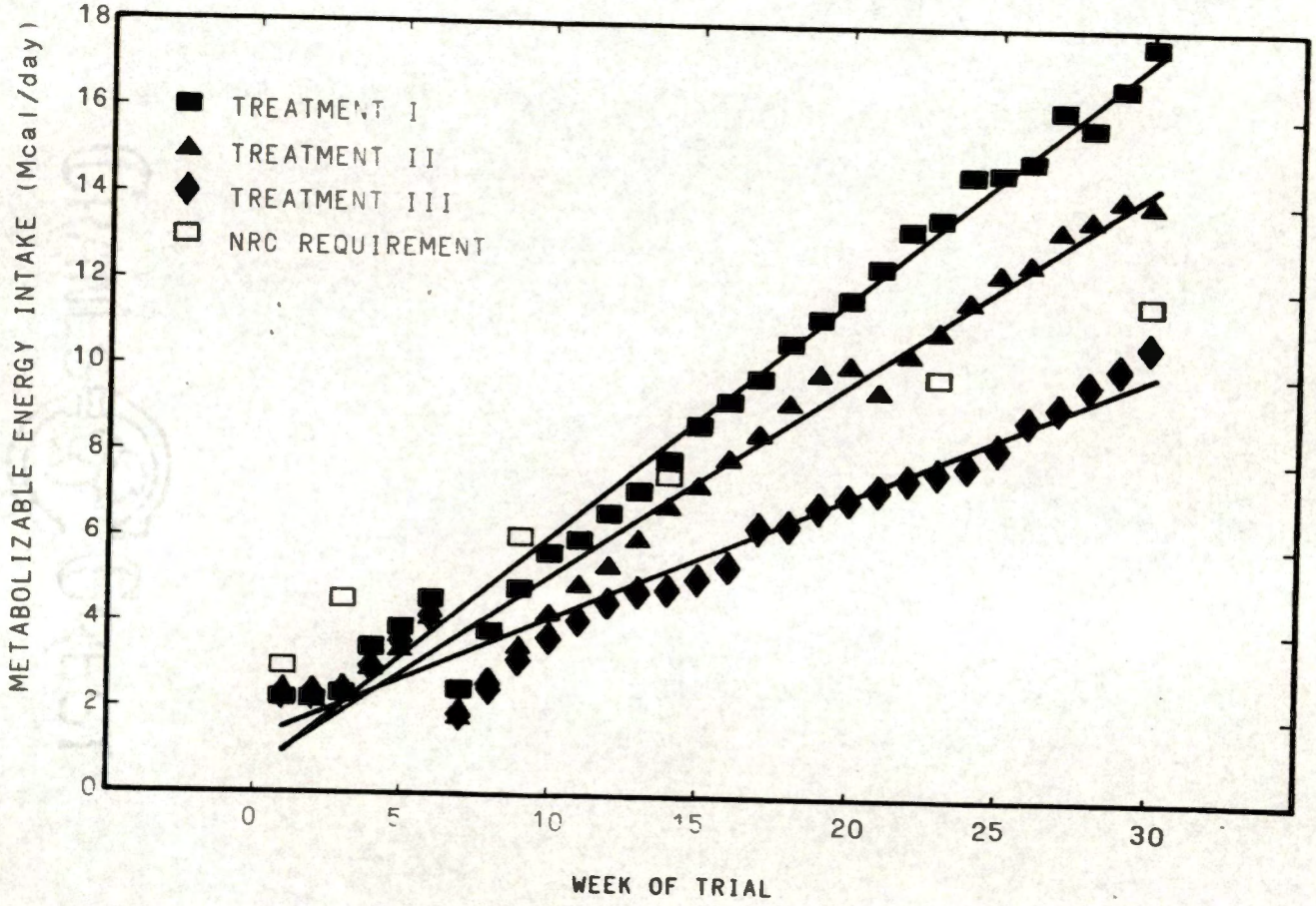


Figure 13. Average daily metabolizable energy intake by treatment versus daily NRC metabolizable energy requirements for Holstein heifers gaining 1.6 pounds per day.

storage quality of Maltlage throughout this study. In addition, the aroma and handling characteristics appeared to be unchanged during storage. Negligible spoilage losses were detected. The pH of randomly selected fresh Maltlage samples was approximately 4.0.

CHAPTER V

SUMMARY AND CONCLUSIONS

An 18 week lactation trial was conducted to determine the value of Maltlage (a commercial source of wet brewer's grains) in complete rations for dairy cows. Lactating Holstein cows were individually fed the following complete rations: 1) a 3:1 as fed ratio of corn silage and concentrate plus soybean meal and 2) a 1:1 as fed ratio of corn silage and Maltlage (a commercial source of wet brewer's grains). The Maltlage ration produced yields of milk, milk fat and fat corrected milk, which were not significantly ($P>.05$) different from the 3:1 complete ration.

Cows in second or later lactation consuming the 3:1 ration had non-significantly ($P>.05$) higher daily milk yields than similar cows consuming the Maltlage ration. The Maltlage ration was more efficient in fat corrected milk production per unit of net energy intake than Treatment 1.

Cows consumed significantly ($P<.05$) less dry matter from the Maltlage ration, which may have limited milk production in early lactation. Net energy intake of the Maltlage treatment was not adequate to meet requirements at any time during this study.

The Maltlage treatment did not affect crude protein or total solids of the milk.

To determine the value of Maltlage for growing dairy calves, Holstein heifers were individually fed the following rations from birth to

30 weeks: 1) 3:1 as fed ratio of corn silage and concentrate plus soybean meal, 2) 1:1 as fed ratio of corn silage and Maltlage and 3) corn silage ad libitum plus Maltlage fed separately at the rate of two pounds per 100 pounds of body weight. Soybean meal was added to Treatment 1 to make rations approximately isonitrogenous. Significant ($P<.05$) treatment differences were observed in the following growth measurements: body weight, length, wither height, and paunch circumference, with Treatment 3 heifers having smaller growth measurements than Treatment 1 and 2 heifers. Mean average daily gain (ADG) for the 30 weeks for Treatment 1, 1.03 pounds, was significantly greater than ADG for Treatment 2, .85 pounds and Treatment 3, .75 pounds. Cumulative ADG (pounds) for Treatments 1, 2, and 3 at 30 weeks of age was 1.62, 1.52 and 1.15, respectively. Treatment 3 heifers had significantly ($P<.01$) lower average body weights than Treatment 1 and 2 heifers.

Dry matter consumption was significantly ($P<.01$) less for Treatment 3 than for Treatment 1 and 2, and crude protein intake of Treatment 3 heifers was not adequate to maintain an acceptable growth rate. Growth response of Treatment 3 heifers was inferior to Treatments 1 and 2. The poor growth of Treatment 3 heifers was probably due to inadequate protein intake.

These data suggest that Holstein heifer calves can be raised successfully on complete rations containing a 1:1 as fed ratio of corn silage and Maltlage, and that feeding ad libitum corn silage plus approximately 1 percent Maltlage dry matter per 100 pounds of body weight does not provide sufficient protein intake for an acceptable growth rate.

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APPENDIX

TABLE A1

INTERCEPT AND REGRESSION COEFFICIENTS FOR PRODUCTION CURVES OF HOLSTEIN COWS

Production variable	Intercept	B_1	B_2	B_3
Milk				
Treatment I, $\bar{x}$	47.11832105^{a}	7.65916433^{a}	$-.72712931^{a}$	$.01940668^{a}$
Lactation 1	35.87788889^{b}	6.96011900^{b}	$-.56229715^{b}$	$.01311794^{b}$
Lactation 2	57.32471000^{c}	8.28830512^{b}	$-.87547825^{b}$	$.02506654^{c}$
Treatment II, $\bar{x}$	42.98399474^{a}	7.44648254^{a}	$-.69063051^{a}$	$.01864539^{a}$
Lactation 1	37.18604444^{b}	6.86896256^{b}	$-.58752684^{b}$	$.01501370^{b}$
Lactation 2	48.20215000^{bc}	7.96625051^{b}	$-.78342382^{b}$	$.02191391^{bc}$
Milkfat				
Treatment I, $\bar{x}$	4.30195237^{a}	$-.24364389^{a}$	$.01040100^{a}$	$-.00011254^{a}$
Lactation 1	4.37009804^{bc}	$-.21907799^{bc}$	$.00276344^{b}$	$.00021261^{b}$
Lactation 2	4.24062127^{b}	$-.26575320^{bc}$	$.01727480^{b}$	$-.00040518^{b}$
Treatment II, $\bar{x}$	4.74106987^{a}	$-.41918273^{b}$	$.02491270^{a}$	$.00046302^{a}$
Lactation 1	3.93481489^{b}	$-.13444111^{c}$	$-.00266060^{b}$	$.00029928^{b}$
Lactation 2	5.46669935^{c}	$-.67545018^{c}$	$.04972867^{b}$	$.00114909^{b}$
4% FCM				
Treatment I, $\bar{x}$	49.78737368^{a}	5.07552503^{a}	$-.60931390^{a}$	$.01810349^{a}$
Lactation 1	38.37426667^{b}	5.40133951^{b}	$-.60058994^{b}$	$.01760159^{b}$
Lactation 2	60.05917000^{c}	4.78229200^{b}	$-.61716547^{b}$	$.01855519^{b}$
Treatment II, $\bar{x}$	50.02585789^{a}	3.24731350^{a}	$-.44547528^{a}$	$.01459848^{a}$
Lactation 1	38.37426667^{b}	5.40133951^{b}	$-.60058994^{b}$	$.01760159^{b}$
Lactation 2	60.05917000^{c}	4.78229200^{b}	$-.61716547^{b}$	$.01855519^{b}$

B_1 = Linear regression coefficient for week.
B_2 = Quadratic regression coefficient for week.
B_3 = Cubic regression coefficient for week.

Treatment I = 3 parts corn silage: 1 part concentrate (18% CP).
Treatment II = 1 part corn silage: 1 part Maltlage.

Lactation 1 = first lactation
Lactation 2 = second or later lactation

^{a} = Treatment means for production variables with different superscripts differ significantly ($P<.05$).

^{b,c} = Treatment - lactation subclass means of production variables with different superscripts differ significantly ($P<.05$).

TABLE A2

INTERCEPT AND REGRESSION COEFFICIENTS FOR TOTAL DRY MATTER CONSUMPTION AND DRY MATTER CONSUMPTION OF COMPLETE RATIONS BY HOLSTEIN COWS

Variable	Intercept	B_1	B_2	B_3
Total Dry Matter				
Treatment I, $\bar{x}$	24.08470074[a]	2.00934883[a]	-.06685246[a]	-.00026908
Lactation 1	19.98124444	1.79513001	-.04271541	-.00114453
Lactation 2	27.77781140	2.20214577	-.08857580	.00051883
Treatment II, $\bar{x}$	18.46702329[b]	2.33277538[a]	-.16878763[a]	.00405299
Lactation 1	18.80422222	1.44176892	-.09237530	.00224001
Lactation 2	18.16354424	3.13468120	-.23755873	.00568468
Complete Ration Dry Matter				
Treatment I, $\bar{x}$	14.18470079[a]	2.00934883[a]	-.06685246[a]	-.00026908
Lactation 1	10.08124968	1.79513001	-.04271541	-.00114453
Lactation 2	17.87780679	2.20214577	-.08857580	.00051883
Treatment II, $\bar{x}$	8.56701938[b]	2.33277538[a]	-.16878763[a]	.0045299[a]
Lactation 1	8.90420793	1.44176892	-.09237530	.00224001
Lactation 2	8.26354968	3.13468120	-.23755873	.00568468

B_1 = Linear regression coefficient for week.
B_2 = Quadratic regression coefficient for week.
B_3 = Cubic regression coefficient for week.

Treatment I = 3 parts corn silage: 1 part concentrate (18% CP).
Treatment II = 1 part corn silage: 1 part Maltlage.

Lactation 1 = first lactation
Lactation 2 = second or later lactation

[a,b] = Treatment means with different superscripts differ significantly ($P<.05$).

TABLE A3

INTERCEPT AND REGRESSION COEFFICIENTS FOR BODY WEIGHT OF HOLSTEIN COWS

Treatment	Intercept	B_1	B_2	B_3
I, $\bar{x}$	1265.12431579[a]	-13.41343763[a]	2.50933147[a]	-.08513188[a]
Lactation 1	1153.3235556	-10.99288184	2.16158771	-.07391771
Lactation 2	1365.74500000	-15.59193784	2.82230086	-.09522464
II, $\bar{x}$	1229.07105263[a]	-16.09153994[a]	2.43061944[a]	-.07672971
Lactation 1	1149.95333333	-18.61409778	2.40352584	-.07257283
Lactation 2	1300.27700000	-13.82123789	2.45500368	-.08047090

B_1 = Linear regression coefficient for week.
B_2 = Quadratic regression coefficient for week.
B_3 = Cubic regression coefficient for week.

Treatment I = 3 parts corn silage: 1 part concentrate (18% CP).
Treatment II = 1 part corn silage: 1 part Maltlage.

Lactation 1 = first lactation
Lactation 2 = second or later lactation

[a] = Treatment means with different superscripts differ significantly ($P < .05$).

TABLE A4

INTERCEPT AND REGRESSION COEFFICIENTS FOR HOLSTEIN GROWTH CURVES

Variable	Treatment	Intercept	B_1	B_2	B_3
Weight	I	71.28747857[a]	3.86786878[ab]	.34610218[a]	-.00291523[a]
	II	75.92823571[a]	2.65710793[b]	.33474830[a]	-.00233421[a]
	III	72.61156667[a]	5.03906631[a]	.04210455[b]	.00218269[b]
Height	I	29.92197143[a]	.17303373[a]	.02073407[a]	-.00039440[a]
	II	30.27811429[a]	.15501304[a]	.01475494[ab]	-.00021328[ab]
	III	29.7632250 [a]	.27567182[a]	-.00131502[b]	.00012943[b]
Length	I	20.12410000[a]	.02667897[a]	.0238447[a]	-.00036005[a]
	II	20.80710714[a]	-.02468026[a]	.02034528[ab]	-.00021778[ab]
	III	20.58618333[a]	.05576407[a]	.00987116[b]	-.00003531[b]
Paunch	I	25.25260000[a]	2.52959704[a]	-.07523142[a]	.00111939[a]
	II	25.70502143[a]	2.22937592[a]	-.06083554[a]	.00092651[a]
	III	26.26025000[a]	2.26583314[a]	-.07249244[a]	.00112432[a]

B_1 = Linear regression coefficient for week.
B_2 = Quadratic regression coefficient for week.
B_3 = Cubic regression coefficient for week.

[a] = Treatment I = 3 parts corn silage: 1 part concentrate (18% CP).
Treatment II = 1 part corn silage: 1 part Maltlage.
Treatment III = Corn silage ad libitum plus Maltlage fed separately at the rate of two lbs./100 lbs. of body weight.

Means of production variables in a column with different superscripts differ significantly ($P<.05$).

VITA

Bobby E. Jones was born in Mobile, Alabama on November 17, 1948. He graduated from Baldwin County High School, Bay Minette, Alabama in 1967. Following graduation from W. L. Yancey State Junior College in 1969, he enrolled at Auburn University and received a Bachelor of Science degree in Agriculture with a major in Animal Science in 1971.

He has been employed by the Alabama Cooperative Extension Service since 1971, presently assigned to Montgomery County, Alabama with major responsibilities for beef, dairy and forage crop production. When granted study leave by his employer in 1977, he entered graduate school at The University of Tennessee, majoring in Animal Science.

He is married to Gwendolyn White of Bay Minette, Alabama.

He has served as a member of the Alabama Army National Guard since 1971.