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To the Graduate Council:

I am submitting herewith a thesis written by Bobby Parkins entitled "A Study of Calf Raising Methods Using Reconstituted Skim Milk." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Dairying.

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A STUDY OF CALF RAISING METHODS USING RECONSTITUTED SKIM MILK

A THESIS

Submitted to
The Graduate Council
of
The University of Tennessee
in
Partial Fulfillment of the Requirements
for the degree of
Master of Science

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by

Bobby Parkins

March 1957

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CHAPTER I

INTRODUCTION

The successful raising of young dairy calves for use as herd replacements constitutes a very important role in dairy management. Dairy calves, especially the smaller breeds, are generally considered difficult to raise. The present day systems of marketing and the value of fresh whole and skim milk makes their use as calf feed almost prohibitive. From the standpoint of nutrition, a certain amount of milk or milk solids must be fed for normal calf growth. Conversely, only a limited amount of fresh whole milk can be fed if economical calf-raising methods are employed. The difficulty and cost of rearing young dairy calves has prompted many dairymen to prefer to purchase herd replacements. These problems have led to many investigations of more efficient and economical methods of raising young dairy calves.

For many years workers have been seeking to develop milk replacers that are efficient, economical, and practical for farm use. Many have been failures because the young calf does not have the ability to utilize fibrous or starchy ingredients found in many of the vegetable milk replacers. Other workers have been conducting experimental studies on hand feeding methods, limited milk feeding, methods of housing, and various other aspects of more efficient calf-raising methods. The importance of feeding minimum amounts of marketable whole milk and getting the calf to eat larger amounts of hay and

grain at an early age has been emphasized in recent investigations.

This study, consisting of three different experiments, was conducted to determine the effects of feeding various amounts of solids in reconstituted skim milk upon the growth, efficiency, and well being of the calf. By increasing the milk solids in low-fat milk replacers, it is possible to enrich them. Thus, it is important to know what effect milks of different solids content have on the calf. Experiment II was conducted to study the comparative effect of feeding calves the same amount of milk solids but in varying volumes of reconstituted milk. This experiment was needed to show whether volume of milk alone, with the same solids, would influence the appetite for hay and grain, growth, gastrointestinal disorders, and well being of the calf in a significant manner. Experiment III was conducted to compare an extracted-fat milk replacement with one supplemented with 1% fat, and inside pens versus outside pens. The results of these studies should contribute some information on more efficient and economical calf-raising methods.

CHAPTER II

REVIEW OF LITERATURE

Introduction. Since the earliest studies in calf nutrition, workers have been striving to formulate a method to replace whole milk efficiently in the ration of young dairy calves. The development of milk substitutes to meet the calf's nutritive requirements has resulted in satisfactory and economical methods of raising young calves. Dried skim milk powder is an important feed in this work. Supplementation of milk replacers with vitamins, minerals, fats, antibiotics, and other substances has improved their efficiency. This review of the technical literature concerning calf feeding summarizes some of the important developments in this field.

Development of milk substitutes. Studies in 1909 by Savage and Tailby (83) showed that whole milk could be replaced satisfactorily by skim milk, skim milk powder, and a calf meal containing oat meal, wheat meal, and condensed milk to furnish 15-19% protein. Skim milk and skim milk powder gave better results than the calf meal. Since that time numerous milk replacement formulas have been tested. Williams and Knodt (101, 102) though not the earliest, were among the foremost workers in this investigation. After comparing many animal and vegetable ingredients in milk replacement formulas, they found that formulas containing at least 50% dried skim milk consistently produced better growth results than formulas containing less than

this amount. Inclusion of 40% ground raw soybeans was lethal to all calves at 29 to 58 days of age. Post-mortem examination revealed enlarged gall bladders, kidney discoloration, distended urinary bladder, and excess fluid over the entire body. Muscular weakness and lack of coordination was also noted before death. Inclusion of 20% beet pulp resulted in poor growth, hair loss, weakness, lacrimation and papilledema. Wallace, et al. (96) reported that milk replacers containing 20% high-fat soya flour or dried beet pulp, or 60% dried whey resulted in lower growth rates and more digestive disturbances than the other mixtures studied. Holstein calves made normal growth when large amounts of dried skim milk were included in the replacer. The toxicity of cottonseed meal containing .02% to .68% gossypol to young calves has been shown by Leighton, et al. (47). Holstein and Jersey calves were fed grain rations containing 90% cottonseed meal from birth to six months of age. Four Holstein calves died at approximately 100 days of age. Jersey calves, the same age and consuming more gossypol per 100 lbs. body weight than the Holsteins, showed no toxic effects. Post-mortem examination revealed internal pathological changes including degeneration of the heart. Jarvis and Waugh (34) included 3.5% hydrogenated and nonhydrogenated cottonseed oil in a synthetic milk diet fed to grade, purebred, and crossbred calves. Calves fed the hydrogenated cottonseed oil survived, but those fed the nonhydrogenated oil grew very poorly and died within a few weeks. Gullickson, et al. (27) found that calves fed fats of

animal origin made significantly greater gains than those fed vegetable oils. The oils were homogenized into skim milk to make 3.5% fat. Average daily gains were .40, .31, and .32 lb. for calves fed corn oil, cottonseed oil, and soybean oil, respectively. The calves were unthrifty, listless, and emaciated. Some were saved only by changing to whole milk. Average daily gains for calves receiving butter oil, tallow, and lard were 1.22, 1.24, and 1.17 lb., respectively. Hopper, et al. (30) found that when lard and butyrated lard were emulsified and mixed with reconstituted skim milk to provide 4% fat, average daily gains to eight weeks were 1.90 and 2.16 lb., respectively. It appears from the results of these studies that dried skim milk is more satisfactory as a milk replacer than the other known feeds.

Skim milk as a milk substitute. Savage and Tailby (83) demonstrated the efficiency of skim milk as a milk substitute in a feeding trial using skim milk, skim milk powder, and two different calf meals. Average daily gains were 1.53, 1.23, 1.10, and .87 lb., respectively. Hay consumption for these groups averaged 360.6, 370.4, 324.8, and 307.9 lb., respectively, to five months. The larger gains of the skim milk-fed calves can undoubtedly be partly attributed to the greater amount of hay consumption than the calf meal-fed calves. These workers concluded that skim milk, though not equal to whole milk in nutritional value, was superior to all other feeds. They advocated that the best substitute for fresh skim milk was one lb. dried skim milk powder reconstituted in nine lb. of water for obtaining

best growth results with young dairy calves. The gross chemical analysis of skim milk shows that it contains all of the proteins, sugar, minerals, and water-soluble vitamins found in whole milk (42). It is lacking the fat-soluble vitamins and fat. Perhaps one of the greater assets of skim milk is milk protein. The use of milk protein (casein, lactalbumen, and globulin) in the calf's ration is very important. It has the highest feeding value of any protein in animal feeding. Spitzer and Carr (91) found that proteins derived from different sources vary in quantity and kind of amino acids they yield. In an experiment using Holstein calves, the efficiency of liquid blood protein, vegetable protein, and milk protein was compared in calf feeding trials. Average daily gains were 1.32, 1.03, and 1.28 lb., respectively. The percentage of nitrogen retained by the calves for absorption was 24.4%, 31.9% and 42.8%, respectively. These results indicate that proteins derived from animal origin are principle factors in promoting growth, and that the nitrogen in the skim milk ration was absorbed to the greatest advantage. Though liquid blood protein and milk protein were almost equal in efficiency, the practicability of using liquid blood is almost precluded due to its rapid deterioration. These workers found that dried blood had no more effect in stimulating metabolism than feed composed of vegetable protein. Miyawaki, et al. (64) ran a peptic digestion trial and found that the drying of milk does not impair the digestibility of milk protein. McCollum, et al. (61, 62) demonstrated the superiority of animal

protein over vegetable protein in an experiment with swine. This study showed that the pig was able to retain only 24% corn protein, 25% oat protein, but 63% skim milk protein for construction of body tissue.

Milk is highly digestible and very satisfactory as a feed. It is an almost perfect emulsion. Its solids, except fat, remain in molecular dispersion until acted upon by some internal or external influence (66). Another important value of milk in digestion is the formation of a friable, easily liquified curd in the stomach. After the whey has left the abomasum, the curd usually remains and supplies nutrients as it is acted upon by gastric juices. Mortenson, et al. (66) indicated that the digestibility of milk was enhanced when heated due to lowered curd tension which permitted the curd to break up more easily.

Reconstituted skim milk as a milk substitute. As early as 1919, Larsen and White (45) found that a good quality starter could be made by using reconstructed skim milk as a substitute for normal skim milk. Williams and Bechdel (100) and Wiese, et al. (99) tried feeding skim milk powder and other synthetic rations in a dry form. They found that liquid milk replacers proved better for calves than solid diets fed dry or as a slurry. Staples and Seath (92) and Savage, et al. (84) expressed the opinion that skim milk powder reconstituted with water is more palatable and better for young calves than the dry powder form.

Numerous investigators (16, 38, 42, 48, 79, 83) have obtained satisfactory results utilizing reconstituted skim milk in the ration of young dairy calves. Krauss and Crawford (42) conducted a trial using Holstein calves to determine the effects of feeding whole milk, farm separated skim milk, and reconstituted skim milk. Grain (starter) was fed at the maximum rate of three pounds per day and hay was fed ad lib. The average daily gains of the groups fed whole milk, fresh skim milk, and reconstituted skim milk were 1.65, 1.64, and 1.86 lb., respectively. Though all groups made satisfactory gains in weight and skeletal growth, the calves getting the reconstituted skim milk made the most rapid gains. These workers advocated that high grade skim milk powder when mixed with water at the ratio of 1:9 is practically equal in feeding value to ordinary fresh skim milk. A comparison of the chemical constituents of these milks is shown in Table 1. Krauss and Crawford (42) conducted an experiment to compare the roller process with the spray process dried milk powders for calf feeding. Though both milks were satisfactory, they obtained better results with the roller processed powder. Rupel (79) obtained average daily gains of 1.69 lb. with Holstein calves fed reconstituted skim milk. Knodt, et al. (38) obtained an average daily gain of 1.42 lb. for all Holstein calves at the age of six months when fed reconstituted skim milk for 35 days. Skim milk powder was included in the grain mixture after weaning. Berry (11) conducted an experiment to compare nurse cow feeding and hand feeding of whole milk, reconstituted skim

Table 1

Average chemical composition of whole milk, fresh skim milk, reconstituted skim milk, and skim milk powder[a]

Constituent	Whole milk	Skim milk	Skim milk powder (Spray dried)	Reconstituted skim milk (1:9)
Water	87.10	90.50	3.00	90.30
Fat	3.90	.10	1.20	.12
Protein	3.40	3.57	37.70	3.77
Sugar	4.75	4.95	49.90	4.99
Ash	.75	.78	8.20	.82

[a]Krauss, W. E. and Crawford, C. H. Powdered Skim Milk as a Feed for Dairy Calves. Ohio Agr. Expt. Sta., Bi.-Mo. Bull. IV, 137. 1929.

milk, and a calf meal. The calves raised on reconstituted skim milk had the largest daily gain of 1.51 lb. followed by the calf meal (1.39 lb.), nurse cow (1.36 lb.), and whole milk group (1.24 lb.), to 42 days. The poorer results of the calves fed whole milk was probably due to the fact that limited amounts were fed. Berry successfully fed the reconstituted skim milk cold. The change from warm milk to cold was gradual as the calves were changed from whole milk to reconstituted skim milk.

The economy of using reconstituted skim milk has been demonstrated recently by Cleveland and Ross (16). These workers successfully raised Guernsey bull calves by feeding reconstituted skim milk supplemented with vitamins A and D and aureomycin. The whole milk feed cost was $15.02, while the reconstituted skim milk was only $9.74. At the end of the 42 day milk feeding trial, the reconstituted skim milk group slightly exceeded the whole milk group in total weight gain, weighing 113 and 109 lb., respectively. However, at the end of 13 weeks, the calves averaged 146 and 154 lb. body weight, respectively, in favor of the whole milk group. Both groups were normal or above in body weight.

Possible deficiencies of skim milk. Though skim milk contains all of the proteins, sugar, minerals, and water-soluble vitamins found in whole milk, it is lacking in fat and in the fat-soluble vitamins. Also all normal milks are deficient in iron, copper, and manganese. Krauss (41) prevented nutritional anemia in rats fed an

exclusive whole milk diet by the addition of small amounts of copper and iron. Knoop and Krauss (40) reported that Holstein calves on a sole milk diet developed nutritional anemia which could be prevented by supplementing iron and copper. Sato and Murata (82) showed that though colostrum milk is high in manganese, normal milks contain little of this element. Herman (29) fed milk alone to dairy calves and normal growth to six months was attained, but the calves then developed anorexia, lost weight, and died at 11 to 12 months of age. He supplemented iron, copper, manganese, and cod liver oil to another group, and they continued growing longer than the calves on the sole milk diet but survived only a month longer. Duncan, et al. (22) found that a sole milk diet produced tetanic convlusions in calves as early as 31 days. Though calcium and phosphorous requirements are maintained by increasing milk intake, magnesium requirements are not met by milk alone. Magnesium tetany occurred on a ration high in fat as well as one low in fat. Wing, et al. (105) in an attempt to detect mineral deficiencies in the blood constituents of calves fed low fat diets of milk observed that blood levels of calcium, phosphate, and hemoglobin were normal.

Since the fat-soluble vitamins, A, D, E, and K are contained in the milk fat, these vitamins are not present in skim milk. Vitamins A and D seem to warrant more consideration as supplements in the diets of young calves than vitamins E or K. Several workers (14, 17, 67) have demonstrated that vitamin A deficiency of calves may result in

nightblindness, keratitis, susceptibility to infection, diarrhea, and emaciation. Studies by Huffman (32) have shown that calves fed a vitamin D deficient diet develop rickets.

The absence of appreciable milk fat in skim milk and its effect on the calf's growth and well-being has received attention by many investigators (20, 43, 44). This fact coupled with the other known deficiencies of skim milk has led investigators to propose certain supplements for calves fed skim milk such as these described below.

Supplements proposed for skim milk--minerals. The use of mineral supplements in feeding young dairy calves has received attention from many investigators (13, 22, 29, 32, 65, 67). Though most of these studies have failed to evaluate conclusively the justification for feeding mineral supplements to calves on a normal diet, the need for certain essential elements has been established. Among the essential elements needed by growing calves are calcium and phosphorous for skeletal growth (31). Trace minerals are also needed in very small amounts and are essential for good health. They include iron, copper, manganese, iodine, cobalt, sulphur, magnesium, zinc and potassium (13). A need for a small amount of salt (sodium chloride) has been demonstrated by Sheehy (87). He reported that a salt deficiency in calves is reflected in unthrifty condition and harsh hair coat. Iron and copper are necessary for formation of hemoglobin (41, 59). Jones, et al. (35) supplemented a calf ration with iron, copper, manganese, cobalt,

zinc, and iodine, while another ration consisted of these trace minerals plus calcium, phosphorous, and manganese, certain vitamins, and aureomycin. These quantities supplied approximately 2.5 times the amount of iron, copper, and manganese as fed by Herman (29) to prevent anemia in calves on milk alone. Although the calves on both of the supplements grew at significantly faster rates than unsupplemented calves on a basal ration, the differences in feed consumption and efficiency of gain were not statistically significant.

Morrison (65) advocates that the mineral needs of calves are generally met, with the exception of salt, when calves are fed milk, grain, and hay in adequate amounts. Most of the minerals needed by calves are well supplied by feed crops, especially roughage, when grown on fertile soil (32). Lindsey, et al. (49) have shown that good quality hay from mixed grasses will supply enough calcium for satisfactory growth and that legume or legume-grass hay will supply excess calcium. Roughages are adequate in magnesium, copper and iron. In the opinion of Bohstedt (13), phosphorous is the mineral most likely to be deficient. He noted the importance of feeding grain, particularly protein concentrates to young calves to raise the phosphorous level. Calcium deficiencies are almost precluded if a considerable portion of the roughage fed is legumes.

Vitamin supplements for calves. The dietary need for certain essential vitamins in the ration of the dairy calf has long been recognized (17, 32, 65, 72) but the value of excess vitamin

supplementation in most instances has remained questionable. Several investigators (12, 35) have found that supplementing with vitamins does not increase growth of calves above that obtained when colostrum and normal rations are fed. Phillips and Lundquist (74) reported that vitamin A and certain members of the B-vitamin complex were effective in preventing and curing nutritional scours when adequately supplied in the calf's diet. In a later study these workers (52) reported that supplementary feeding of vitamins A, C, D, and nicotinic acid was effective in reducing incidence of diarrhea and death loss in calves. Subsequent investigations have failed to confirm these reports supporting vitamin supplementation (23, 68, 69, 71, 87). Norton, et al. (71) conducted a study involving 60 heifer calves of various breeds and showed that supplementing a normal diet (whole milk) with capsules containing vitamins A, D, E, C and several B-complex vitamins, failed to reduce incidence or severity of scours or to induce extra growth. Nelson and Cunningham (68) fed shark-liver oil as a source of vitamin A and found that the calves receiving the supplement had no more vitamin A and less carotene in their blood plasma than the control calves. They believed that the vitamin A supplement may have prevented proper utilization of carotene from the alfalfa hay. These findings were in agreement with those of Skaggs (89) who conducted a similar experiment. The supplemented calves consumed more feed but made only slightly faster growth than the calves in the control group. This treatment was ineffective against scours.

Erb, et al. (23) sought to determine whether or not massive doses of vitamins A and D administered at birth resulted in beneficial response in dairy calves. Though the blood plasma levels were higher in the experimental calves, the supplemental feeding of 125,000 I. U. vitamin A, 25,000 I. U. vitamin D, and 250 mg. of niacin at birth was of no benefit in reducing colds, pneumonia, scours, and death losses under a wide variety of conditions.

The blood picture of the newborn calf shows low levels of vitamin A, and needs for vitamin D and certain of the B-vitamins (52, 54). Since colostrum is high in vitamin A, it should be fed during the first few days after birth as a source of vitamin A and other essential factors. Several investigators (67) are of the opinion that of the many vitamins, only A and D have been shown to have any practical significance in feeding calves, though others are needed and probably furnished under practical feeding conditions. If the calf is taken off milk at an early age, or if skim milk is substituted for whole milk, vitamin A supplement may be desirable. Boyer, et al. (14) demonstrated that calves on skim milk during early weeks have a low vitamin A blood plasma level. Whole milk will generally supply adequate amounts of vitamin A. A vitamin D supplement usually provides good insurance when calves are kept in enclosed barns or are too young to consume ample hay. A few drops of fish liver oil added to the daily milk ration have been recommended as practical sources of A and D.

The importance of hay in the diet of the young calf cannot be over-emphasized. Green, sun-cured, high quality hay consumed in amounts of two to three pounds daily, prevents any vitamin deficiencies. Such hay is high in vitamins A and D and contains an adequate content of the B-complex vitamins (65). Legume hay has been shown to be more beneficial to calves than grass hay (92). Though milk contains some B-vitamins, they are later provided by rumen synthesis (54), which makes the calf less dependent on milk for water-soluble vitamins. Silage feeding to young calves as a source of carotene and other constituents has been suggested. Some experimental work indicates that it may cause digestive trouble (92). Other trials (75) indicate that good grass silage can be used as a sole source of roughage for young calves. Holstein calves were fed silage as a sole source of roughage and as a supplement to hay. The calves received whole milk for six weeks. Grain was fed at a five lb. maximum per day and hay and silage ad lib. At the end of the 16-week trial, there was no statistically significant difference between treatments. Branaman and Davis (15) reported that Hereford calves fed corn silage gave very good results which were very comparable to hay-fed calves. No detrimental effects were mentioned. The use of silage in a calf-raising program in some instances would therefore seem feasible since the calf is evidently able to digest it without bad effects. Hay is usually the preferred roughage for the first four weeks of the calf's life.

Fat supplements for calves. The value of supplementing whole milk to a skim milk ration for young calves has not been determined. Although the dietary need for fat has been demonstrated (3, 20, 43, 44) the amount required for young calves to make normal gains has not been determined. Several investigators (72, 105) have shown very satisfactory results when feeding calves a low-fat diet. Since fat comprises approximately one-fourth of the total solids of milk, one might suppose that a considerable amount of fat is necessary in the diet of the calf. However, the U.S.D.A. workers (18) reported that the principle feeding value of milk fat is the fat-soluble vitamins it contains, mainly vitamin A which can be supplied by various oils and roughages. They believed that energy supplied by fat can be more economically supplied by carbohydrates of good quality.

Cunningham and Loosli (20) showed that total lipids in the plasma of all calves were low at one day of age but rose in those calves receiving sources of fat as time progressed. These workers suggested that body storage of essential fatty acids at birth may be adequate to last a calf several months, but dietary fat may be necessary during the first few days. Arrington and Reaves (3) compared the levels of blood lipids found in calves fed whole milk with those fed a reconstituted skim milk diet. They reported that the blood lipid levels were lower in calves on the low-fat diet but increased with intakes of grain and hay. Wing, et al. (105) reported similar findings. Allen, et al. (2) fed young calves colostrum and whole milk

and produced marked increases in the plasma levels of linoleic and linolenic acids and lesser increases in arachidonic acid. During the four days of this study, total blood plasma fatty acids increased four-fold. Though the fatty acids appear to be important to young dairy calves (33, 85), their exact role has not been specified (44). Schantz, et al. (85) sought to reveal some information regarding the nutritive roles of the fatty acid fractions of butterfat. The fatty acids of butterfat were separated into volatile acids, saturated, and unsaturated acids and fed to weanling rats in corn oil in approximately the compositions found in butter. They found the saturated fraction with corn oil to be slightly superior to butterfat and concluded that the fatty acids that are responsible for superior growth of young rats lie in the saturated fraction of butterfat. In a recent study, Cunningham and Loosli (20) showed that a synthetic milk containing 2% hydrogenated coconut oil prevented the appearance of fat deficiency symptoms. The calves that were fed only a fat-free synthetic milk diet developed leg weakness and died within one to five weeks. On the basis of these data, these workers suggested that the early death of the fat deficient calves was not the result of an essential fatty acid deficiency.

Although attempts have been made from early times to substitute products rich in fat for milk fat (84), butterfat is still regarded superior in nutritive value to all other fats and oils used in milk replacements. Animal fats have given more satisfactory results than

vegetable fats (27, 30). Jacobson and Cannon (33) found that vegetable fats could be greatly improved by hydrogenation. Calves fed 3% hydrogenated soybean oil grew well but those receiving 3% nonhydrogenated soybean oil grew poorly. These findings are in agreement with Jarvis and Waugh (34) who reported that hydrogenation allowed the calves to tolerate cottonseed oil in contrast to the nonhydrogenated form which caused detrimental effects and death.

In an effort to determine the lipid requirement of the young dairy calf, Lambert, et al. (43,44) fed lipid-free synthetic milk containing vitamin-free casein, lactose, minerals and vitamins. Another group of calves received a similar diet plus lipids. The results of this study showed that the lipid-free diet reduced the growth rate considerably. The mean weight gain to 56 days was 11 lb. for the lipid-free diet and 30 lb. for the lipid-supplemented diet. The lipid-free group developed rough hair coats, dandruff, partial alopecia, and diarrhea. Their blood lipids and blood plasma fatty acids were also very low. Inclusion of fat in their diet caused rapid recovery in most instances. Work by Arrington and Reaves (3) indicated that certain low fat diets may affect the development of calves. They placed calves on a reconstituted skim milk diet fortified with vitamins A and D after three days of age. One Holstein and four of six Jersey calves died within two to four weeks following the change to reconstituted skim milk. On the basis of their poor results, they believed the calves could not stand the abrupt change of milk or possibly did

not have adequate fat reserve to carry them over until consuming feed. These findings are not in agreement with reports by other workers who have made similar studies. Gullickson, et al. (27) suggest that only an extremely limited amount of fat is needed in the calf's ration. These workers fed a very fat-poor diet consisting of skim milk (.01 to .02% fat) along with a concentrate mixture of ground molasses, beet pulp, dry skim milk, starch, and cerelose. The calves received colostrum only two or three days and were changed to the experimental milks. No hay was fed, but the calves received cod liver oil. Average daily gains of 1.07 lb. were made by the calves on this low-fat diet. The calves were healthy and thrifty, but their hair coats were rough. Wing and Jacobson (105) have shown very satisfactory results with calves fed low fat rations. Other workers (16, 38, 42, 48, 79, 83) have reported similar findings with successful rearing of calves on low fat diets.

Enzymes and other products as supplements for calves. Williams and Knodt (103) made a study to determine the effects of supplementing powdered skim milk with certain enzymes and carbohydrate material. Enzyme preparations of papain and pancreatin were fed to one group and another group received dextrose, maltose, and dextrin supplementations. The effects of the enzymes in the skim milk powder were deleterious to growth and feed consumption. Dehydration and intestinal degeneration was noted, and two calves died. The calves receiving the carbohydrate supplements produced sub-normal growth

results.

Antibiotics in calf feeding. The use of antibiotic supplements in the rations of young dairy calves has created widespread interest. The principle interest concerning antibiotics for young calves has been their effect on growth, feed consumption and efficiency, and diarrhea. Though several forms of antibiotic supplements have been reported, Lassiter (46) points out in a review that aureomycin (chlortetracycline) and terramycin (oxytetracycline) are the only ones which have been studied sufficiently to warrant valid conclusions. Considerable more research has been conducted with aureomycin than terramycin. Other antibiotics which have been used widely in animal feeds are penicillin, bacitracin, and streptomycin.

Amount of antibiotics to feed calves. Bartley, et al. (9) reported an extensive trial comparing two levels of aureomycin supplementation, three and nine grams of aureomycin supplement (5 mg. aureomycin per gram) per 100 lb. of body weight daily. This trial was conducted from one week to 22 weeks of age. The percentage gain of body weight for the control group, three gram-fed group, and nine gram group was 356, 410, and 400%, respectively. In an earlier report Bartley (5) had obtained good results feeding an APF concentrate equivalent to 15 mgs. of aureomycin per 100 lb. of body weight. In this study the APF fed calves gained 71.1% more than the controls. Incidence of scours was much lower in the aureomycin fed group.

The amount of antibiotic which must be fed to obtain a maximum growth response and to have a significant effect on incidence of scours is difficult to determine due to the inconsistency of methods of feeding antibiotics. Bartley, et al. (4) in their 1954 study fed calves 15 and 45 mgs. of aureomycin per 100 lb. of body weight daily from birth to 25 weeks of age. The 45 mg. level was more effective than the 15 mg. level in controlling infection. However, during one through 25 weeks of age, average growth rate was increased significantly by the 15 mg. level of aureomycin feeding. Another statistically significant increase resulted when the level of aureomycin was increased to 45 mg., but the growth rate was not in proportion to the increased aureomycin. In the Holstein breed, the 45 mg. level of feeding was effective in increased growth rate up to ten weeks of age, whereas the 15 mg. level-fed calves responded from birth to 25 weeks of age. The Jersey calves responded to both levels from birth to 25 weeks of age. The greatest response from aureomycin feeding was obtained the first five weeks of the trial. Bloom and Knodt (12) received the greatest growth effect during the first four weeks when feeding one gram of aureomycin per cwt. of milk replacer. These workers also reported a greater consumption of calf starter and increased firmness of feces by the aureomycin-fed calves. In another experiment Bartley, et al. (6) fed 45 mg. and 90 mg. of crystalline aureomycin from birth to 25 weeks of age. The 45 mg. level produced significantly greater gains than the 90 mg. level up to 12 weeks of

age. Both levels reduced the incidence of infections. On the basis of this experiment, these workers proposed that the optimum level of aureomycin feeding should be 45 mg. per 100 lb. body weight for the first 12 weeks and 15 mg. from 13 to 25 weeks of age.

Knodt and Ross (39) conducted a trial testing various levels of aureomycin in milk replacement feeds. They fed levels of two, four, six, and ten grams of aureomycin per cwt. of milk replacer. All levels fed improved the growth rate of the calves at eight and 12 weeks of age. The two-gram level improved growth more than any other level at eight weeks of age, and they concluded that this level of feeding aureomycin per cwt. of milk replacer was adequate to produce a maximum growth response. Lassiter (46) concluded in his review that milk replacement feeds should contain about 20 mg. of antibiotic per lb. of feed.

Effects of antibiotics on growth and well-being of calves. Bartley, et al. (7) compared the effects of streptomycin and aureomycin on the growth and well-being of young dairy calves. The results of this study indicated that both aureomycin and streptomycin increased feed efficiency with 30 mg. of aureomycin fed per 100 lb. calf weight possibly more effective than 30 or 90 mg. of streptomycin. Aureomycin also appeared to be more effective than streptomycin in controlling infections. Galgan (25) fed terramycin at the rate of 25 mg. per 100 lb. of body weight and received improved gain exceeding the control calves gains for the first 28 days.

Swanson, et al. (95) conducted a study to determine how much growth response could be secured with and without aureomycin when calves were fed liberally on milk and a milk replacement mix and allowed a liberal starter ration along with good quality hay. Aureomycin was stirred into milk at the rate of 50 mg. per feed for Holstein and 30 mg. for Jerseys. The milk replacer contained 50 mg. of aureomycin per lb. and the calf starter contained 75 mg. aureomycin per lb. The results of this study showed that the average gains of the aureomycin-fed calves exceeded the controls during the milk feeding period as well as after weaning. These differences were not statistically significant. Incidence of scours apparently was not reduced by the presence of aureomycin; nor did it have any effect in preventing death since four of the aureomycin-fed calves died from pneumonia or undetected causes between weaning and 120 days of age. These results indicated that growth stimulation due to aureomycin supplementation will not be attained consistently when calves are on a liberal milk feeding regime.

Effect of antibiotics on age of calves. The effect of the calf's age upon growth response to antibiotic supplementation is important. Rusoff, et al. (80) observed that aureomycin-fed calves began to gain in weight faster than control calves at five weeks of age. Breed differences were also noted. Aureomycin produced a 25% growth increase in Jersey calves but only 18% in Holsteins. These differences were not statistically significant. Loosli (51), in an

antibiotic study with calves fed a milk replacement ration early in life supplemented with hay and calf starter, found that the supplemented calves made gains over the controls for the first eight weeks. Growth data to 16 weeks of age indicated no further growth improvement over the controls.

Mode of action of antibiotics. The mode of action of antibiotics in producing growth response in young calves has been a matter of speculation and controversy (28, 46, 51, 81). Bartley, et al. (8) conducted a study to determine the effect of administering aureomycin on the digestibility of various rations. There were no marked or consistent effects of aureomycin on any of the rations except crude fiber. Aureomycin appeared to have reduced digestibility of crude fiber by 13-week-old calves fed milk and oats and by nine-week-old calves fed milk and alfalfa hay but did not reduce digestibility of crude fiber by 13-week-old calves fed milk and alfalfa hay. These findings indicated that the beneficial effects of aureomycin on growth and feed efficiency were not due to improvements in digestibility of feeds. Rusoff (81) attributes the antibiotic growth effects to stimulation of the pituitary gland to produce more growth hormone. Hibbs (28) suggested the mode of antibiotics is one of an alteration in energy metabolism possibly involving the microflora of the rumen. Radisson, et al. (77) indicated from the results of their study that the effect of antibiotics on growth may be due to their effect on the physiology of bacteria in making them more susceptible to the body

defense mechanisms. Though oral administration of aureomycin did not materially affect phagocytic activity of the leucocytes in the blood of calves, the differences between bacteria isolated from feces of aureomycin-fed calves and those receiving no aureomycin were statistically significant. Leucocytes from young calves up to two weeks of age had a lower phagocytic activity than leucocytes from older calves. These findings suggest that antibiotics may contribute a greater part to body defense and thus induce growth-response during the early life of the calf when it is most susceptible to intestinal disturbances. Loosli (51) proposed that antibiotic calves grow faster because of an increased appetite. More research data is needed to determine definitely how antibiotics produce growth response in young calves.

Rumen development and activity. The gastrointestinal system of the newborn calf has been said to resemble that of a dog in the manner it digests food (84). The rumen is small with the abomasum being twice as large as the rumen and reticulum combined (21). Therefore, during the early days of life, the calf is dependent upon milk since it is unable to handle sufficient quantities of hay or grain. The first few days of the calf's life are very important from the standpoint of digestive disturbances and diet intakes. The ultimate effects of the diet are also very important in stimulating early transformation of the gastrointestinal tract to an adult-like structure capable of handling feed. Becker, et al. (10) showed that

the rumen constituted approximately 30 to 36% of the total stomach weight from the sixth month of fetal life. Early rumen development is indicated by Marshall, et al. (53) who reported that the weight and volume of rumen tissue and weight of fresh contents exceeded that of the abomasum between seven and 30 days. These workers also found grass, leaves, hay, bedding, and sand in the stomach compartments during early life. Kesler, et al. (37) observed the stomach and intestinal contents of male Holstein calves slaughtered from eight days to 16 weeks of age. They found that between the ages of 32 days and six weeks, the rumen contents changed and became more like those of an adult rumen. It also appeared that rumination had begun by that age. McCarthy and Kesler (58, 59) found an indication of a change of blood levels of metabolites from predominantly glucose to an increased level of short-chained fatty acids and a decreased level of glucose. At one week of age, the rumen fluid was able to digest cellulose. These workers observed that calves fed milk replacements had higher levels of fatty acids in their blood and rumen juice and that cellulose digestion was greater in this group at six weeks of age than the groups fed whole milk diets. Therefore, they concluded that feeding milk replacements appeared to affect the rate of transition to adult-like levels of metabolites.

Warner, et al. (97) suggested that the relative size of the stomach compartments is determined to some extent by the nature of the diet consumed. In feeding milk and hay versus mineralized milk,

and dry calf starter, they noted that the milk and hay diet produced larger reticulo-rumen volumes and that hay fed per se stretches the organs. Other reports (72) indicated that hay ingestion by young calves stimulated early development of rumen function and appeared to have a favorable physiologic effect.

Favorable reports by several investigators indicate that the use of low-fat milks in the calf's diet tends to induce earlier feed consumption and thus stimulate development of the stomach compartments. Knodt, et al. (38) found that calves on a reconstituted skim milk diet could consume up to five pounds of concentrates daily without ill effects. However, Morrison (65) advocates if calves eat more than four pounds of concentrate daily, they will not eat as much hay as calves consuming smaller amounts of grain. McCandlish (56, 57) reported that grain consumption reached its peak when calves were taken off whole milk and placed entirely on skim milk. Consumption of grain was greater during the first ten days than hay consumption. Mead, et al. (63) have demonstrated that calves could be reared with normal growth on a ration devoid of roughage, provided alfalfa ash and cod liver oil are supplied. The need for roughage has been illustrated by numerous workers (84). Bulk helps distend the digestive tract and renders proper digestion possible (55).

System of feeding. Much interest has been manifested in the system of feeding calves milk and the effect they have on influencing the course followed by the milk through the esophageal groove. Since

it is commonly believed that the transmission of part of the milk to the rumen causes undesirable fermentation and digestive disturbances, Wise, et al. (106, 107) conducted studies to determine methods that minimize milk passage into the rumenoreticular cavity. The results of this work show that the elevation of head and neck is not an important factor affecting such passage to the rumen but that the system of feeding was an important factor. The frequency of milk entrance into the rumen using nipple pails was significantly smaller than when using open pails. Ingestion of milk through a nipple has also been found to increase lipolytic activity (109). Pounden, et al. (76) indicated from their study of rumen contents observed in young calves that the presence of milk in the rumen of very young calves is natural. These workers placed milk into the rumen of a young calf by stomach tube and noted that it was quickly moved out without harmful effects. Kesler, et al. (36) conducted a study with Holstein bull calves to determine whether the method of hand-feeding had any appreciable effect on the growth and health of the young calf. In three trials, a comparison of open pail, nipple pail, and nipple bottle feeding indicated that the method of feeding had little or no effect on scouring. Each calf was fed approximately 10 lb. of herd milk daily for 42 days. Calves fed milk from an open pail placed on the floor gained at a faster rate than those fed from elevated pails or nipple pails. The pail-fed calves consumed their milk much more rapidly (52 seconds) than those nipple-fed (three minutes, 49 seconds).

Combined data for the trials showed that the 24 pail-fed calves made average total gains at weaning of 41.0 lb. compared to 35.2 lb. gain for the 24 nipple-fed calves. Pail-fed calves ate 4.3 lb. more starter and 1.1 lb. more hay than the nipple-fed calves. These workers concluded that under the conditions of that study, nipple feeding was not superior to pail feeding.

Effect of level of feeding on gastrointestinal system. The amount or volume of milk to feed is a very important consideration in efficient calf management. Though Morrison (65) and other workers warn against the effects of feeding the young calf large volumes of milk, only limited research on the effects of over-feeding has been reported. Wise, et al. (108) conducted an experiment with Holstein calves to study the changes in whole milk "sham-fed" at the rate of 25 lb. in five successive five lb. increments. As successive increments were consumed, the volume of saliva decreased along with a decrease in the alteration of the milk including lipolysis and coagulation. The results of this study indicate that large volumes of milk may cause digestive disturbances due to incomplete alteration or breakdown of the milk. Resultant effects may be only partial digestion and diarrhea, but conclusive evidence of the effects of over-feeding is lacking.

The usual allowance for hand feeding is 10% of the calf's body weight (38, 65, 92), but more recent investigations have shown that a higher rate of feeding milk to calves results in greater gains. Williamson (104) fed Holstein calves at the rate of 15% of body weight

for 44 days and obtained calves that averaged 21 lb. heavier at four months than those fed at 10% of body weight for 63 days. McCullough, et al. (60) fed milk at the rate of 10, 14, and 18% of body weight, and the average daily gains for four months for these groups, respectively, were 1.26, 1.42, and 1.50 lb. These differences were statistically significant ($< .01$) for the first six weeks between the 10 and 14% and the 10 and 18% group but significant ($< .05$) only between the 10 and 18% group for the entire four-month period. These findings are in agreement with those of Woodard (110) who compared skim milk fed at the rate of one-seventh, one-sixth and one-fifth of body weight and ad lib. Gains increased with the quantity of milk fed. The ad lib. group made 50% larger gains than the one-seventh group and at various times up to 70 days consumed more than 40 lb. of skim milk per day without bad results. Krauss and Crawford (42) fed Holstein calves at the rate of 16 lb. whole milk, 24 lb. fresh skim milk, and 24 lb. of reconstituted skim milk per day for 60 days. Average daily gains were 1.65, 1.64, and 1.86 lb., respectively. No detrimental effects were reported. Hopper, et al. (30), Gardner, et al. (26) and Swanson (94) reported satisfactory results when Holstein, Guernsey and Jersey calves were fed milks ad lib. Approximately 18 to 20 lb. of milk were consumed per day per calf. Swanson used the nurse-cow method of feeding. The other workers used nipple pails. No digestive troubles were reported. These data indicate that over-feeding may not be the common cause of scours.

Amount of solids to feed calves. Though general recommendations for total solids fed in reconstituted skim milk are one lb. to nine parts of water (11, 42), present data indicate that young calves can tolerate larger amounts of solids without detrimental effects. This has been demonstrated by Gardner (26) in a study that showed ad lib. feeding with nipple pails resulted in calves consuming 15-18 lb. (13% solids) daily per 100 lb. of body weight. Allen (1) reported an experiment which further substantiates the hypothesis that added nutritive value of high solids reflect greater calf gains. He compared the effects of feeding whole milk and skim milk for nine weeks versus fresh and/or frozen colostrum for nine weeks. One group of calves received colostrum the first ten days and were then changed to herd milk which was fed until the fifth week when skim milk was substituted for the herd milk. The other group received colostrum for the entire nine-week trial. Average gains for the first 62 days were 54.2 and 60.3 lb., respectively. Milk fed per lb. of gain averaged two lb. less for the colostrum-fed group. There was no serious difficulty due to digestive upsets. This was interesting since the total solids content of average colostrum milk is 25.5% (88). Wing, et al. (105) fed solids in low-fat milk at the level of 18% and received very satisfactory results.

Change from herd milk to milk replacers. Another important factor in the feeding of milk replacements to young calves is the change from colostrum or herd milk to the milk replacer without

causing digestive disturbances. Frequently when the change is made gradually, some looseness of the bowels occurs (48). Various methods have been employed in changing from whole milk to the milk replacer (11, 27, 101, 104). These methods ranged from a gradual change at three to four weeks of age to an abrupt change at six days. All of these methods apparently were satisfactory from the standpoint of the calf's digestive apparatus. Leighton, et al. (48) changed abruptly to reconstituted milks (skim milk powder and whey) after five days of colostrum feeding. The calves responded without any apparent detrimental effects. It appears from the results of these trials that a gradual change to the milk replacer after several days of whole milk feeding would be the best method to prevent a digestive disturbance in the very young calf, because in some instances it may be unable to withstand abrupt changes of diet.

Length of time to feed milk. The length of time to feed milk to young calves from the standpoint of economy and nutrition is of utmost importance. Milk is one of the most expensive items in a calf-raising program. If calves can be fed milk and weaned in a minimum of time without affecting their normal growth, this would result in more efficient gains. Present day recommendations of milk-feeding periods in a calf-raising program offer an interesting comparison with those methods of a half century ago. Lindsey (49), in a 1915 report, relates substituting skim milk for whole milk after two weeks and continuing skim milk feeding until the end of four

months. Feeders wanting large animals frequently fed skim milk until eight to 12 months of age. However, as early as 1883, Stewart (93) was cognizant of the expense involved in such profuse milk-feeding methods. He advocated feeding whole milk a month or two and then changing to vegetable meal and water mixed with equal parts of skim milk. Though this type of ration was apparently deficient in vitamin A, his study probably induced later workers to seek more efficient methods.

Conover (17) fed whole milk for two weeks and then changed to reconstituted skim milk which was fed until the seventh week. The reconstituted milk was gradually reduced and stopped at the eighth week. Skim milk powder was then fed as 30% of the grain-mix until the calf was four months of age. Other workers (11) agreed with Conover in the belief that the length of time to feed milk was dependent upon the composition of the grain mix. They reasoned that if the grain-mix contained no dry skim milk, reconstituted skim milk should be continued in the calf's diet until four months of age and preferably six.

Since that time, many procedures have been employed in successfully raising calves on very small rations of milk. Morrison (65) noted that limited milk feeding causes subnormal growth rates until the calves were able to consume enough hay and grain to meet their growth requirements. Converse (19) reported in 1949 that he weaned calves at 90, 60, 45, and 30 days without adverse effects.

Knodt, et al. (38) fed reconstituted skim milk for five weeks and discontinued it by the sixth week with very satisfactory results. In a similar study, Cleveland, et al. (16) reported normal gains when the calves were weaned at seven weeks. Berry (11) concluded that calves may be weaned from reconstituted skim milk as early as 42 days depending upon the size and vigor of the calf. He advocated that calves could be raised successfully on as little as 100 lb. of whole milk and 75 lb. of skim milk powder.

In an experiment at the University of Tennessee, Williamson (104) indicated that prolonged milk feeding may reduce hay and feed consumption. Therefore, it would seem feasible to conclude that stopping milk feed at an early age when the calf is able to handle hay and grain would be most advantageous and just as satisfactory as extending it beyond this time. This reasoning is supported by the findings of several investigators who have reported studies that indicate early development of rumen function in the young calf and the calf's ability to handle some roughage as early as one week of age (58, 59). Kesler, et al. (37) observed that the rumen contents of young calves changed between 32 days and six weeks to those characteristically seen in the rumen. In another study (53), the presence of increasing roughage in the stomach compartments between seven to 30 days of age also indicated the calf's ability to handle some bulky feeds during early life. Hay ingestion by very young calves apparently stimulates early development of rumen function (67, 97).

McCandlish (57) found that young calves consume greater amounts of grain (starter) during the first ten days than hay.

Digestibility of various calf feeds. Several investigators have conducted experiments to determine the utilization of carbohydrates in the diet of young calves. This is especially important in the use of calf starters which consist mostly of carbohydrates, a large portion of which are starches. Shaw, et al. (86) reported that calves were unable to utilize starch to any appreciable extent until nearly one month of age. Flipse, et al. (24) conducted a study to determine the effects of lactose on utilization of carbohydrates in synthetic rations. The results of this study showed that alteration of response produced by adding lactose to either a corn syrup or starch ration was remarkable. Addition of lactose to corn syrup changed the response from no gain to 28 lb. gain in 31 days. Therefore, these data indicate that lactose favorably influences utilization of certain carbohydrates and thus provides a basis for the use of non-fat solids in the calf's diet.

The digestibility of milk and milk replacements has been studied recently by Noller, et al. (70). The digestibility of whole milk and evaporated milk is reported as being 94.8% with little variation due to the age of the calf. However, these workers found a low-digestibility value for vegetable milk replacements fed to calves at a very early age. They advocated that such milk replacements could not be utilized satisfactorily until calves are approximately

25 days old. Whiting and Clark (98) noted the superiority of skim milk feeding for young calves over that of vegetable diets which was apparently due to the calf's ability to properly digest the skim milk.

Proper digestibility of the calf's feed is very important since the failure to do so may result in scours or diarrhea. Inclusion of low-fat diets in the calf's ration has generally resulted in more frequent scouring due to the high levels of lactose and ash in skim milk (16, 73, 96, 106). Wallace, et al. (96) fed skim milk and whey which also has a high level of lactose and noted normal growth in the skim milk diet, but when as much as 60% of dried whey was included in the diet, growth rates were depressed and digestive disturbances resulted. It is generally agreed by most workers that other than being more laxative, skim milk is normally digested without gastrointestinal disturbances. Owen, et al. (73) reported that diarrhea was reduced by inclusion of 3% milk fat; increased slightly by doubling the lactose; increased moderately by increasing the milk mineral content four-fold in the calf's diet.

SUMMARY

A review of the data reported by numerous investigators indicates that young calves can be successfully raised on milk replacer diets with only limited amounts of whole milk. Milk replacers containing at least 50% dried skim milk have given better results than those containing less than this amount. This is due to the milk protein which probably has the highest feed value of any protein used in animal feeding and the inability of calves to digest properly feeds other than milk. The use of reconstituted skim milk as a milk replacer has shown very satisfactory results in growth, efficiency, and economy. The possible deficiencies of skim milk are the fat-soluble vitamins, iron, copper, manganese, and fat. These deficiencies can be met by supplementing vitamins A and D and providing the calf with good quality, sun-cured, hay and a concentrate containing high levels of protein up to 18%. The value of supplementing fat has not been determined. The value of feeding antibiotics, especially aureomycin, has been recognized and is believed to be important to the calf's well being in keeping down infection and enhancing growth and appetite. The exact mode of action of antibiotics has not been demonstrated. Rumen development and function as early as one week has been reported, thus enabling the calf to utilize some bulky feeds at an early age. Hay ingestion is believed to stimulate rumen function. This is very important in considering the length of time milk must be fed. Some workers have weaned calves as early as 42 days with satisfactory

results which indicates early rumen function. The amount of milk to feed and solids content of milks are important considerations. Though some workers advise against feeding large volumes or high solids to young calves, experiments have shown that up to 20 lb. of milk per day can be fed without detrimental effects; likewise, calves can tolerate milks containing up to 20% solids with good results. Greater gains have been obtained from feeding large volumes and milks containing high solids content. Though nipple-pail feeding is generally recommended, recent studies have shown that it is not superior to the open-pail method of feeding. The gradual change from whole milk to the milk replacer after several days of whole milk feeding has shown satisfactory results and is probably the best method to prevent digestive disturbances. The digestibility of whole and evaporated milks are estimated to be as high as 94.8%, whereas vegetable milk replacers have a low digestibility value and cannot be satisfactorily utilized by very young calves. Other than being slightly laxative, skim milk is normally digested without gastrointestinal disturbances. Apparently, skim milk is the best known substitute for whole milk in the diets of young calves.

CHAPTER III

EXPERIMENT I, THE EFFECT OF VARYING THE AMOUNT OF MILK SOLIDS IN RECONSTITUTED MILK

EXPERIMENTAL PLAN AND METHODS

This study was made to determine the effect of reconstituted skim milk containing 10%, 15% or 20% solids upon the growth, feed intake, and well being of calves when fed at a rate approximating 15% of body weight per day. It was conducted at the University of Tennessee Agricultural Experiment Station at Knoxville. The experiment started August 1, 1955, and continued through June 21, 1956.

Animals. Normal Holstein calves were assigned to one of three groups at two to three days of age according to their size and sex, alternating to keep the groups as nearly equalized as possible at all times. Each group consisted of ten calves. These were divided and compared as shown in Table 2.

All calves were allowed to remain with their dams for the first two or three days after birth to facilitate adequate colostrum intake. The calves were taken from their dams and placed in individual pens in an enclosed barn. Bedding consisted of wood shavings which were supplemented daily as needed. The pens were cleaned as often as necessary.

Table 2

Outline for the comparison of different treatments for Holstein calves, Experiment I

	Groups fed — % milk solids		
	10	15	20
Male calves (no.)	5	4	4
Female calves (no.)	5	6	6
Total (no.)	10	10	10
Av. 7-day wt. (lb.)	90.6	90.5	91.4
Milk fed (% of body wt.)	15.0	15.0	15.0
Total solids (% of milk fed)	10.0	15.0	20.0
Milk feeding period to a weight of — (lb.)	150	150	150
Maximum starter fed per day (lb.)	4	4	4
Hay fed	ad lib.	ad lib.	ad lib.

Feeds. Colostrum and whole milk were fed for the first five days and the calves were taught to drink from nipple pails after separation from their dams. Reconstituted skim milk was introduced gradually on the sixth and seventh days so that by the eighth day, the calves were entirely on the experimental milks. All calves were fed the same amount of reconstituted milk daily. This amount was determined on the basis of an 80 lb. calf at birth, and after the ninth day the amount fed increased 0.2 lb. per day up to 20 lb. No calf was fed more than 20 lb.

Non-fat dry milk solids fortified with vitamins A and D, and aureomycin, were used for reconstituting the skim milk. The composition of the milk is shown in Table 3. The amount of warm water used to reconstitute the dried milk was calculated by multiplying the amount of milk being fed (based upon 15% body weight) times the respective total solids group and subtracting this amount from the original figure. Milk was fed twice daily and allowances were adjusted on the basis of normal growth rate. Milk feeding was stopped abruptly when the calves reached 150 lb., a normal nine-week weight.

Water, chopped hay, and pelleted calf starter were available at all times after the calves were placed in individual pens. The calf starter formula and the milk replacement formula are shown in Table 3. Maximum concentrate feeding was four lb. daily. Coarse, chopped hay which consisted of a grass-legume mixture was fed ad lib.

Table 3

Formulas used for milk replacer and calf starter pellets

Milk replacement formula

Ingredients	lb.
Skim milk	460
Aureofac D	4.6[a]
Quadrex 10	.46[b]
	465.06

[a]Provides 50 mg. aureomycin/lb. dry milk.

[b]Provides 4000 units vit. A & 500 units vit. D/lb. dry milk.

Calf starter pellets formula

Ingredients	lb.
Yellow corn	380.0
Oats	200.0
Wheat bran	100.0
Linseed oil meal	100.0
Soybean oil meal	100.0
Fish meal	30.0
Fish solubles	20.0
Molasses	50.0
Salt, iodized	10.0
Trace mineral limestone	10.0
"A" oil	--[a]
Irradiated yeast	--[b]

[a]Contains 2724 units vit. A/lb. finished feed.

[b]Contains 1225 units vit. D/lb. finished feed.

Records. Records were kept of all milk, hay, and concentrates consumed. Body weights, height at withers, and heart girth measurements were made at weekly intervals. Notations were made of all ailments and treatments. All records were maintained through 17 weeks. In mild cases of diarrhea, a scours remedy consisting of Kaolin, Bismuth, and Pectin with Sulfathiazole, was administered by the persons feeding the calves. This was given at the rate of two fluid ounces per 25 lb. of body weight per day in three equal doses. Dosage was reduced by one-third after the third day if the calf required further treatment. In severe cases, the University veterinarian administered treatment to the calves.

The analysis of variance method was used in determining whether a statistically significant difference existed between the various groups.

RESULTS

Weight gains. The average weekly gains for the three groups are presented in Figure 1. The 15% solids group showed slight gains over the 10% and 20% groups for the 16-week trial. After the seventh week when all calves had been weaned, it was interesting to note that all groups followed a comparable growth trend and remained proximated until the end of the trial. The first six weeks of the trial, the heavier fed 20% solids group led all groups. This is clearly shown in Figure 1. The 15% solids group held a slight edge over all groups from the tenth through the 17th week. After the fourth week, all groups remained above the standards reported by Ragsdale (78).

The average weekly gains are summarized in Table 4. The total gains were 174.8, 178.1 and 171.4 lb. for the 10%, 15%, and 20% groups, respectively; weekly mean gains were 10.9, 11.1, and 10.7 lb., respectively. The average daily gains were 1.56, 1.59, and 1.53 lb., respectively. There was not a statistically significant difference between any of the groups for the 112-day period.

From the seventh to 35 days of age, the 20% group's average cumulative gain was 51.6 lb, and the 10% and 15% groups averaged 40.4 and 44.1 lb., respectively. When analyzed statistically, this was a significant difference approaching the 1% level of probability. The ratio of variances for this period was 5.23 which was compared with Snedecor's (90) F value of 5.49 at the 1% level.

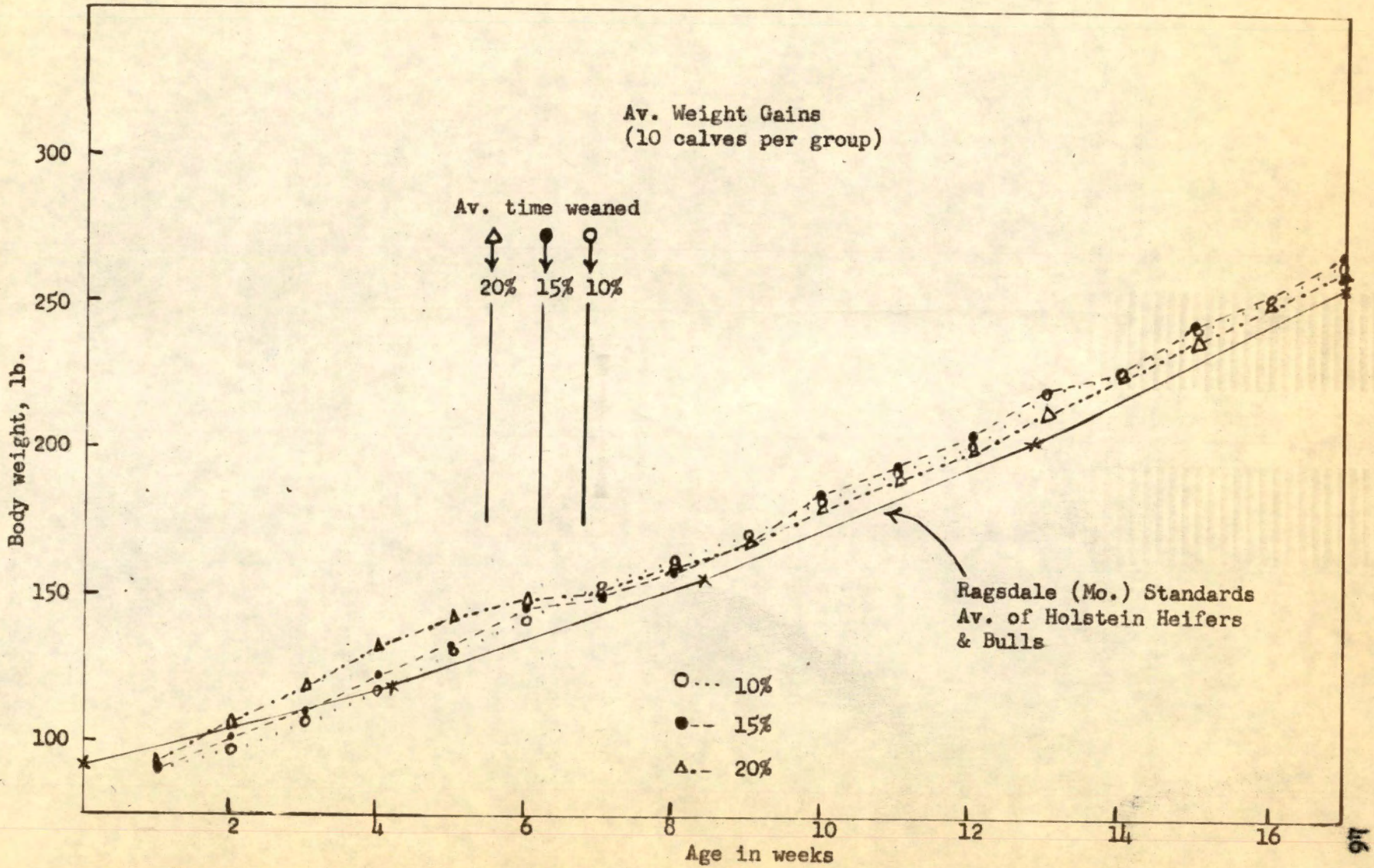


Figure 1. Average gain in weight of three groups of calves comparing milk reconstituted at 10, 15, and 20% milk solids.

Table 4

Effect of feeding reconstituted milk at 15% of body weight and 10, 15, and 20% milk solids upon weight gains

Age days	Av. weekly wts. of groups fed — % solids			Av. weekly gain of groups fed — % solids			Av. cumulative gain wt. of groups fed — % solids		
	10%	15%	20%	10%	15%	20%	10%	15%	20%
	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
7	90.6	90.5	91.4						
14	98.3	101.8	105.5	7.7	11.3	14.1	7.7	11.3	14.1
21	107.8	110.3	118.4	9.5	8.5	12.9	17.2	19.8	27.0
28	119.1	123.0	133.0	11.3	12.7	14.6	28.5	32.5	41.6
35	131.0	134.6	143.0	11.9	11.6	10.0	40.4	44.1	51.6
42	141.6	146.4	147.7	10.6	11.8	4.7	51.0	55.9	56.3
49	154.8	149.9	153.1	13.2	3.5	5.4	64.2	59.4	61.7
56	162.1	158.7	163.1	7.3	8.8	10.0	71.5	68.2	71.7
63	171.3	170.4	170.3	9.2	11.7	7.2	80.7	79.9	78.9
70	182.5	184.5	180.6	11.2	14.1	10.3	91.9	94.0	89.2
77	194.6	195.4	191.0	12.1	10.9	10.4	104.0	104.9	99.6
84	202.9	206.8	203.1	8.3	11.4	12.1	112.3	116.3	111.7
91	221.1	221.9	214.2	18.2	15.1	11.1	130.5	131.4	122.8
98	231.5	231.2	229.0	10.4	9.3	14.8	140.9	140.7	137.6
105	242.5	243.4	238.6	11.0	12.2	9.6	151.9	152.9	147.2
112	254.3	254.8	252.2	11.8	11.4	13.6	163.7	164.3	160.8
119	265.4	268.6	262.8	11.1	13.8	10.6	174.8	178.1	171.4
Total gain	174.8	178.1	171.4						
Av. daily gain	1.56	1.59	1.53						
Av. weekly gain	10.9	11.1	10.7						

Gains in height at withers. The average weekly gains are shown in Figure 2. There was no appreciable difference in total height gains between the groups for the 112-day trial. The total height gains were 7.6, 7.5, and 8.0 inches for the 10%, 15%, and 20% solids groups, respectively, the larger gain being made by the 20% group. With the exception of the 20% group, from the fourth week to the eighth week, all groups were slightly below the Ragsdale (78) standards until near the end of the trial.

The cumulative gain of the 20% total solids group averaged 2.6 inches from the 7th to the 35th day. The 10% and 15% groups averaged 1.8 and 2.0 inches, respectively. These differences were statistically significant at less than the 5% level of probability.

Heart girth changes. The average weekly gains are presented in Figure 3. The differences between the groups were not statistically significant. Though the average linear growth rate in Figure 3 indicates that the heart girth gains of the 20% solids group exceeded the others from the 7th to the 35th day, the probability of significance exceeded 5%. At the end of the 112-day trial, all groups showed a close comparison in total growth advances. The 10% group made the largest gain of 12.4 inches. The 15% and 20% groups followed with 11.9 and 11.8 inches, respectively. All groups were slightly under the Ragsdale standards but not significantly so. Ragsdale (78) reported that variations in linear measurement may vary from 5 to 10% and still be considered normal.

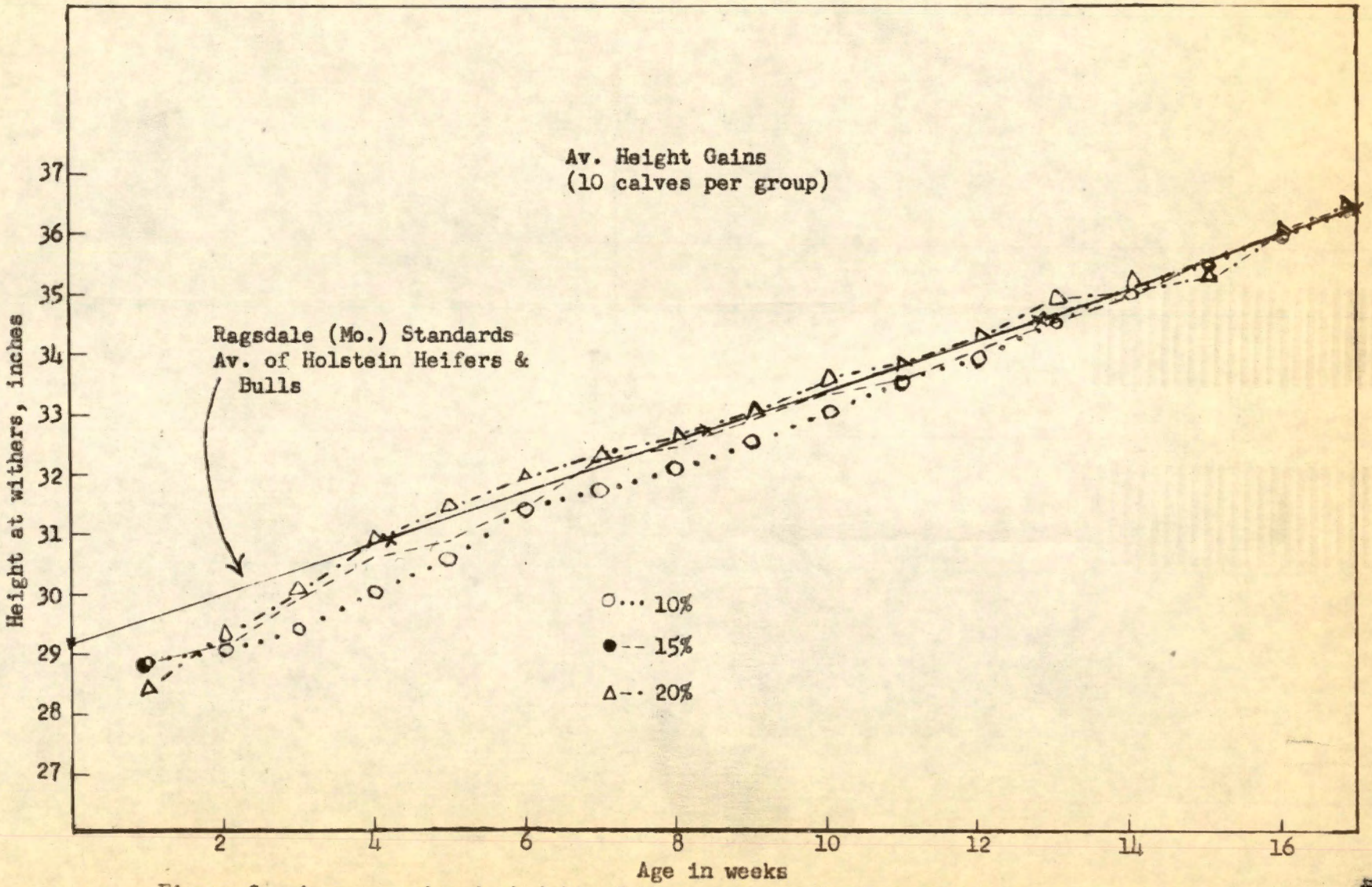


Figure 2. Average gains in height of three groups of calves comparing milk reconstituted at 10, 15, and 20% milk solids.

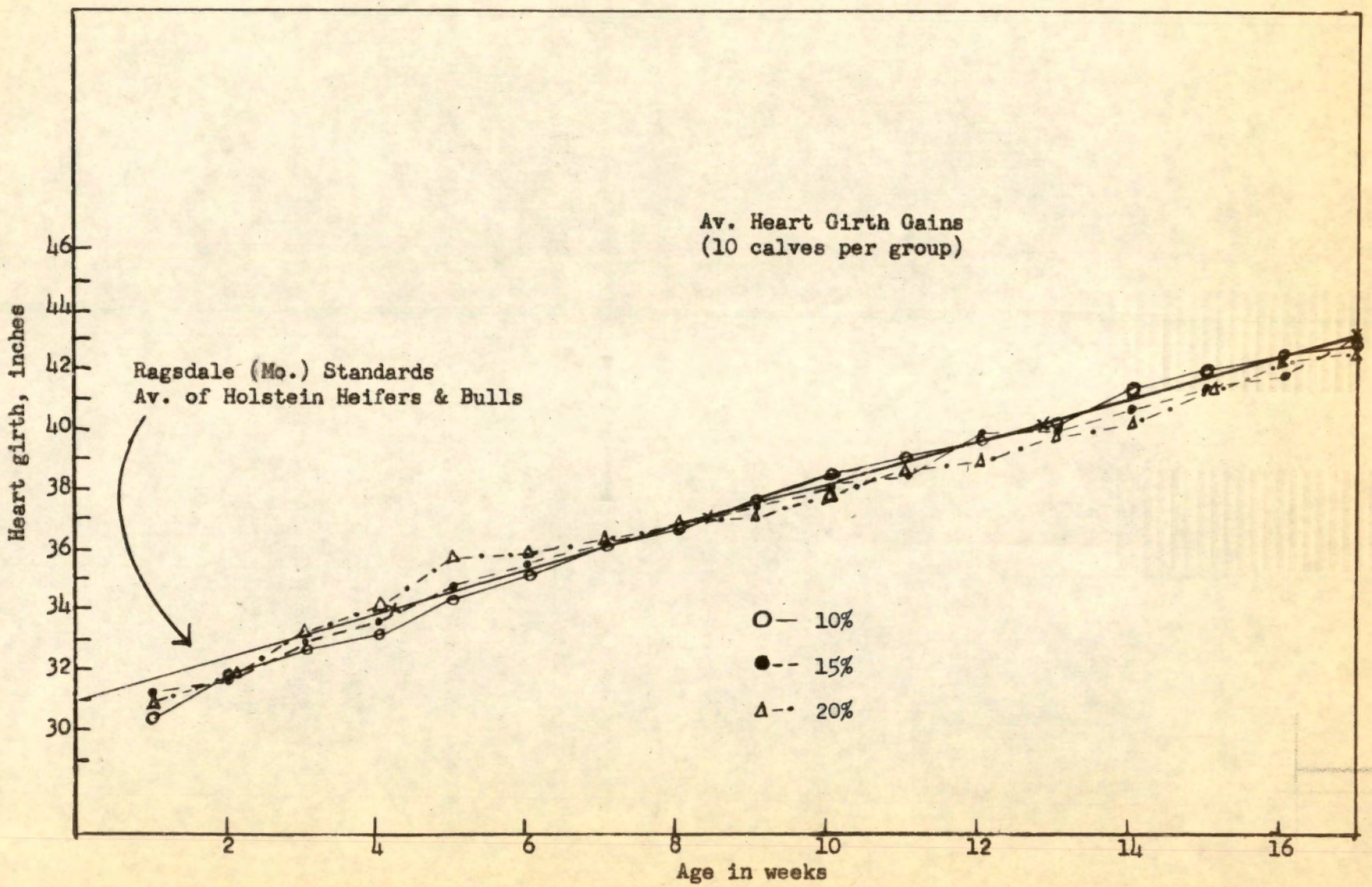


Figure 3. Average gains in heart girth of three groups of calves comparing milk reconstituted at 10, 15, and 20% milk solids.

Milk consumption. The average total consumption of milk from the seventh day until weaning was 713.7, 612.2, and 514.9 lb. for groups fed 10%, 15%, and 20% solids, respectively (Table 5). This was equivalent to 71.4, 91.8, and 103.0 lb. of milk solids, respectively. The milk solids consumed per lb. gain for 112 days were .40, .51, and .60 lb., respectively, for the 10%, 15%, and 20% solids groups. The 20% group had the shortest milk-feeding period, 38.7 days. The 15% group followed at 44.1 days, and the 10% group was weaned at 47.4 days. The fact that the 20% group was weaned in the shorter period of time is indicative that heavy initial feeding of calves results in much faster weight gains, since all calves were weaned at about 150 lb. body weight.

Grain and hay consumption. The average total amount of hay and grain consumed by all groups was similar as shown in Table 6. The 10% solids group led the other groups both in total hay and grain consumption. This is shown in Figures 4 and 5, especially in regard to grain consumption from the 3rd to the 8th week and hay consumption from the 8th to the 11th week. The 20% group lagged behind the other groups in hay and grain consumption, but more notably so in hay consumption. These differences were not statistically significant at the 5% level of probability. The greatest increase in weekly grain consumption occurred at the seventh week with the exception of the 10% group. The 10% group followed a more consistent increase than either of the other groups.

The greatest increase in hay consumption occurred in all groups at the 13th week. The 10% group followed a more consistent trend in hay consumption than the other groups, especially during the first 13 weeks (Figure 5).

Table 5

Comparison of feed consumption of calves fed skim milk reconstituted at 10, 15, and 20% solids

Week no.	Av. milk consumed groups fed — % solids			Av. grain consumed groups fed — % solids			Av. hay consumed groups fed — % solids		
	10%	15%	20%	10%	15%	20%	10%	15%	20%
	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
1				0.2	0.5	0.2	0.8	0.9	0.5
2	100.0	97.0	94.2	0.7	0.5	0.2	0.4	0.4	0.1
3	111.7	105.6	104.2	1.4	1.7	0.7	0.4	1.1	0.4
4	121.7	119.7	115.1	3.1	1.9	1.3	0.8	0.8	1.0
5	131.3	116.4	109.3	6.1	3.1	3.1	1.3	1.4	1.3
6	124.9	100.2	67.3	8.9	6.8	7.8	2.6	3.0	2.0
7	88.9	51.0	24.6	14.1	11.6	12.1	3.1	3.7	2.8
8	35.0	15.4		19.7	19.9	20.6	5.2	5.2	5.1
9		6.7		24.4	24.6	23.8	7.5	6.1	6.2
10				26.8	27.0	26.5	10.6	8.2	9.2
11				27.0	27.3	26.9	12.8	13.5	12.8
12				27.2	28.0	27.4	15.1	15.1	13.6
13				27.2	28.0	27.5	17.0	17.1	17.9
14				27.4	27.1	27.8	23.3	22.5	23.3
15				27.6	27.2	27.4	25.3	25.2	24.7
16				26.8	27.2	26.7	26.7	27.0	26.1
17				27.2	27.4	27.6	28.4	30.0	30.7
Total	713.7	612.2	514.9	295.8	289.8	287.6	181.3	181.2	177.7

Table 6

Average cumulative grain and hay consumption of calves fed skim milk reconstituted at 10, 15, and 20% solids

Age days	Av. grain consumption groups fed — % solids			Av. hay consumption groups fed — % solids		
	10%	15%	20%	10%	15%	20%
	lb.	lb.	lb.	lb.	lb.	lb.
7	0.2	0.5	0.2	0.8	0.9	0.5
14	0.9	1.0	0.4	1.2	1.3	0.6
21	2.3	2.7	1.1	1.6	2.4	1.0
28	5.4	4.6	2.4	2.4	3.2	2.0
35	11.5	7.7	5.5	3.7	4.6	3.3
42	20.4	14.5	13.3	6.3	7.6	5.3
49	34.5	26.1	25.4	9.4	11.3	8.1
56	54.2	46.0	46.0	14.6	16.5	13.2
63	78.6	70.6	69.8	22.1	22.6	19.4
70	105.4	97.6	96.3	32.7	30.8	28.6
77	132.4	124.9	123.2	45.5	44.3	41.4
84	159.6	152.9	150.6	60.6	59.4	55.0
91	186.8	180.9	178.1	77.6	76.5	72.9
98	214.2	208.0	205.9	100.9	99.0	96.2
105	241.8	235.2	233.3	126.2	124.2	120.9
112	268.6	262.4	260.0	152.9	151.2	147.0
119	295.8	289.4	287.6	181.3	181.2	177.7

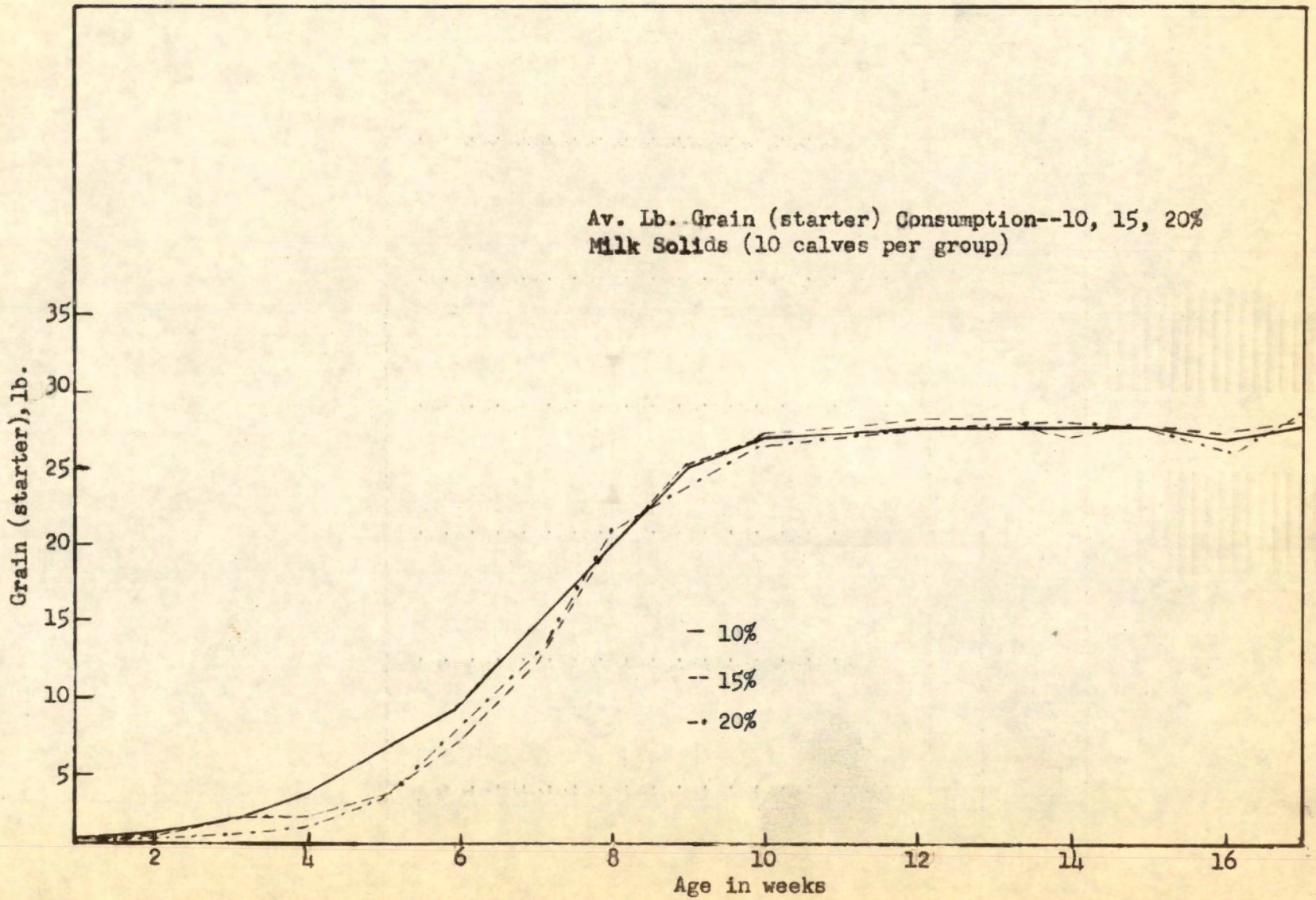


Figure 4. Average concentrate consumption of three groups of calves comparing milk reconstituted at 10, 15, and 20% milk solids.

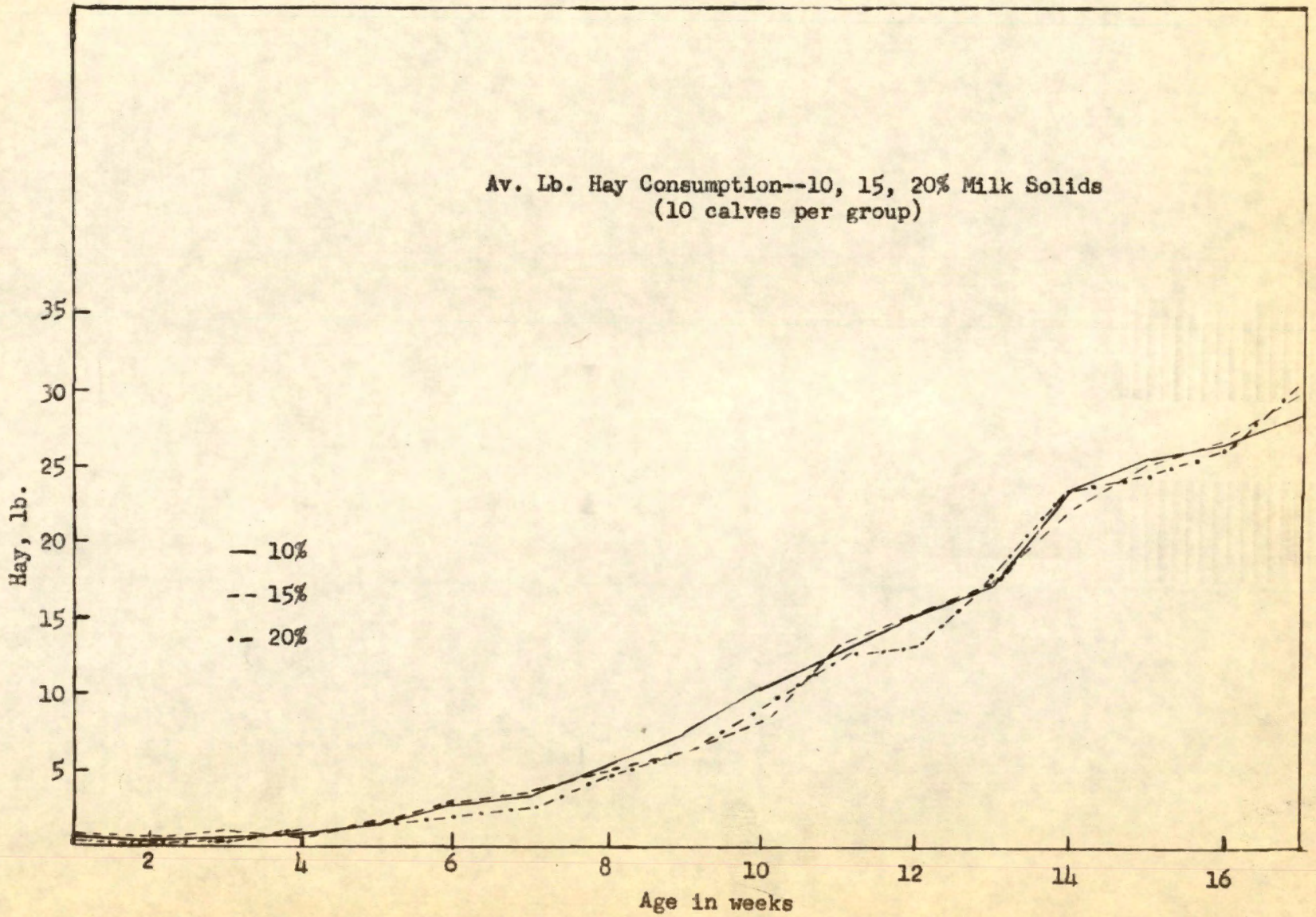


Figure 5. Average hay consumption of three groups of calves comparing milk reconstituted at 10, 15, and 20% milk solids.

Disease. Incidence of diarrhea was not severe in any of the groups. Although some of the calves manifested watery feces at various times, only ten calves of all the groups exhibited diarrhea to any notable extent. The 10% group had no calves notable for diarrhea; the 15% group had three; and the 20% group had seven. The type of feces observed from most of the calves with diarrhea was a watery, yellow to brown colored feces with the exception of one calf which passed a whitish-colored feces. This calf also had a temperature of 103.6°F. at the time of the diarrhea.

Three calves were noted to have respiratory ailments and were treated with terramycin. After treatment, the calves quickly regained normal health.

One calf was treated for navel infection with streptomycin and penicillin. Recovery was complete. Another calf developed scaliness, dandruff, and alopecia starting on the head and spreading to the entire body. The calf recovered from this condition without treatment, as it grew older. There were no deaths in any of the groups.

DISCUSSION

This experiment demonstrated that highly concentrated milks containing up to 20% total milk solids could be tolerated by calves without any noticeably detrimental effects. Although the 20% group had the lowest growth average, it was not significantly below the 10% and 15% groups. These findings are in agreement with Wing, Jacobson, and Allen (105) who reported that low fat milks fed at the rate of 18% solids were equal to or better than whole milk for weight gains. However, these workers reported more frequent scouring when feeding a high rate of solids. Woodard (110) also obtained better growth results when feeding skim milk ad lib. and at one-fifth of body weight. Previous work at the University of Tennessee showed that calves respond with better growth when fed milk at the rate of 15% body weight than at 10% body weight (104).

The fact that the 15% group achieved slightly greater growth gains is believed to be due to several factors. The total average hay and grain consumption was not significantly different between groups. However, the earlier age that hay and grain was consumed in larger amounts was believed to be a very important factor. The 10% group, although fed milk for the longest time, began consumption of hay and grain earlier than the other groups and was more consistent in its consumption. The reason was believed to be due to the lower rate of feeding milk solids, thus causing the calves to remain hungry after milk feeding and to consume more hay and grain to fulfill their appetite.

The reason the 10% group did not attain the largest growth gain was probably due to their slow start in growth for the first four weeks when depending mainly upon milk and receiving smaller amounts of solids than the other groups. This is evident in Figure 1 which shows that greater gains were made on milk the first five weeks by the 20% group. The 20% group, due to their larger milk consumption, ate less hay and grain the first few weeks than either of the other groups. This was especially notable in hay consumption. Meanwhile the 15% group apparently struck a medium between the two groups, consuming large enough intakes of milk solids to attain comparable growth gains to the 20% groups at the initial periods and continuing their advance in growth due to their earlier weaning age than the 10% group and their more consistent hay consumption before and after weaning. The 20% group also consumed less grain up until the fifth week. Therefore, it appears from these data that while the lower rate of feeding milk solids (10%) gave more efficient gains than the heavier rate of feeding (20% solids), the medium level between the two groups or the 15% group produced slightly superior gains than the 10% group and even greater gains than the 20% group.

It was noted in all groups that grain and especially hay consumption increased rapidly following weaning. No harmful effects were noted in withdrawing the milk from the calves' diet abruptly. Though most of the calves lost some weight the week after weaning, normal gains were resumed thereafter (Figure 1). This resulted in a higher consumption of dry feed at an earlier age since only hay and grain was fed after milk feeding was discontinued.

It was interesting to note from the standpoint of calf management (Table 6) that the weaned 20% group was not consuming as much hay and grain as the groups still on a milk diet at six weeks of age. It is also an important consideration to note that the grain consumption of the 10% group while on a milk diet was above that of the other two groups.

The health, thriftiness, and well being of the calves in all groups were favorable, though their hair coats were rougher and coarser than would be expected from a higher fat diet. This is in agreement with the report by Gullickson, et al. (27) from their study of fats in the rations of dairy calves.

Scours appeared in the 15 and 20% groups but were not notable in the 10% group. The fact that watery feces were frequently observed was believed to be due to the high content of lactose and ash present in the skim milk solids (96). Though there were some cases of scours requiring treatment in the 20% and 15% groups, diarrhea was not a major problem in any of the groups. This is evident in pointing out the superior growth results of the 20% group while still on a milk diet. On the basis of this experiment, it is believed that milk solids can be fed up to the rate of 20% to young dairy calves without noticeable detrimental effects. The low incidence of respiratory ailments and the control of infectious scours were believed to be due to the effects of aureomycin in the skim milk powder.

Under most conditions, the use of skim milk powder is most advantageous from the standpoint of economy. Wholesale prices on feed grade dried skim milk powder are approximately 14 cents per lb. Feeding at

the rate of 15% milk solids, the cost would be $0.21 per 10 lb. of reconstituted skim milk; whereas, the same amount of Class II whole milk at $3.38 per cwt. would be $0.34 per 10 lb.

On the basis of milk consumption and average daily gains, the 10% and 15% groups were the most economical of the three groups since the total amount of hay and grain consumed by all groups was practically the same (Table 5). The 10% group consumed 71.4 lb. of milk solids; 15% group, 91.8 lb., and the 20% group, 103.0 lb. The most economical gain between groups was the 10% group whose total cost of milk solids averaged $9.99. Total cost of milk solids consumed by groups 15% and 20% was $12.85 and $14.42, respectively. Since there was not a statistically significant difference between the groups in regard to total growth rate, it would seem feasible under normal farm conditions to recommend either the 10 or 15% rate of feeding milk solids with the 10% level appearing to be the more economical rate.

The use of reconstituted skim milk in a farm program designed for raising dairy calves for replacement stock seemed very satisfactory under the conditions of this experiment. This type of program could easily be adopted on most dairy farms where whole milk is being sold.

CHAPTER IV

EXPERIMENT II, THE EFFECT OF FEEDING MILK SOLIDS AT A CONSTANT PERCENTAGE OF BODY WEIGHT IN DIFFERENT VOLUMES OF WATER

EXPERIMENTAL PLAN AND METHODS

This study was made to determine the comparative effect of feeding the same amount of milk solids in three different volumes of reconstituted skim milk upon the growth, appetite, gastrointestinal disturbances, and well being of calves. The calves were fed 10, 15, and 20% solids at 15, 10, and 7.5% of body weight, respectively. The experiment was conducted concurrently with Experiment I at the University of Tennessee Agricultural Experiment Station at Knoxville. It began December 5, 1955, and was completed November 8, 1956.

Animals. Normal Holstein, Jersey, and crossbred calves were assigned to one of three groups at two to three days of age according to size and sex. The groups were kept as nearly equalized as possible at the start of the tests. Each group consisted of 11 calves. The calves were predominantly Jerseys because they are generally easier to upset and more difficult to raise than Holsteins. They were divided and compared as shown in Table 7.

Feeds and records. The experimental procedure regarding housing, feeds, and management was the same for this study as in Experiment I. The amount of reconstituted skim milk fed was based upon each calf's individual birth weight. The amount of milks was progressively

Table 7

Outline for the comparison of different treatments for calves, Experiment II

	Groups fed — % body wt.		
	15	10	7.5
Holstein calves (no.)	3	3	3
Jersey calves (no.)	6	7	6
Cross-bred calves (no.)	2	1	2
Total (no.)	11	11	11
Av. 7-day wt. (lb.)	64.5	65.5	60.6
Milk fed (% of body wt.)	15	10	7.5
Total solids (% of milk fed)	10	15	20
Maximum starter fed per day (lb.)	4	4	4
Hay fed	ad lib.	ad lib.	ad lib.

increased on the basis of normal daily gains of the respective breeds. Milk feeding was stopped abruptly when the Holstein calves reached 150 lb. in body weight and the Jerseys and crossbreeds, 100 lb.. The trial continued through 16 weeks.

The analysis of variance method was used to determine if statistically significant differences existed between groups.

RESULTS

Weight gains. The average weekly gains for the three groups are presented in Figure 6. The group fed 10% of body weight slightly exceeded the 15 and 7.5% groups at 112 days. These differences were not statistically significant. Differences between breeds were significant (P = .01) at 112 days. The Holstein calves consistently gained more than the Jersey and crossbred calves throughout the trial. All groups followed comparable growth trends throughout the entire trial as shown in Figure 6. Though the 7.5% group appears to lag behind the other groups, this was apparently due to their smaller seven-day beginning weights than the other groups. With the exception of the 7.5% group, all groups remained above the Ragsdale (78) standards after the fourth week. The 7.5% group did not deviate significantly from the standards as shown in Figure 6.

The average weekly gains are summarized in Table 8. The total gains were 118.3, 124.8, and 114.5 lb. for the groups fed at 15, 10, and 7.5% of body weight, respectively. Weekly mean gains were 7.9, 8.3, and 7.6 lb., respectively. The average daily gains were 1.13, 1.19, and 1.09 lb., respectively.

From seven to 42 days of age, the average cumulative gains for the 15, 10 and 7.5% groups were 41.2, 39.7, and 38.8 lb., respectively. The differences between the groups were not statistically significant due to ration. There was a statistically significant (P = .01) difference between breeds and breed times ration interaction.

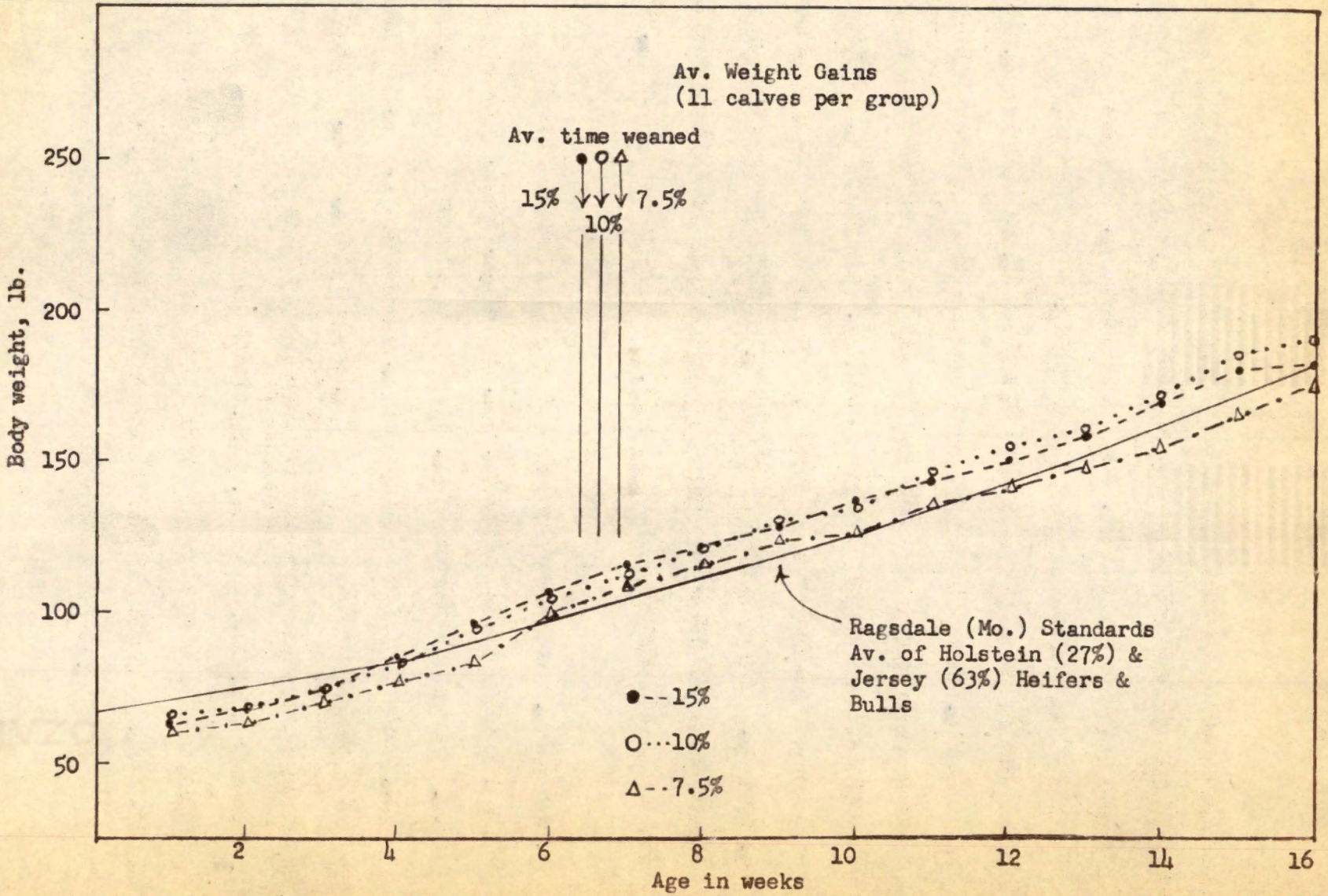


Figure 6. Average gain in weight of three groups of calves comparing milk solids fed at 1.5% of body weight in reconstituted milks fed at 7.5, 10, and 15% of body weight.

Table 8

Comparison of weekly weight gains by three groups of calves when milk solids were fed at 1.5% of body weight in reconstituted milks fed at 7.5, 10, and 15% of body weight

Age days	Av. weekly wts. milks fed — % of body wt.			Av. weekly gain in wt. milks fed — % of body wt.			Av. cumulative gain in wt. milks fed — of body wt.		
	15%	10%	7.5%	15%	10%	7.5%	15%	10%	7.5%
	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
7	64.5	65.5	70.6						
14	69.3	69.4	64.2	4.8	3.9	3.6	4.8	3.9	3.6
21	76.5	76.4	69.5	7.2	7.0	5.3	12.0	10.9	8.9
28	84.4	84.1	77.4	7.9	7.7	7.9	19.9	18.6	16.8
35	96.0	95.4	87.5	11.6	11.3	10.1	31.5	29.9	26.9
42	105.7	105.2	99.4	9.7	9.8	11.9	41.2	39.7	38.8
49	116.0	114.7	108.4	10.3	9.5	9.0	51.5	49.2	47.8
56	122.2	122.9	116.4	6.2	8.2	8.0	57.7	57.4	55.8
63	129.4	130.8	124.4	7.2	7.9	8.0	64.9	65.3	63.8
70	138.3	138.0	127.2	8.9	7.2	2.8	73.8	72.5	66.6
77	144.5	147.7	135.3	6.2	9.7	8.1	80.0	82.2	74.7
84	150.0	155.4	142.1	5.5	7.7	6.8	85.5	89.9	81.5
91	159.4	163.8	149.5	9.4	8.4	7.4	94.9	98.3	88.9
98	170.4	173.8	156.5	11.0	10.0	7.0	105.9	108.3	95.9
105	176.3	182.4	166.2	5.9	8.6	9.7	111.8	116.9	105.6
112	182.8	190.3	175.1	6.5	7.9	8.9	118.3	124.8	114.5
Total gain	118.3	124.8	114.5						
Av. daily gain	1.13	1.19	1.09						
Av. weekly gain	7.9	8.3	7.6						

Height gains. The average weekly height gains are shown in Figure 7. There was no appreciable difference between the groups at 112 days of age. The total height gains were 6.9, 6.5, and 6.6 inches for the 15, 10, and 7.5% groups, respectively. The 15 and 10% groups made gains comparable to those reported by Ragsdale (78) as shown in Figure 7. The 7.5% group lagged behind the other groups due to their smaller seven-day beginning heights but not significantly so. Variation in linear measurement may vary from 5 to 10% and still be considered normal (78).

The average cumulative gains of the 15, 10, and 7.5% groups were 2.7 inches for all groups from seven to 42 days of age. These consistent gains by all groups are clearly shown in Figure 7. There were no statistically significant differences due to breed during this period.

Heart girth changes. The average weekly heart girth gains are presented in Figure 8. All groups gained consistently and were below the Ragsdale (78) standards but not significantly so. At the end of the 105 day trial, all groups showed a close comparison in total growth. The total heart girth gains were 10.0, 10.4, and 9.5 inches for the 15, 10, and 7.5% groups, respectively.

The average cumulative gain from seven to 42 days of age was 3.6 inches for the 15 and 7.5% groups and 3.5 inches for the 10% group. These differences were not statistically significant.

Milk consumption. The average total consumption of reconstituted milk from seven days to weaning was 464, 325, and 246 lb., respectively for the 15, 10, and 7.5% groups. The milk solids consumed

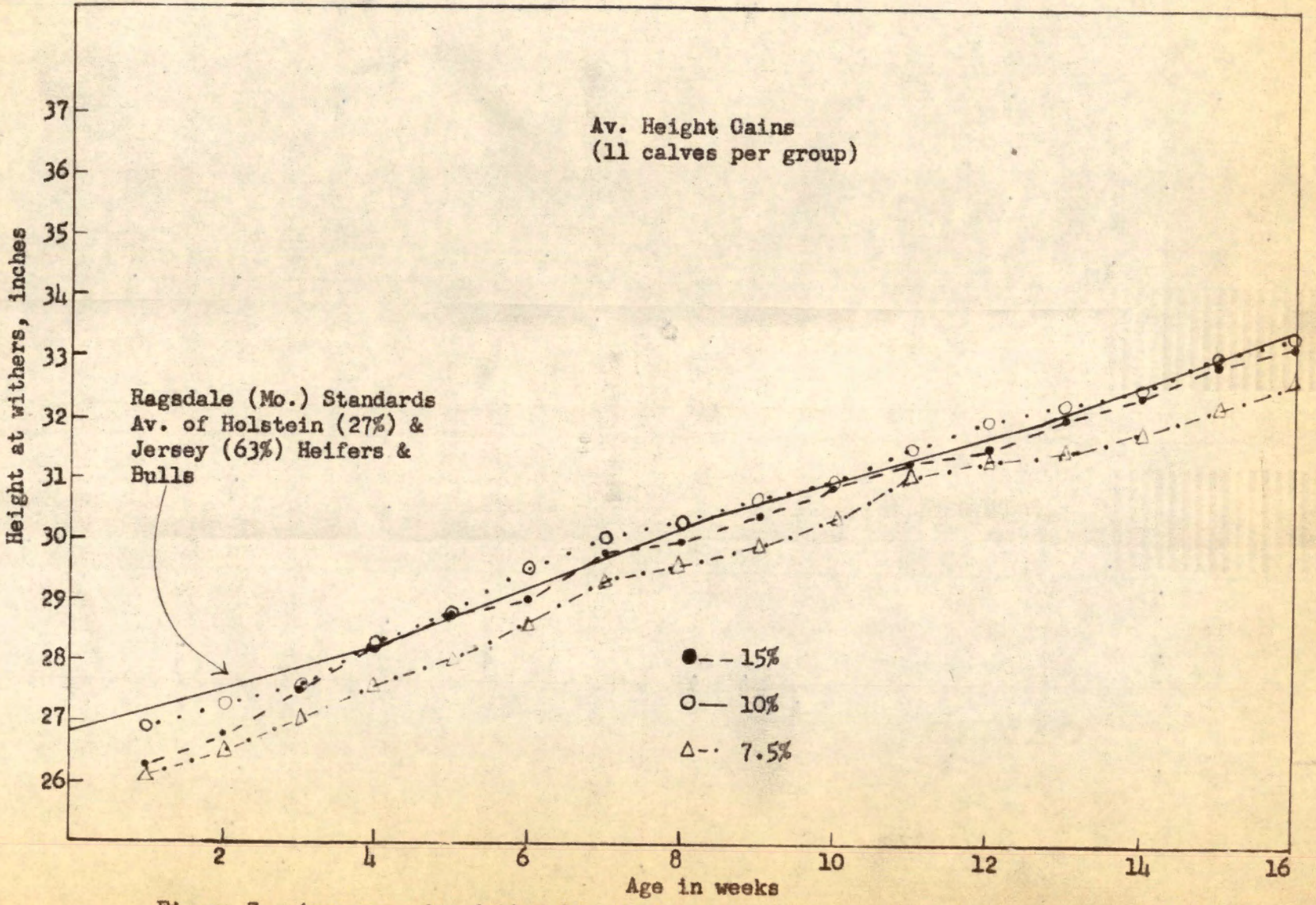


Figure 7. Average gains in height of three groups of calves comparing milk solids fed at 1.5% of body weight in reconstituted milks fed at 7.5, 10, and 15% of body weight.

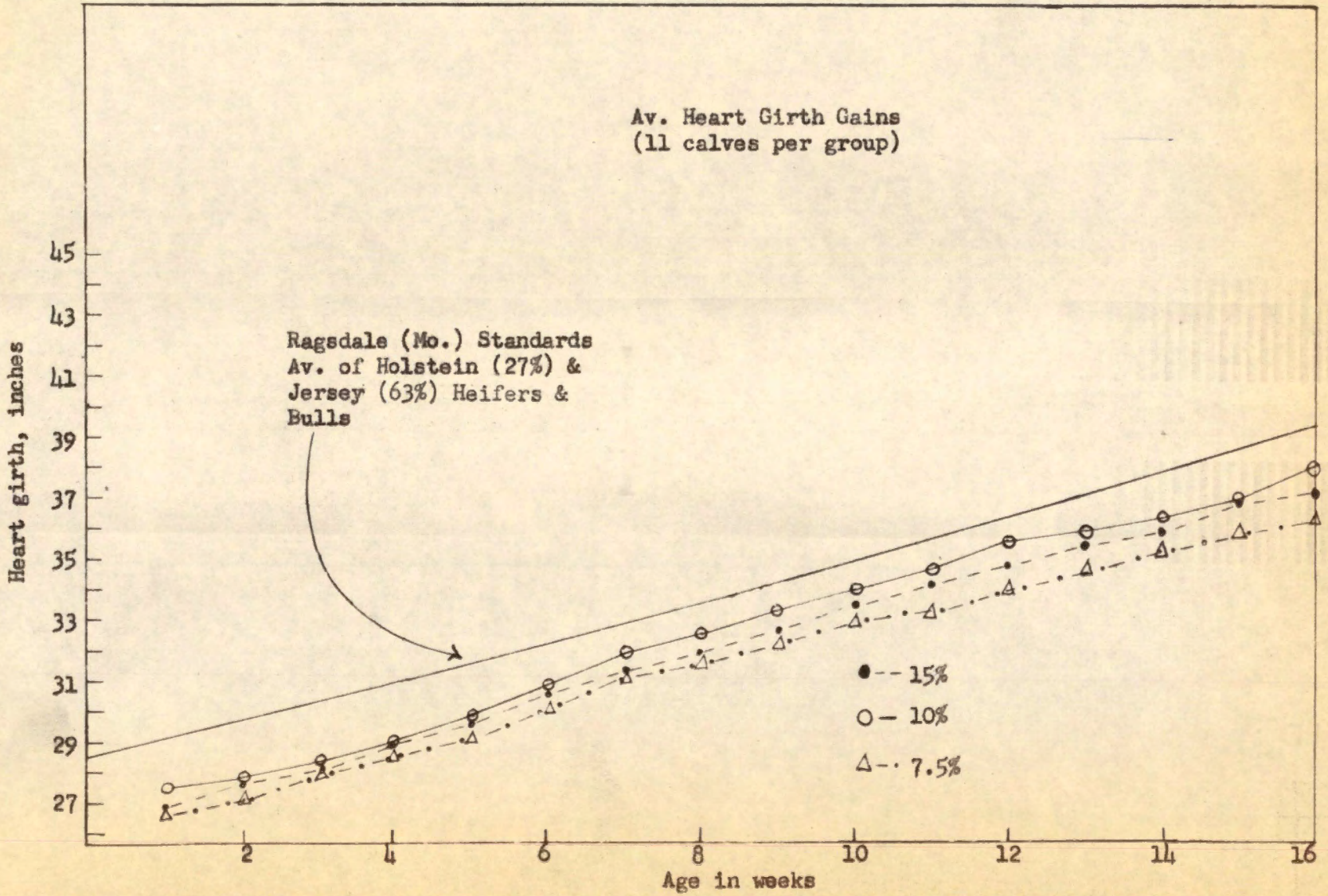


Figure 8. Average heart girth gains of three groups of calves comparing milk solids fed at 1.5% of body weight and reconstituted milks fed at 7.5, 10, and 15% of body weight.

averaged 46.4, 48.7, and 49.2 lb. per calf in the respective groups. Since all groups received approximately the same amount of solids, there was no appreciable difference in nutritive value between the various volumes of milk. The average weaning ages of all groups were comparable. The 15, 10, and 7.5% groups averaged weaning ages of 45.5, 46.6, and 48.2 days, respectively. Difference in weaning ages caused the differences in milk consumption per calf. Two calves in the 10% group, weaned at 28 days each, were consuming one-fourth of all the milk in this group. This accounted for the rapid drop in average milk consumption per calf after the fourth week in the 10% group.

Grain and hay consumption. The average total amount of grain consumed by all groups was similar as shown in Table 9. The calves in all groups were consistent in grain consumption. An accelerated increase in grain consumption (Figure 9) was made after the calves were weaned at 42 to 49 days of age. The average cumulative consumption of grain (Table 10) from one to 42 days of age was 35.9, 39.2, and 36.8 lb. for the 15, 10, and 7.5% groups, respectively. These differences were not statistically significant.

The average cumulative hay consumption for all groups the first 42 days was 8.7, 8.1, and 6.3 lb. for the 15, 10, and 7.5% groups, respectively. Though these differences appear to be statistically significant, the probability due to breed exceeded the 5% level. The average total consumption was 100.5, 106.1, and 86.6 lb., respectively. The lag in hay consumption by the 7.5% group occurred from the 9th through the 12th week (Figure 10). When analyzed statistically for

Table 9

Comparison of feed consumption when reconstituted milks were fed at 15, 10, and 7.5% of body weight and milk solids were fed at 1.5% of body weight

Age days	Av. milk consumed when fed — % of body wt.			Av. grain consumed when milks fed — % of body wt.			Av. hay consumed when milks fed — % of body wt.		
	15%	10%	7.5%	15%	10%	7.5%	15%	10%	7.5%
	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
7				0.7	0.8	0.6	0.0	0.1	0.0
14	70.4	51.0	35.1	1.6	2.3	1.4	0.8	0.3	0.6
21	78.1	54.7	36.7	3.5	3.6	3.5	1.1	1.2	1.0
28	84.3	58.4	39.9	6.9	5.9	7.6	1.4	1.8	1.1
35	90.7	47.5	42.8	10.3	11.8	10.9	3.1	2.5	1.8
42	72.8	50.8	47.5	12.9	14.8	12.8	2.3	2.2	1.8
49	36.4	39.7	23.8	17.9	18.1	17.2	3.6	3.4	2.3
56	19.2	22.9	16.2	21.2	20.6	20.6	4.4	3.9	1.8
63	12.1		4.2	23.4	23.1	23.9	4.3	5.5	4.2
70				23.2	25.6	24.6	5.8	8.0	4.7
77				23.7	14.4	24.7	8.3	10.4	4.6
84				24.9	26.7	25.1	9.2	11.1	6.4
91				26.1	27.1	26.6	9.6	12.2	10.7
98				25.3	27.3	25.6	13.6	14.3	14.2
105				26.6	27.4	26.7	16.0	14.0	14.7
112				26.4	27.1	26.6	17.0	15.2	15.7
Total	464.0	325.0	246.2	274.6	286.6	278.4	100.5	106.1	86.6

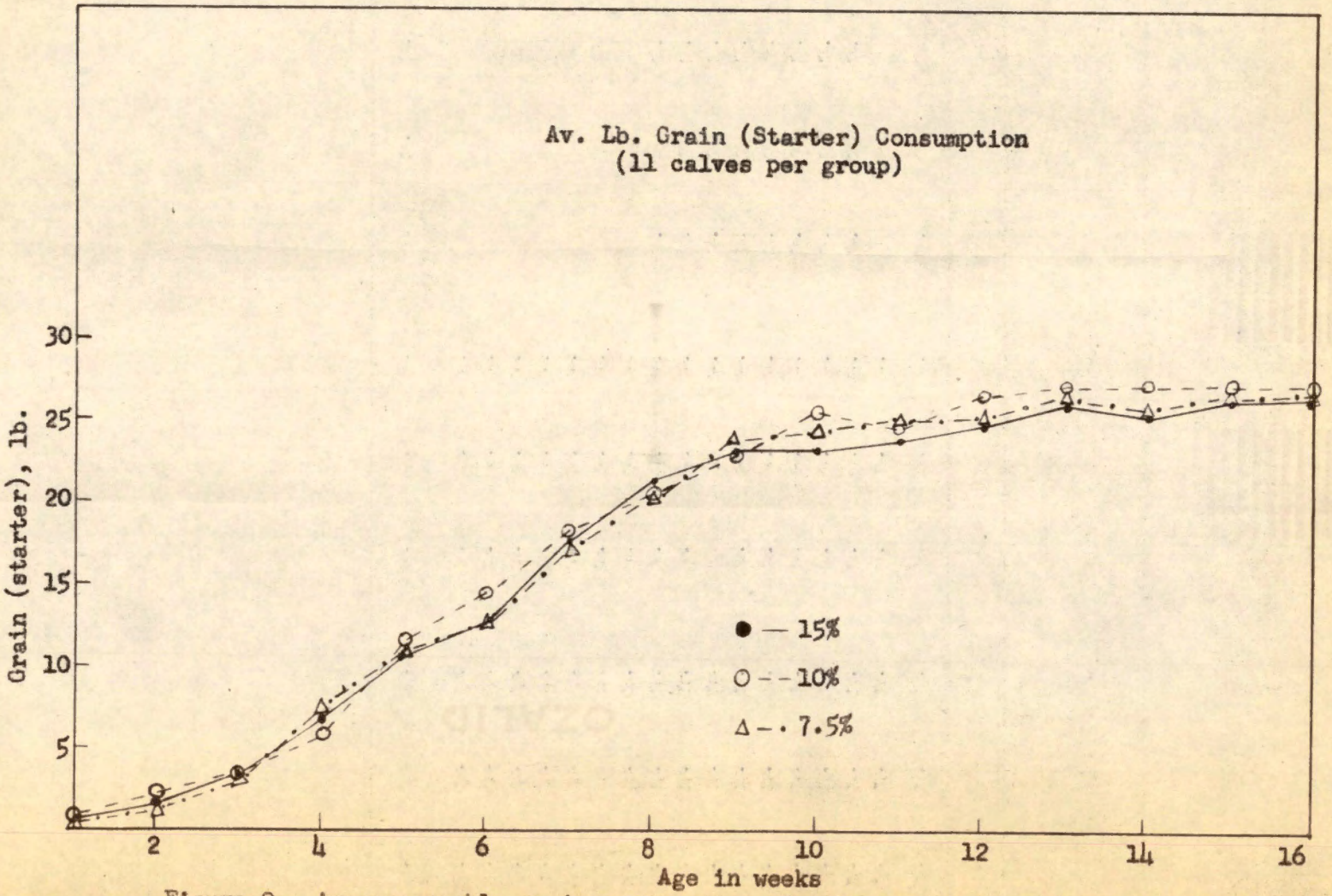


Figure 9. Average weekly grain consumption of three groups of calves when reconstituted milks were fed at 15, 10, and 7.5% of body weight and solids were fed at 1.5% of body weight.

Table 10

Average cumulative grain and hay consumption when milks were fed at 15, 10, and 7.5% of body weight and solids were fed at 1.5% of body weight

Age days	Av. grain consumption when milks fed — % of body wt.			Av. hay consumption when milks fed — % of body wt.		
	15%	10%	7.5%	15%	10%	7.5%
	lb.	lb.	lb.	lb.	lb.	lb.
7	0.7	0.8	0.6	0.0	0.1	0.0
14	2.3	3.1	2.0	0.8	0.4	0.6
21	5.8	6.7	5.5	1.9	1.6	1.6
28	12.7	12.6	13.1	3.3	3.4	2.7
35	23.0	24.4	24.0	6.4	5.9	4.5
42	35.9	39.2	36.8	8.7	8.1	6.3
49	53.8	57.3	54.0	12.3	11.5	8.6
56	75.0	77.9	74.6	16.7	15.4	11.4
63	98.4	101.0	98.5	21.0	20.9	15.6
70	121.6	126.6	123.1	26.8	28.9	20.3
77	145.3	154.0	147.8	35.1	39.3	24.9
84	170.2	177.7	172.9	44.3	50.4	31.3
91	196.3	204.8	199.5	53.9	62.6	42.0
98	221.6	232.1	225.1	67.5	76.9	56.2
105	248.2	259.5	251.8	83.5	90.9	70.9
112	274.6	286.5	278.4	100.5	106.1	86.6

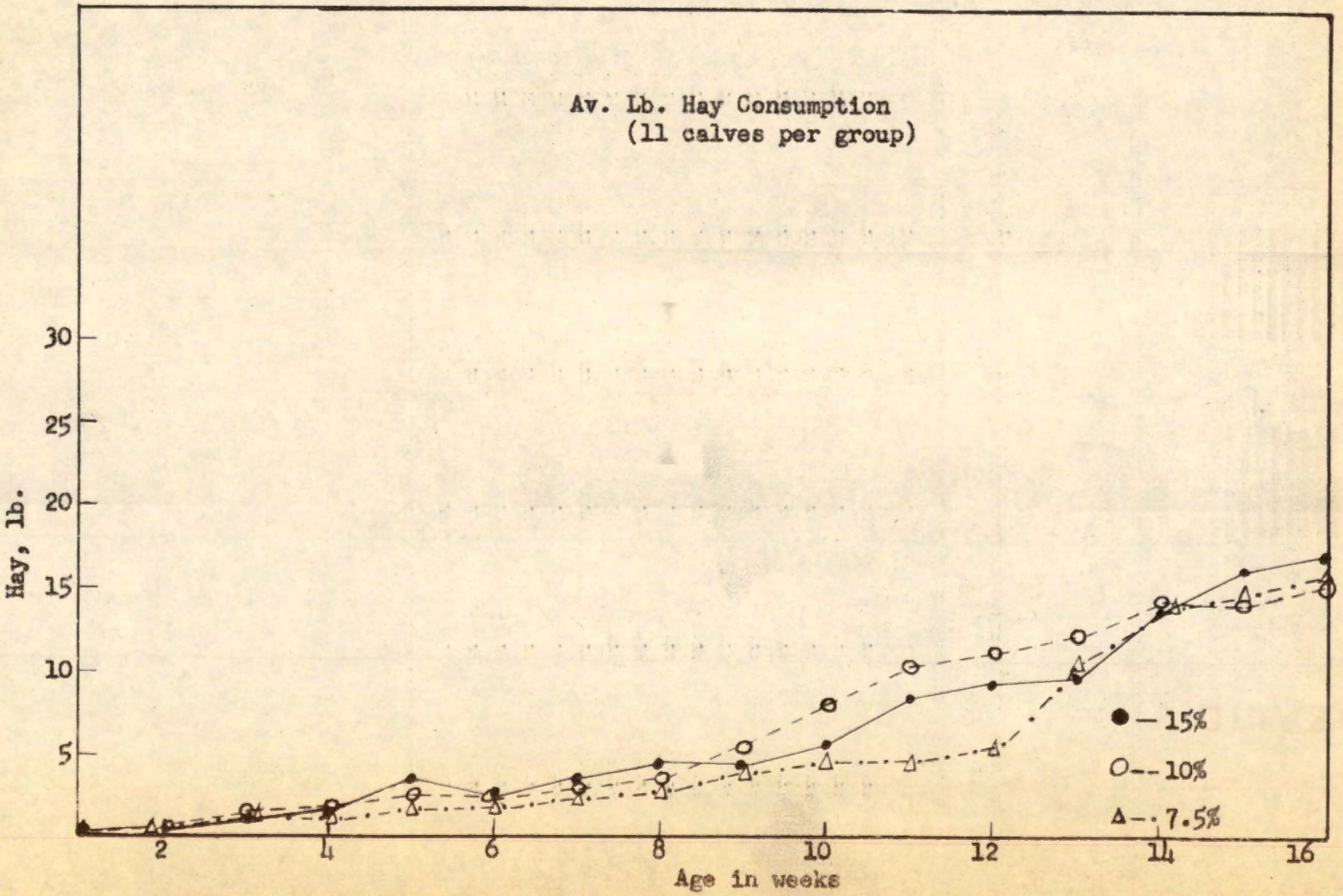


Figure 10. Average weekly hay consumption of three groups of calves when reconstituted milks were fed at 15, 10, and 7.5% of body weight and solids were fed at 1.5% of body weight.

the 105 day trial, the differences due to treatment were not statistically significant, but there was a highly significant difference (P = .01) due to breeds.

The average hay consumption by all groups was below what would be expected normally. This is evidenced by the very low consumption of hay by several calves representative of all groups. One calf from the 15% group ate only 25.7 lb. during the entire trial; one calf from the 10% group ate only 30.2 lb., and one calf in the 7.5% group ate only 20.7 lb.. These were the lowest, but several other calves from all groups consumed only slightly more hay than these.

As shown in Figure 10, the linear trend toward increased hay consumption, by all groups generally, began to rise several weeks after weaning at about the 9th week. With the exception of the 7.5% group, the groups continued an increased hay consumption until the end of the trial.

Disease. All groups exhibited watery feces at various times while on the experimental milks, but incidence of diarrhea was not severe in any of the groups. Incidence of scours was low and generally divided among all groups. The 15 and 10% groups each had two calves notable for scours, and the 7.5% group had three. Only two of the nine Holsteins of all groups were affected with diarrhea. During the latter part of the summer, several of the small Jersey calves began to show poor appetite for hay and grain, after they had been weaned from milk. This resulted in weight losses accompanied by diarrhea. The feces were

dark brown, and the calves appeared sick. They were treated by the University veterinarian with terramycin and a scours remedy. In addition, aureomycin supplement (Aureofac) was fed with the grain (5 grams) per day) until the calves began to recover. Four of these calves were in the 7.5% group; one was in the 15% group, and two were in the 10% group.

One young Holstein calf with swollen ankles was placed under a heat lamp. The calf recovered after several days without any serious weight loss. There were no deaths in any of the groups.

DISCUSSION

This experiment demonstrated that heavy milk feeding, up to 15% of body weight, does not promote gastrointestinal trouble in young calves. By varying the volumes of milk and maintaining the same amount of solids in all groups, the higher volumes of milk apparently had no effect on appetite, growth, diarrhea, or well being of the calf. These findings are in agreement with McCullough, et al. (60) who reported daily gains of 1.26, 1.42, and 1.50 lb. when feeding whole milk at 10, 14, and 18% of body weight, respectively. No intestinal disorders were mentioned. Other studies (26, 30, 42, 94, 104, 110) have shown very satisfactory results when large volumes of fluids are fed to the young calf.

Except for breed differences in the weight gains, no statistically significant differences were found in growth gains in this study. Only little difference was found between the treatments in regard to the calf's health and well being. With the exception of the total average consumption of hay by the 7.5% group, all groups consumed nearly equal amounts of feed. The fact that the 7.5% group had the lowest average daily gain and consumed less hay than the other groups was not believed to be due to treatment. The 7.5% group received the smallest volume of milk of all groups but the same solids. The smaller volume of fluid intake would lead one to expect the calf to eat more hay and grain to fill their stomach. The 7.5% group's failure to do this may have been due to several factors. All calves had access to fresh water

at all times. Possibly the 7.5% group drank more than the other groups, and thus filled their stomachs. Conversely, it is possible that they failed to drink enough water. Ample water is very important for the calf's entire physiology. Water, just as bulk, helps distend the digestive tract and renders digestion possible. Thus an insufficient intake of water could cause constipation and a reduced appetite for hay and grain. Another reason for this group's poor showing was evidently due to their much smaller hay consumption per calf by the majority of the calves in the 7.5% group. The differences in hay consumption were probably not due to treatment since the 7.5% group's lag in consumption occurred after the calves were all off milk. From one though 42 days of age, there was not a statistically significant difference between groups in regard to hay consumption.

All groups produced smaller gains than would be normally expected from the type of diet fed in this study. This was believed to be due to the poor hay consumption by all groups and to several of the older calves representing all groups becoming sick with diarrhea during the summer months. Seven of the older calves were affected with diarrhea, including one from the 15%, two from the 10%, and four from the 7.5% group. This resulted in weight losses, and loss of appetite. Several of the calves were very slow in recovering. The exact cause of the diarrhea by the older calves was not definitely determined. A change from grass-legume hay to legume hay occurred prior to the sickness, and this may have been a major contributing factor. The diarrhea continued even after a change back to another lot of grass-legume hay.

The appearance of the calves, generally speaking, was rough. However, during the milk feeding period, rough hair coats are expected when calves are fed a low-fat diet (27). Though several of the older calves representative of all groups were underweight, the general health and well being of the calves were satisfactory. All calves were normal and above the Ragsdale (78) standards at weaning (Figure 6). Diarrhea was not a major problem in any of the groups. Though the feces were softer while the calves were on a reconstituted skim milk diet, incidence of scours was very low. Only two calves each from the 15% and 10% groups had scours that were notable, and the 7.5% had three. A comparison of three different levels of volume feeding under the conditions of this study indicates that feeding large volumes of fluid may not be the cause of gastrointestinal disturbances and that calves can be fed up to 15% of body weight without harmful results.

CHAPTER V

EXPERIMENT III, A COMPARISON OF THE EFFECTS OF FEEDING AN EXTRACTED-FAT MILK REPLACEMENT WITH ONE CONTAINING 1% FAT AND INSIDE OR OUTSIDE PENS

EXPERIMENTAL PLANS AND METHODS

This study was made to compare indoor pens with outdoor pens and a minimum-fat milk replacement formula with one containing enough milk to furnish 1% fat upon the growth, appetite, and well being of calves. The experiment began August 21, 1954, and was completed August 4, 1955. It was conducted at the University of Tennessee Agricultural Experiment Station at Knoxville.

Animals. Normal Holstein and Jersey calves were assigned to one of four groups, alternating to keep the groups balanced in regard to breed, sex, and birth weight. The groups were divided and compared as shown in Table 11.

Feeds. Milk and milk replacement formula (Table 12) were fed at 15% of body weight and 16.6% solids (1 lb. powder with 5 lb. water). The amount of milk fed was progressively increased weekly for expected rates of gain for the respective breeds. The groups receiving a minimum-fat diet were fed the milk replacer unchanged. The other groups were fed a mixture of three parts milk replacer with one part whole milk of 4% fat content to furnish 1% butterfat. Milk feeding was stopped when the Jersey calves reached 90 lb. and the Holstein calves 150 lb.

Table 11

Outline for the comparison of different treatments for Holstein and Jersey calves, Experiment III

	Holsteins				Jerseys			
	Inside no fat	Inside 1% fat	Outside no fat	Outside 1% fat	Inside no fat	Inside 1% fat	Outside no fat	Outside 1% fat
Calves (no.)	5	5	5	5	3	4	4	4
Av. 7-day wt. (lb.)	98.2	104.6	96.6	95.2	63.3	58.2	60.2	58.7
Milk fed (% of body wt.)	15	15	15	15	15	15	15	15
Milk reconstituted (% solids)	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6
Milk feeding period to a wt. of —(lb.)	150	150	150	150	90	90	90	90
Starter fed(lb./ day) (maximum)	4	4	4	4	4	4	4	4
Hay fed	ad lib.	ad lib.	ad lib.	ad lib.	ad lib.	ad lib.	ad lib.	ad lib.

Table 12

Milk replacement formula for Experiment III

Constituent	lb.
Skim milk	600
Dried whey	200
Soya flour, low fat, high quality	150
Dextrose	40
Salt, iodized	5
Trace minerals[a]	5
A and D meal, stabilized[b]	2.5
	1002.5

[a]

Mineral mixture	lb.
Dicalcium phosphate	15
Magnesium carborate	8
Ferric citrate	1.18
Cupric sulfate	.38
Manganese sulfate	.40
Cobalt chloride	.04
	25.0

[b]Contains 10,000 USP units of vit. A and 1250 USP units of vit. D_2 per gram.

Calf pens. The calf pens used to measure the influence of outdoor versus inside pens were approximately 4 ft. by 6 ft. in size. The pens were too small to permit much exercise.

Records. The other experimental procedure involving management, feeds (water, hay, grain), and records of sickness, feed consumption, and weekly growth measurement was the same as those shown in Experiment I.

The analysis of variance method was used to determine if statistically significant differences existed between groups.

RESULTS

Weight gains. The average daily, weekly, and total gains for the four groups of each breed (Holstein and Jersey) are summarized in Tables 13 and 14. The Jersey inside-1% fat group and the Holstein outside-1% fat group showed slight gains over the other groups for the 16-week trial. The average weekly cumulative gains are shown in Tables 15 and 16. The differences in cumulative gains between the groups during the milk feeding period (7 to 42 days) were not statistically significant due to treatment, but there was a highly significant difference ($P = .01$) due to breeds.

The average 1% and no fat groups weekly gains of the respective breeds are shown in Figure 11. The 1% fat group of the Holsteins held a slight edge over the no fat group during the entire trial. Conversely, the no fat Jersey group maintained a slight edge over the 1% fat group most of the entire trial. The average total gain for the Holstein 1% fat group was 167.1 lb., and it was 159.7 lb. for the no fat group. The average total gain for the Jersey 1% fat group was 110.0 lb., and it was 115.4 lb. for the no fat group. All groups remained above or closely proximated to the Ragsdale (78) standards during the entire trial.

The average weekly gains of the inside and outside groups of the respective breeds are shown in Figure 12. The linear growth trends by all groups remained very closely proximated throughout most of the trial. The Holstein inside group remained above the outside group the first six

Table 13

Comparison of weight gains of groups of Holstein calves fed a milk replacement containing no fat or 1% fat and housed in inside or outside pens

Age days	Inside no fat	Inside 1% fat	Outside no fat	Outside 1% fat
	lb.	lb.	lb.	lb.
7	10.4	14.2	13.8	9.0
14	10.6	6.0	8.7	11.0
21	8.2	12.2	3.9	6.6
28	8.6	14.4	8.4	11.2
35	8.2	8.4	9.2	7.8
42	-0.8	1.6	7.6	6.8
49	8.4	8.8	5.2	14.6
56	11.0	7.0	7.4	5.8
63	11.4	8.6	12.6	8.6
70	10.4	10.4	9.6	9.6
77	8.6	9.4	10.8	13.8
84	15.2	12.4	6.2	17.0
91	11.8	9.4	17.0	9.2
98	8.4	9.6	7.8	11.8
105	17.4	12.2	-9.0	11.2
112	14.2	2.6	28.6	6.2
119	8.8	7.4	0.8	19.4
Total gain	170.8	154.6	148.6	179.6
Av. daily gain	1.44	1.30	1.25	1.51
Av. weekly gain	10.0	9.09	8.74	10.6

Table 14

Comparison of weight gains of groups of Jersey calves fed a milk replacement containing no fat or 1% fat and housed in inside or outside pens

Age days	Inside no fat	Inside 1% fat	Outside no fat	Outside 1% fat
	lb.	lb.	lb.	lb.
7	4.7	7.0	5.5	1.7
14	5.3	4.5	4.8	5.8
21	4.0	4.8	3.5	3.5
28	5.0	7.5	4.7	6.0
35	5.4	5.2	6.3	6.5
42	8.0	5.3	-1.0	8.5
49	-3.7	2.2	0.0	3.5
56	7.0	2.3	15.9	5.5
63	6.3	19.6	8.0	1.7
70	10.7	-5.3	6.5	11.0
77	6.3	9.7	8.5	4.0
84	4.7	9.0	1.5	5.8
91	9.3	9.0	12.0	5.0
98	8.7	8.0	8.5	8.2
105	3.3	9.6	7.5	7.8
112	11.7	9.4	8.0	7.5
119	24.3	15.3	9.5	5.0
Total gain	121.0	123.1	109.8	97.0
Av. daily gain	1.02	1.03	0.92	0.82
Av. weekly gain	7.12	7.24	6.46	5.71

Table 15

Comparison of average cumulative gains of groups of Holstein calves fed a milk replacement containing no fat or 1% fat and housed in inside or outside pens

Age days	Inside no fat	Inside 1% fat	Outside no fat	Outside 1% fat
	lb.	lb.	lb.	lb.
7	10.4	14.2	13.8	9.0
14	21.0	20.2	22.5	20.0
21	29.2	32.4	26.4	26.6
28	37.8	46.8	34.8	37.8
35	46.0	55.2	44.0	45.6
42	45.2	56.8	51.6	52.4
49	53.6	65.6	56.8	67.0
56	64.6	72.6	64.2	72.8
63	76.0	81.2	76.8	81.4
70	86.4	91.6	86.4	91.0
77	95.0	101.0	97.2	104.8
84	110.2	113.4	103.4	121.8
91	122.0	122.8	120.4	131.0
98	130.4	132.4	128.2	142.8
105	147.8	144.6	119.2	154.0
112	162.0	147.2	147.8	160.2
119	170.8	154.6	148.6	179.6

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Table 16

Comparison of average cumulative gains of groups of Jersey calves fed a milk replacement containing no fat or 1% fat and housed in inside or outside pens

Age days	Inside no fat	Inside 1% fat	Outside no fat	Outside 1% fat
	lb.	lb.	lb.	lb.
7	4.7	7.0	5.5	1.7
14	10.0	11.5	10.3	7.5
21	14.0	16.3	13.8	11.0
28	19.0	23.8	18.5	17.0
35	24.4	29.0	24.8	23.5
42	32.4	34.3	23.8	32.0
49	28.7	36.5	23.9	35.5
56	35.7	38.8	39.8	41.0
63	42.0	58.4	47.8	42.7
70	52.7	53.1	54.3	53.7
77	59.0	62.8	62.8	57.7
84	13.7	71.8	64.3	63.5
91	73.0	80.8	76.3	68.5
98	81.7	88.8	84.8	76.7
105	85.0	98.4	92.3	84.5
112	96.7	107.8	100.3	92.0
119	121.0	123.1	109.8	97.0

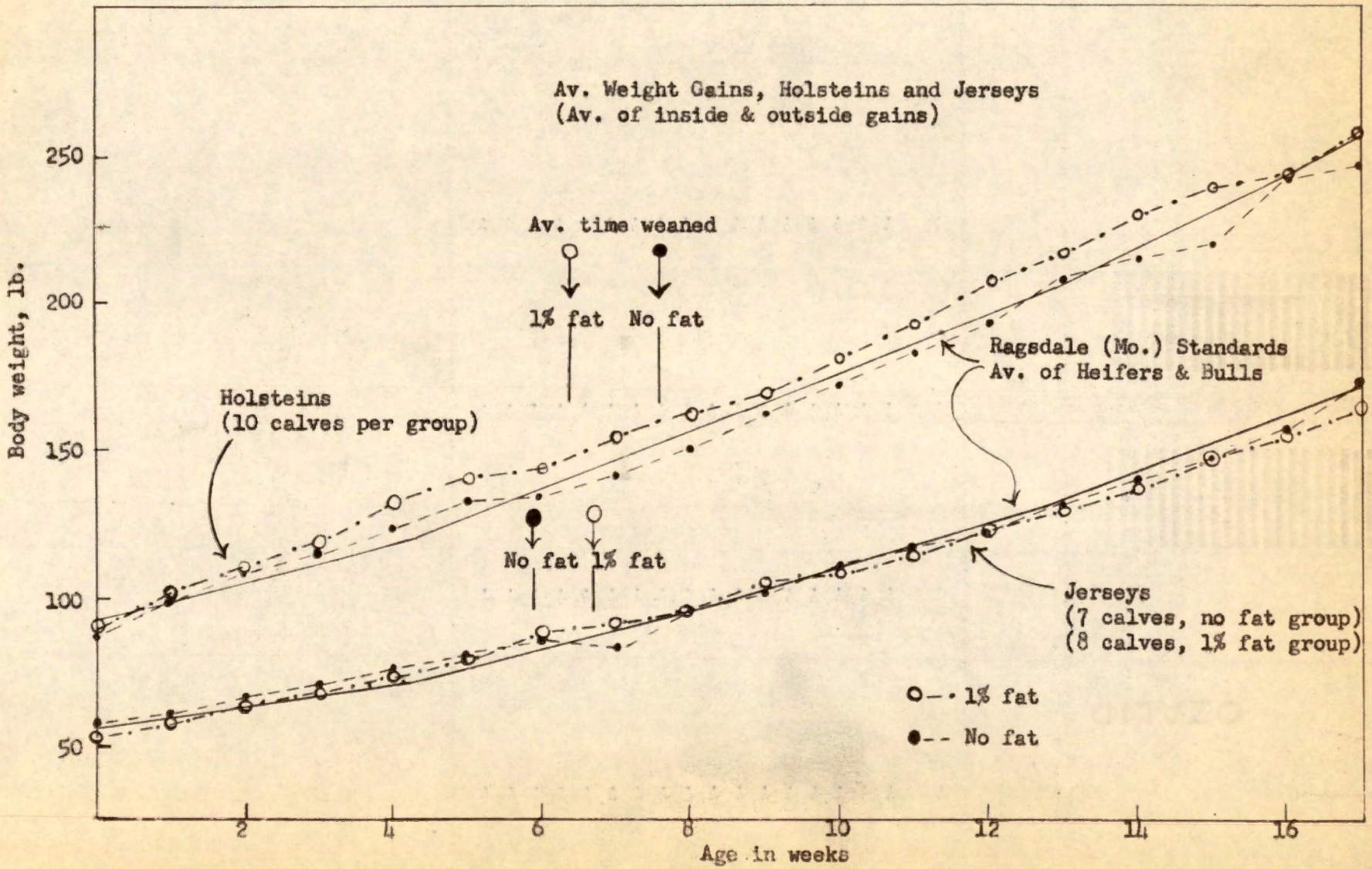


Figure 11. Average gains in weight of Jersey and Holstein calves fed a milk replacement containing no fat or 1% fat.

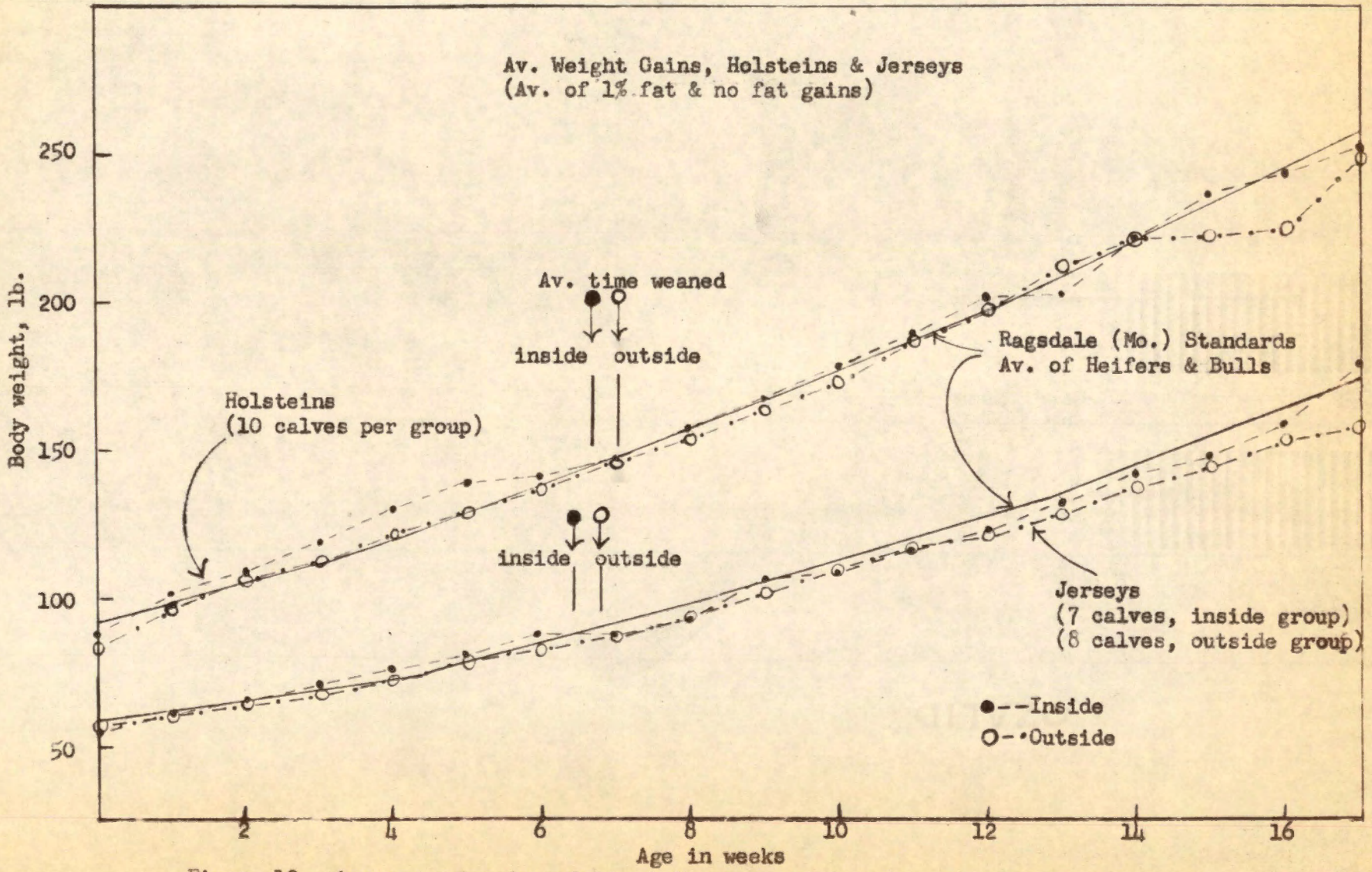


Figure 12. Average gains in weight of Jersey and Holstein calves housed in inside or outside pens.

weeks, but after this period very little difference can be noted between any of the groups. The average total gain for the Holstein inside group was 162.7 lb., and it was 164.1 lb. for the outside group. Though it appears that the Holstein inside group (Figure 12) made significantly larger gains the first six weeks than the outside group, these differences were not statistically significant. With the exception of the outside Jersey group the last two weeks of the trial, all groups made gains comparable to the Ragsdale (78) standards.

Gains in height at withers. The average cumulative gains from seven to 42 days for the four groups of Holsteins were 2.6 and 2.1 inches, respectively, for the inside-no fat and 1% fat calves, and 2.4 and 2.3 inches, respectively, for the outside-no fat and 1% fat calves. The Jersey gains were 1.9 and 2.4 inches for the inside-no fat and 1% fat calves and 1.3 and 1.8 inches for the outside-no fat and 1% fat calves, respectively. These differences were not statistically significant due to treatment but significant ($P = .05$) due to breed.

The weekly average height gains of the 1% fat and no fat groups (average of inside and outside gains) are presented in Figure 13. The gains by all groups were consistent with little difference between groups. With the exception of the Holstein no fat group, which had a smaller beginning height than the other groups, all groups made gains comparable to those reported by Ragsdale (78). The total gains made by the Holstein no fat group were 6.8 inches compared to 6.9 inches of the 1% fat group. The Jersey no fat group made total gains of 5.9 inches, and the 1% fat group, 5.6 inches.

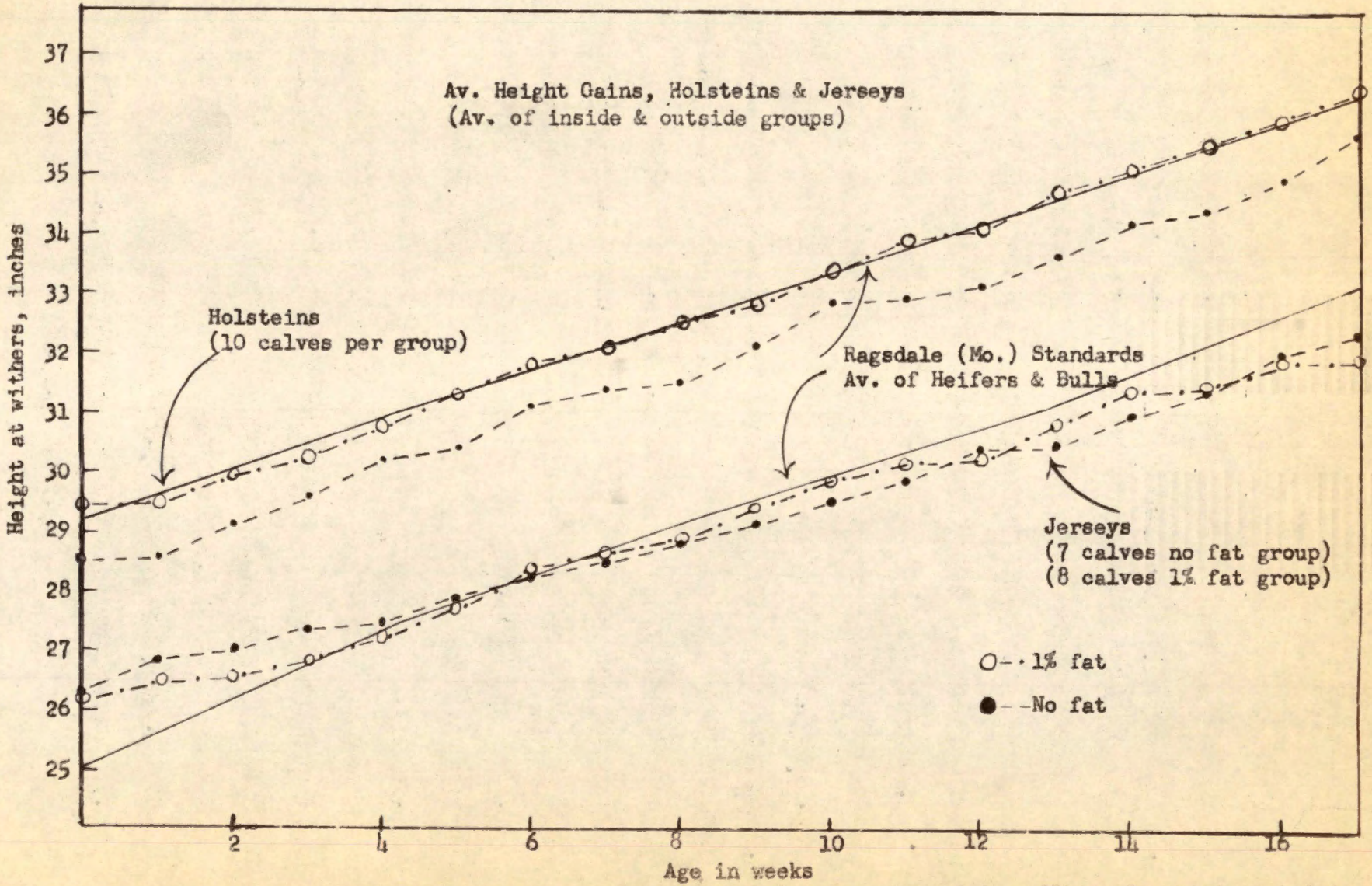


Figure 13. Average height gains of Jersey and Holstein calves fed a milk replacement containing no fat or 1% fat.

The weekly average height gains of the outside and inside groups (average of no fat and 1% fat) are shown in Figure 14. Though the Holstein outside group had a smaller beginning height than the inside group, it made larger total gains. The total gains were 7.1 and 6.5 inches, respectively. The Jersey inside group made gains that exceeded those of the outside group. Total gains were 6.0 and 5.5 inches, respectively. After the fifth week, the outside group dropped below the inside group and the Ragsdale (78) standards but not significantly so.

Heart girth changes. The average cumulative gain made by the Holstein inside-no fat and 1% fat groups (7 to 42 days) was 3.0 and 3.8 inches, respectively. The outside group made gains of 4.5 inches for both the no fat and 1% fat groups. The Jersey calves inside had cumulative gains of 2.8 and 3.8 inches for the no fat and 1% fat group, and 2.1 and 3.7 inches for the outside-no fat and 1% fat groups, respectively. Though these differences appear to be statistically significant, the differences due to breed and ration exceeded the 5% level of probability. The F values were 3.33 compared to Snedecor's (90) 4.20 for the 5% level.

The average weekly gains of the 1% fat and no fat groups (average gain of inside and outside groups) are presented in Figure 15. The Holstein 1% fat group remained above the no fat group during the entire trial but not significantly so. Little difference could be observed between the Jersey groups. The average total gains of the Holstein no fat group and 1% fat group were 11.9 and 12.0 inches, respectively. The Jersey 1% fat and no fat groups were 10.9 and 10.4 inches, respectively. All groups gained consistently. The Jersey calves had

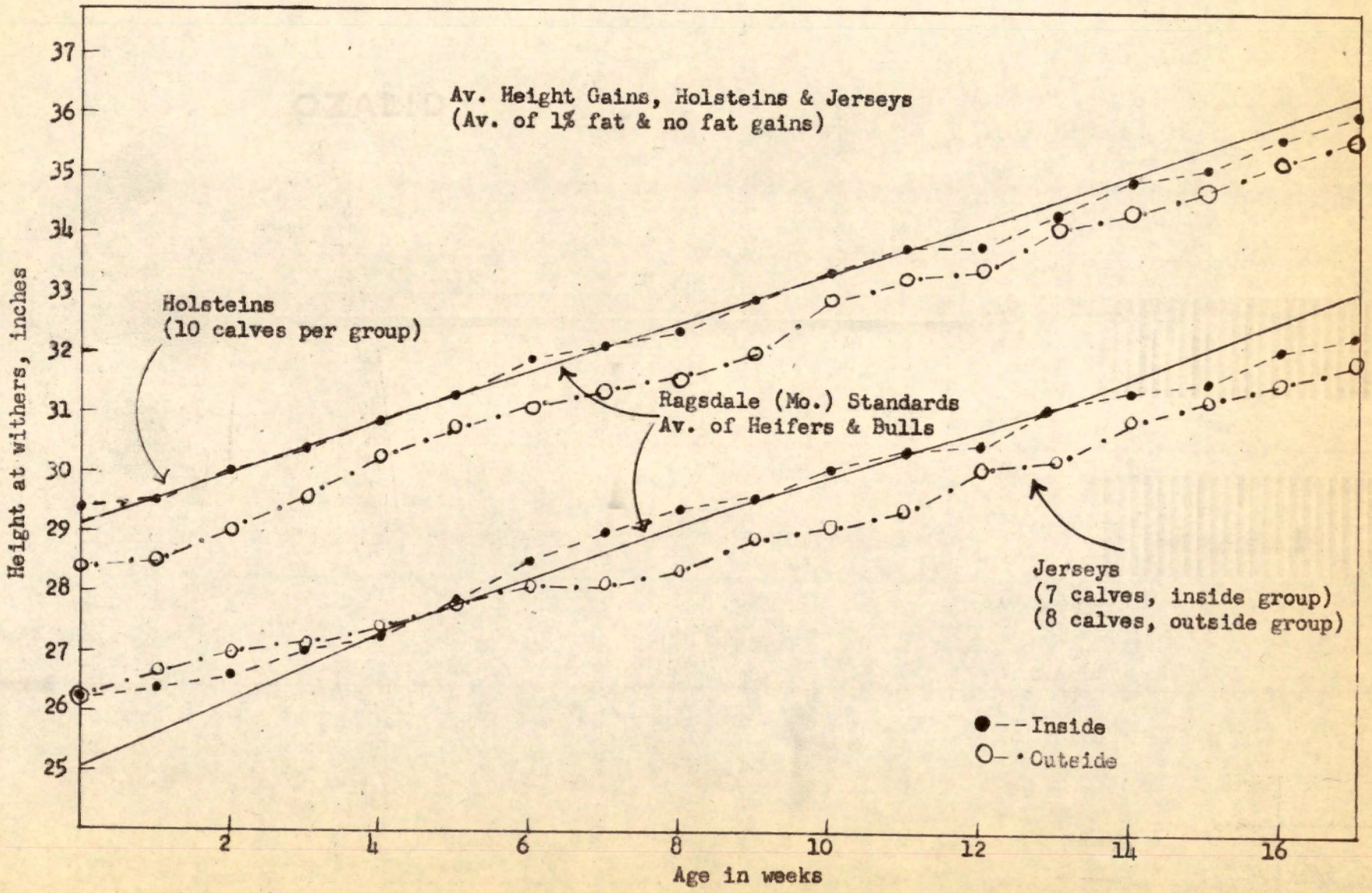


Figure 14. Average height gains of Jersey and Holstein calves housed in inside or outside pens.

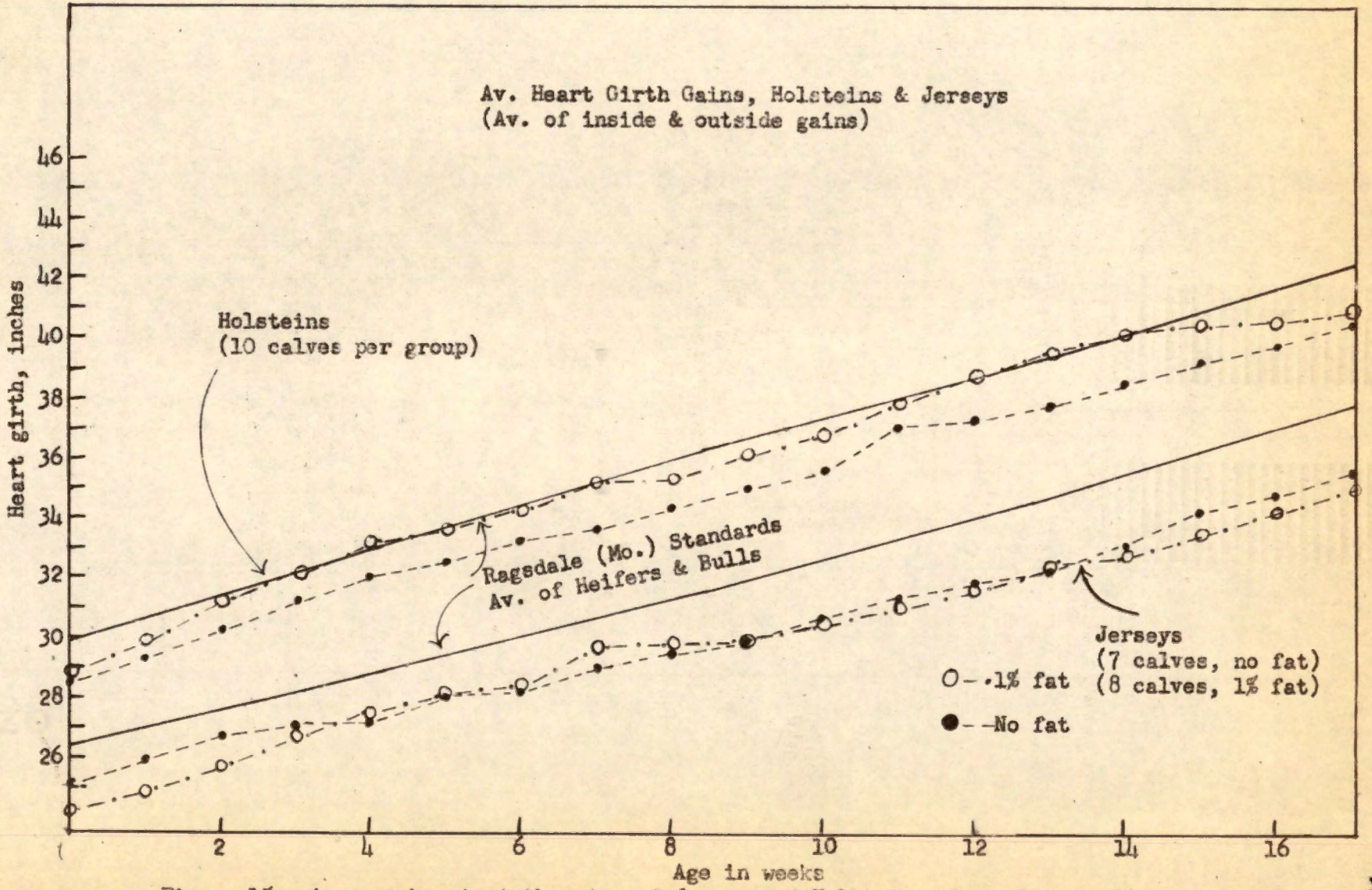


Figure 15. Average heart girth gains of Jersey and Holstein calves fed a milk replacement containing no fat or 1% fat.

smaller beginning heart girth measurements than the Ragsdale (78) standards and remained below them throughout the trial. The Holstein calves did not greatly deviate from the standards.

The average weekly gains of the inside and outside groups (average of no fat and 1% fat) are shown in Figure 16. Except for the Jersey inside group's increased gains over the outside group from the 13th week, little difference can be observed between any of the groups. The average total gains of the Holstein outside and inside groups were 12.2 and 11.7 inches, respectively. The Jersey inside and outside groups made total gains of 11.2 and 10.1 inches, respectively. All of the groups beginning heart girth measurements were smaller than Ragsdale's (78) which partly accounts for their being below the standards during most of the trial.

Milk consumption. The average total consumption of milk replacer from seven days to weaning for the Holstein inside-no fat and 1% fat group was 747.0 and 535.9 lb., respectively. The outside-no fat and 1% fat calves consumed 730.1 and 659.6 lb., respectively. The average age at weaning for the respective groups was 53.6, 43.6, 52.8, and 48.8 days (Tables 17 and 18). The differences in average total milk consumption per group were caused by differences in weaning ages and birth weights.

The Jersey inside-no fat and 1% fat calves consumed an average total of 436.9 and 430.8 lb., and the outside-no fat and 1% fat calves, 397.1 and 464.7 lb., respectively. The weaning ages for the respective

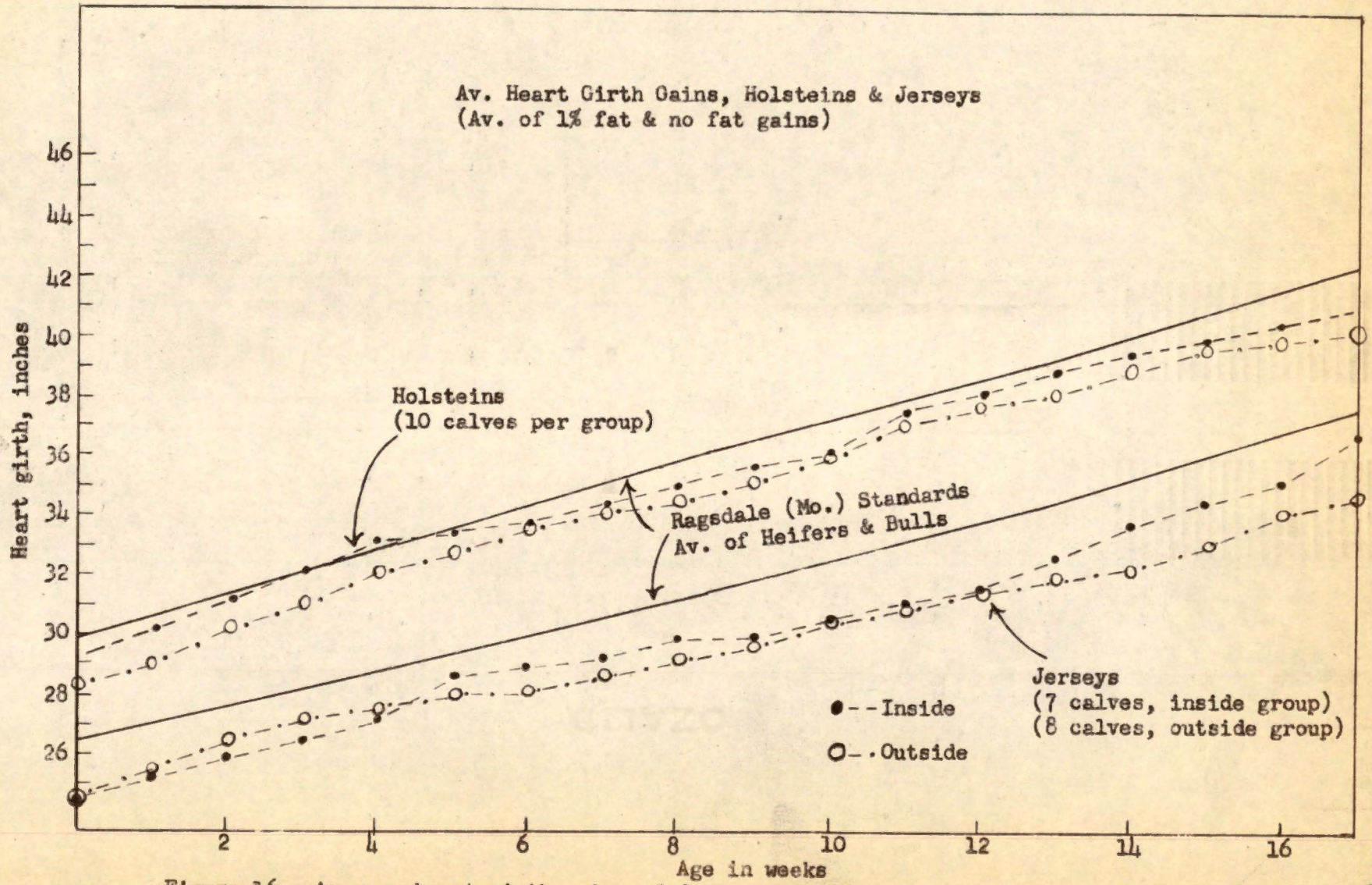


Figure 16. Average heart girth gains of Jersey and Holstein calves housed in inside or outside pens.

Table 17

Comparison of feed consumption of groups of Holstein calves fed no fat or 1% fat and housed in inside or outside pens

	Inside no fat	Inside 1% fat	Outside no fat	Outside 1% fat
	lb.	lb.	lb.	lb.
Milk	747.0	535.9	730.1	659.6
Av. age weaned (days)	53.6	43.6	52.8	48.8
Grain	272.6	294.3	272.5	285.3
Hay	175.3	177.3	155.9	174.7

Table 18

Comparison of feed consumption of groups of Jersey calves fed no fat or 1% fat and housed in inside or outside pens

	Inside no fat	Inside 1% fat	Outside no fat	Outside 1% fat
	lb.	lb.	lb.	lb.
Milk	436.9	430.8	397.1	464.7
Av. age weaned (days)	45.3	45.0	46.5	48.7
Grain	247.6	257.5	273.2	247.7
Hay	72.5	76.8	82.9	101.7

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groups were 45.3, 45.0, 46.5, and 48.7 days. The longer milk feeding period of the 1% fat outside group led to a larger total milk consumption.

Grain and hay consumption. The average total and average weekly cumulative grain consumption of all groups are presented in Tables 19 and 20. The differences in grain consumption from 7 to 42 days were not statistically significant due to treatment. Differences due to breed exceeded the 5% level of probability.

The average weekly grain consumption (average of inside and outside groups) of the 1% fat and no fat groups is shown in Figure 17. Little difference can be observed between the Holstein groups until the ninth week. The 1% fat group ate more grain than the no fat group from the ninth through the 15th week. This resulted in a slightly larger total grain consumption by the 1% fat group. Conversely, the Jersey no fat group consumed more grain than the 1% fat group. This is clearly shown (Figure 17) from the fourth to the seventh week. With the exception of the Jersey no fat group, which began eating grain early, all groups had accelerated grain consumption increases at the sixth week.

The average weekly grain consumption (average of 1% fat and no fat groups) of the inside and outside groups was similar as shown (Figure 18). The Holstein inside group held a slight lead over the outside group during the milk feeding period. Conversely, the Jersey outside group ate more grain than the inside group through the milk feeding period and to the eighth week.

Table 19

Average cumulative grain consumption of groups of Holstein calves fed a milk replacement containing no fat or 1% fat and housed in inside or outside pens

Age days	Inside no fat	Inside 1% fat	Outside no fat	Outside 1% fat
	lb.	lb.	lb.	lb.
7	0.1	0.1	0.1	0.1
14	0.8	0.4	0.4	0.2
21	2.1	1.9	1.1	0.3
28	4.5	3.6	2.3	1.4
35	7.1	7.7	4.4	4.9
42	12.5	11.9	9.0	9.8
29	26.1	25.7	20.5	20.6
56	45.2	45.4	37.9	35.6
63	66.4	70.9	60.2	60.9
70	90.3	98.3	84.6	88.8
77	114.1	126.3	109.3	116.8
84	138.1	154.3	134.0	144.8
91	161.9	182.3	160.5	172.8
98	185.7	210.3	188.1	200.8
105	215.5	238.3	216.1	228.8
112	243.5	266.3	244.1	256.3
119	272.6	294.3	272.5	285.3

Table 20

Average cumulative grain consumption of groups of Jersey calves fed a milk replacement containing no fat or 1% fat and housed in inside or outside pens

Age days	Inside no fat	Inside 1% fat	Outside no fat	Outside 1% fat
	lb.	lb.	lb.	lb.
7	0.0	0.0	0.0	0.1
14	0.5	0.2	0.3	0.4
21	1.5	0.6	0.6	1.3
28	2.9	1.3	2.7	3.0
35	5.5	2.6	7.0	5.1
42	8.4	5.2	14.5	9.3
49	13.4	14.0	24.9	15.8
56	27.4	28.3	40.5	28.5
63	47.5	49.3	60.0	47.9
70	69.0	70.4	81.5	70.3
77	93.6	91.3	106.5	94.2
84	118.5	116.8	132.8	118.7
91	144.3	144.8	160.4	143.5
98	171.6	172.8	188.4	170.0
105	196.5	200.8	216.4	195.7
112	223.3	222.8	244.4	222.0
119	247.6	257.5	273.4	247.2

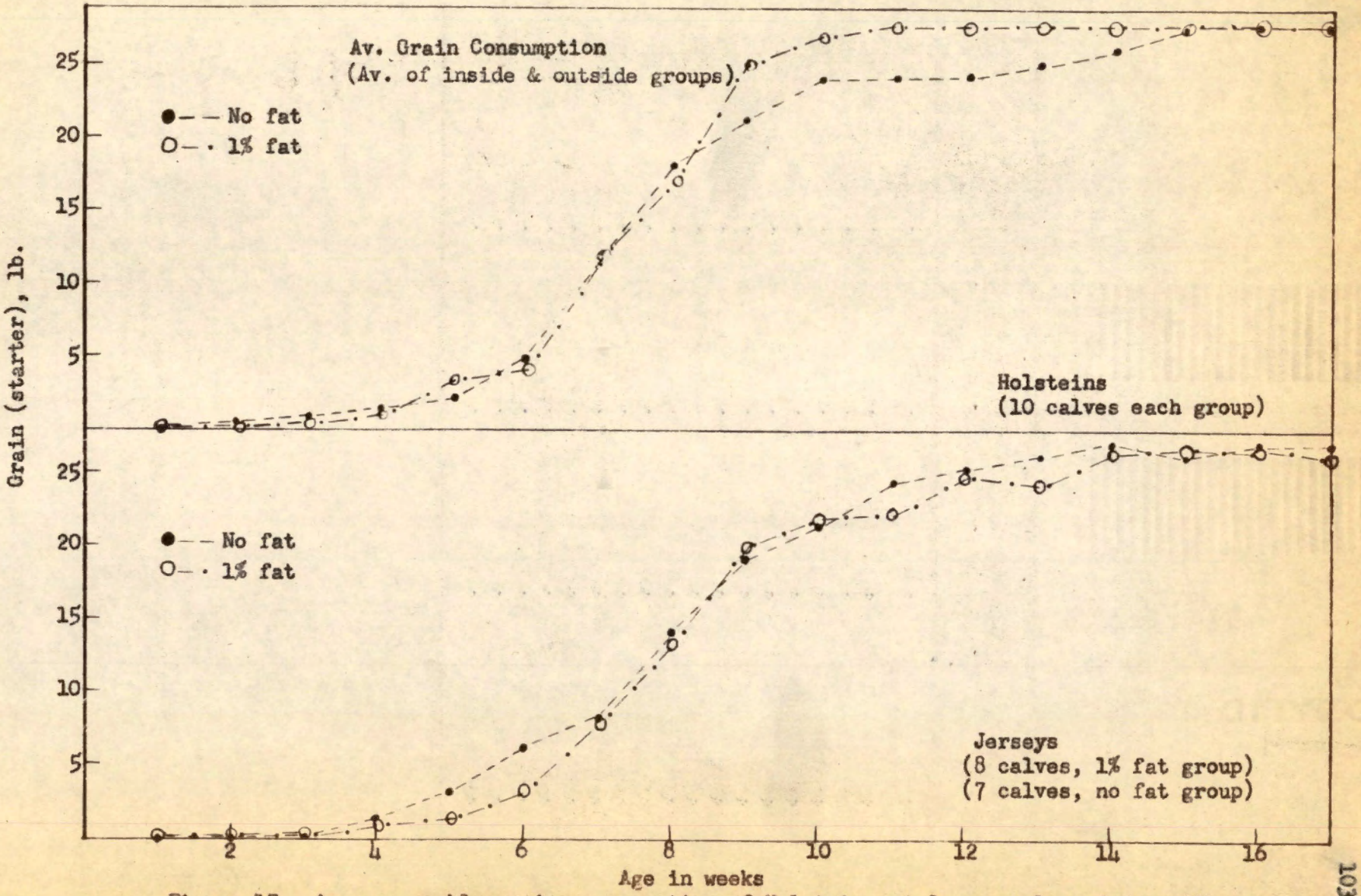


Figure 17. Average weekly grain consumption of Holstein and Jersey calves fed a milk replacement containing no fat or 1% fat.

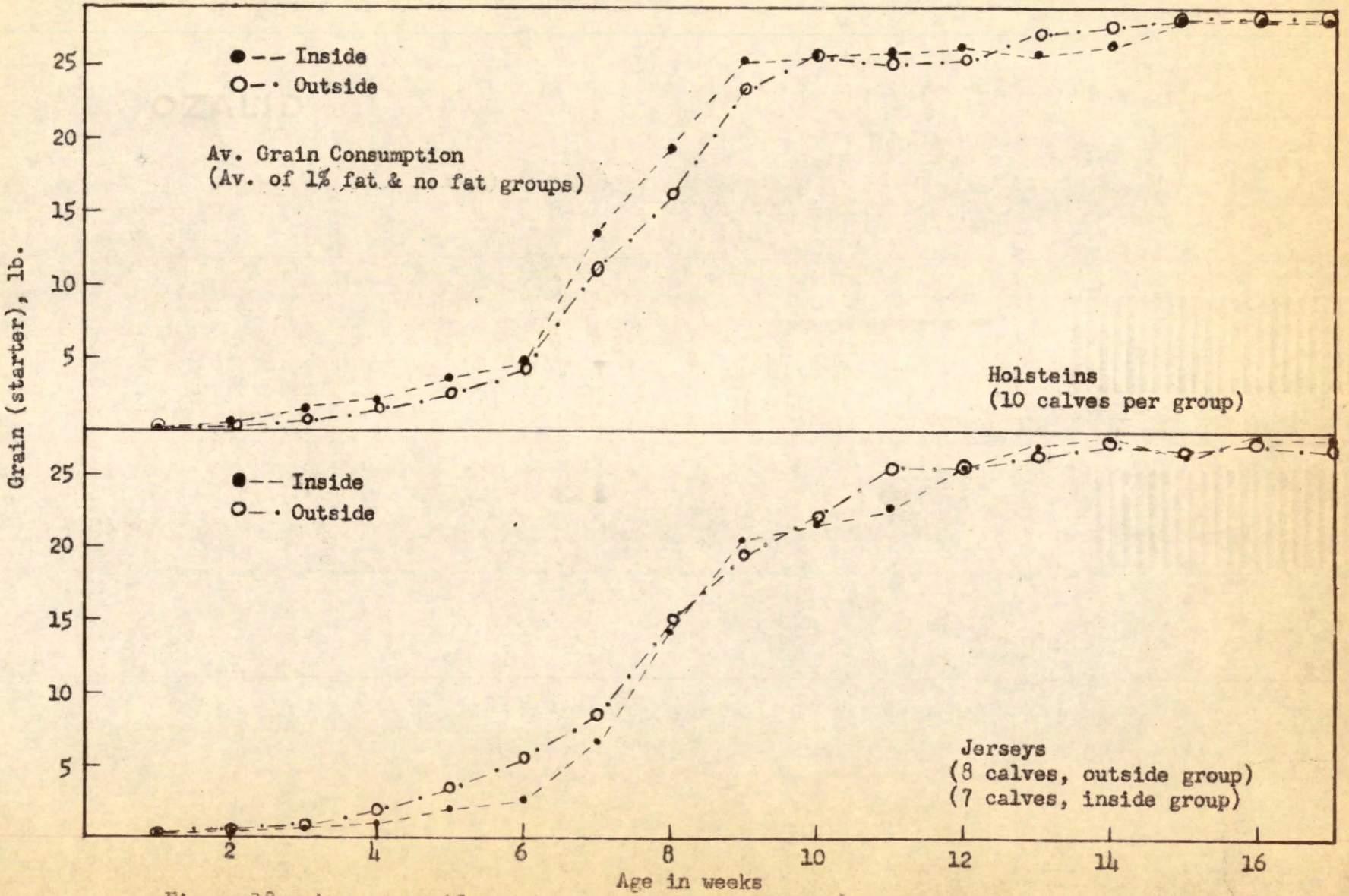


Figure 18. Average weekly grain consumption of Holstein and Jersey calves housed in inside or outside pens.

The average total and average weekly cumulative hay consumption are presented in Tables 21 and 22. The differences in hay consumption from 7 to 42 days were not statistically significant due to treatment. There was a statistically significant difference (P = .05) between breeds.

The average weekly hay consumption of the no fat and 1% fat groups (average of inside and outside groups) is shown in Figure 19. The earlier and greater consumption by the Holsteins can clearly be seen. The Holstein 1% fat group consumed slightly larger total amounts of hay than the no fat group. This was also true with the Jersey groups. The Holstein inside group slightly led the outside group until the 14th week. The Jersey outside group maintained a consistent lead over the inside group during most of the entire trial. This is clearly shown in Figure 20.

Disease. Incidence of diarrhea was high and presented a problem in all groups. Ten of the 20 Holstein calves were affected with scours. Ten of the 15 Jersey calves had diarrhea that was notable. A breakdown of all groups showed that the Holstein inside-no fat and 1% fat calves had four and two cases of diarrhea, respectively. The Holstein outside-no fat and 1% fat calves had two calves each with diarrhea. The Jersey inside-no fat and 1% fat calves had two calves each notable for diarrhea. The Jersey outside-no fat and 1% fat groups had three calves each affected with scours.

An average of all groups for comparison of the 1% fat and no fat groups showed that nine of the 18 calves and 11 of the 17 calves for the respective groups had diarrhea.

Table 21

Average cumulative hay consumption of groups of Holstein calves fed a milk replacement containing no fat or 1% fat and housed in inside or outside pens

Age days	Inside no fat	Inside 1% fat	Outside no fat	Outside 1% fat
	lb.	lb.	lb.	lb.
7	0.0	0.1	0.1	0.0
14	0.1	0.2	0.0	0.1
21	0.4	0.4	0.2	0.1
28	0.9	0.8	0.3	0.5
35	1.7	1.6	0.6	0.9
42	3.4	3.4	1.4	1.6
49	5.7	6.4	3.1	3.0
56	9.2	9.0	5.2	4.9
63	15.0	14.2	8.9	8.9
70	22.2	22.5	14.5	15.4
77	34.3	34.4	24.7	26.5
84	49.2	48.5	37.1	40.9
91	67.3	68.7	53.1	59.1
98	88.5	90.9	74.1	82.5
105	111.3	115.5	99.8	108.9
112	140.1	142.4	126.3	136.8
119	175.3	177.3	155.9	174.7

Table 22

Average cumulative hay consumption of groups of Jersey calves fed a milk replacement containing no fat or 1% fat and housed in inside or outside pens

Age days	Inside no fat	Inside 1% fat	Outside no fat	Outside 1% fat
	lb.	lb.	lb.	lb.
7	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0
21	0.1	0.0	0.0	0.1
28	0.2	0.2	0.2	0.2
35	0.4	0.7	0.7	0.5
42	0.7	0.9	1.4	1.1
49	1.2	1.2	2.2	1.9
56	1.8	2.3	2.6	3.8
63	2.5	3.6	4.7	5.7
70	4.6	5.9	10.2	9.7
77	7.2	8.7	14.9	16.3
84	11.2	13.2	18.2	24.9
91	17.0	20.1	25.7	35.9
98	24.7	29.0	35.9	49.4
105	35.6	41.1	47.0	63.1
112	52.0	56.8	61.9	80.3
119	72.5	76.8	82.9	101.7

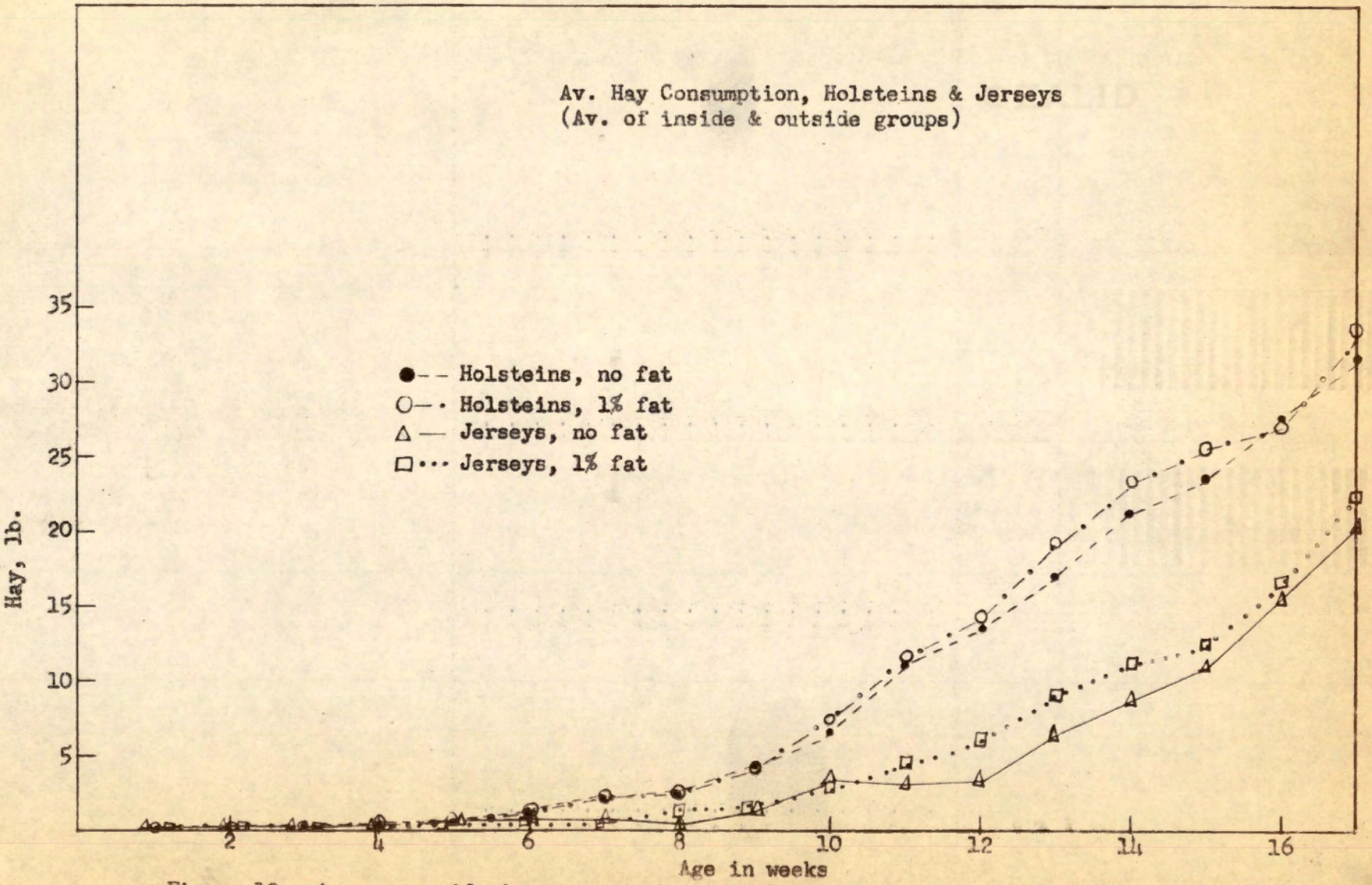


Figure 19. Average weekly hay consumption of Holstein and Jersey calves fed a milk replacement containing no fat or 1% fat.

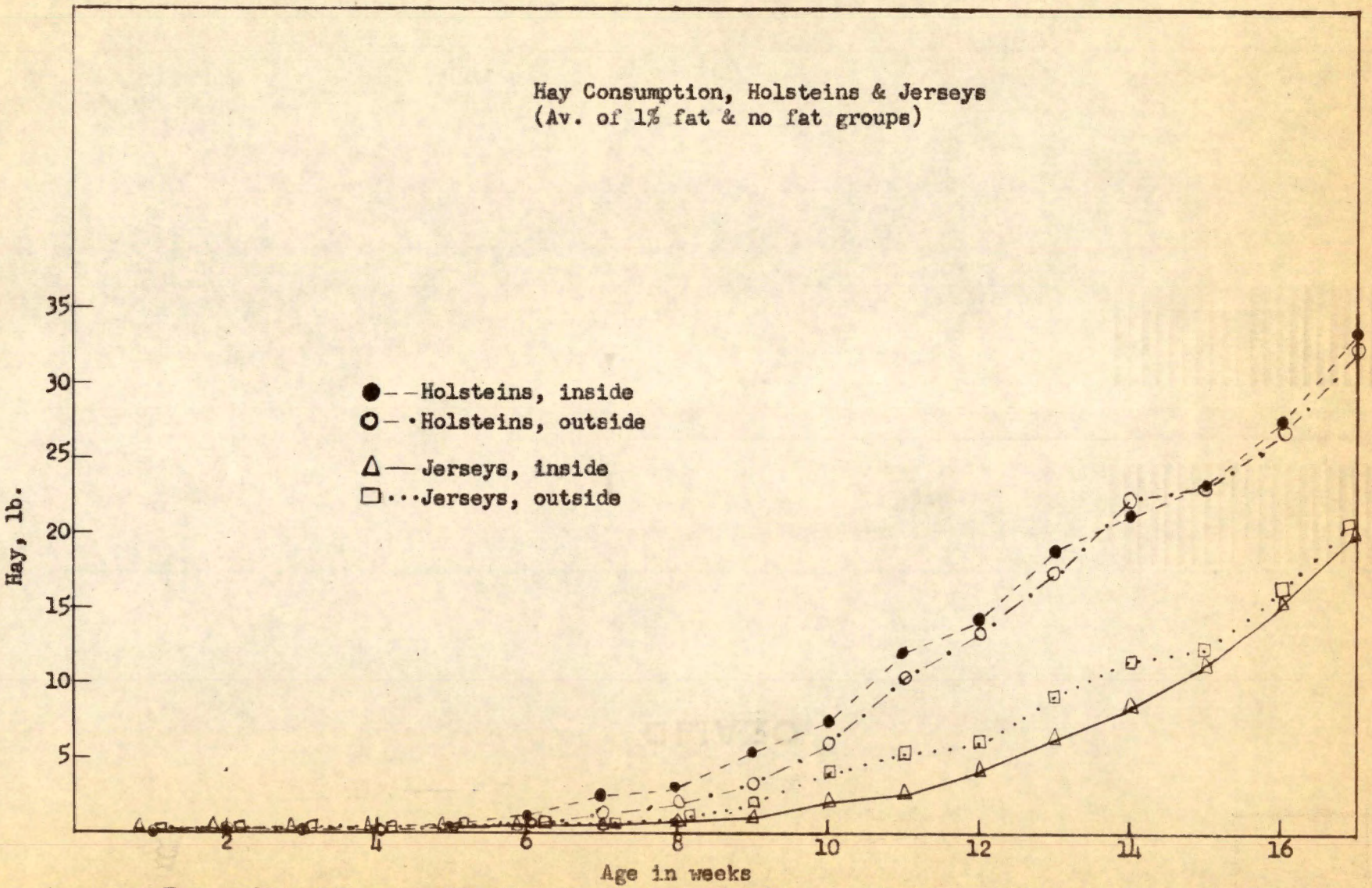


Figure 20. Average weekly hay consumption of Holstein and Jersey calves housed in inside or outside pens.

A comparison of inside and outside groups showed that each group had ten calves each affected with scours. The incidence was lower in the Holstein calves than the Jerseys.

The calves sick with diarrhea were treated with a scours remedy until recovery. Several of the calves in the outside pens became sick with diarrhea and respiratory ailments. The calves were treated with penicillin by the University veterinarian. Three of the calves succumbed to diarrhea and probable pneumonia. Two Jersey calves in the outside-no fat group died at the ages of 51 and 64 days. One Jersey calf in the inside-1% fat group died at 59 days of age.

DISCUSSION

This experiment, to compare a minimum-fat milk replacement to one containing 1% fat, and outside pens to inside pens, demonstrated that there is no significant advantage in supplementing 1% fat in the milk replacer, or housing calves in outside pens. Except for differences due to breed, the differences in growth gain between groups were not statistically significant. None of the groups representing a specific treatment made spectacular gains, nor did any specific treatment seem to have negative growth results upon the calves in regard to nutrition. These findings are in agreement with Gullickson, et al. (27) who fed a very fat-poor diet consisting of skim milk, a concentrate mixture of ground molasses, beet pulp, dry skim milk, starch, and cerelose. No hay was fed, but colostrum was fed the first several days. Cod liver oil was supplemented daily. Though the calves' hair coats were rough, their health was good. Average daily gains of 1.07 lb. were made. Other studies (16, 38, 42, 83, 105) have reported similar success in rearing calves on low-fat diets.

The weight gains of all calves were above the Ragsdale (78) standards at weaning (Figure 11) and remained near them throughout the trial. With the exception of the slight lead by the Holstein calves receiving the 1% fat ration, little difference can be detected between the other groups in regard to weight gains. The height and heart girth gains were consistent in all groups. With the exception of the differences due to breed, the differences between groups were not statistically

significant. Smaller beginning measurements than those reported by Ragsdale accounted for some of the groups remaining below the standards (Figures 14, 16). None of the groups deviated significantly from the standards.

A comparison of inside and outside pens indicated little difference in regard to effects on growth (Figure 12). The differences between groups due to location during the milk feeding period were almost negligible in the statistical analysis. At the end of the 16-week trial however, the Holstein calves were able to tolerate the outside pens more ably than the Jersey calves. This is indicated by a comparison of the total and average daily gains (Tables 13 and 14) of all groups. The Jersey calves in outside pens did not do as well as the Holstein calves in outside pens. This was probably due to the Jersey calves greater susceptibility to respiratory ailments and diarrhea than the Holstein calves. Two of the Jersey calves in outside pens died, and one Jersey calf in an inside pen died.

The differences in milk replacer consumption were great between breeds, but differences within the breeds were not large. The differences between the breeds were due to differences in weaning weights, and the larger quantities of milk fed to the Holsteins on the basis of body weight. The Holsteins were weaned at 150 lb. body weight, and the Jerseys, 90 lb.. The differences within the breeds were due to differences in weaning ages. The Holstein calves receiving 1% fat were weaned earlier than those receiving the minimum-fat diet. The average

weaning ages were 46.2 and 53.2 days respectively. The Jersey calves receiving no fat supplement were weaned before those receiving 1% fat. The average weaning ages were 45.9 and 46.8 days, respectively. Both breeds in the inside pens were weaned earlier than the calves in outside pens. Average weaning ages for the Holstein calves in the inside and outside groups were 48.6 and 50.8 days, respectively, and the Jerseys were 45.1 and 47.6 days, respectively.

The differences in grain consumption between groups from 7 to 42 days were not statistically significant except for breed. The Holsteins consumed greater amounts than the Jerseys (Tables 19 and 20). Little differences can be observed between the Holstein group's grain consumption until the eighth week (Figure 17). The 1% fat group ate slightly more grain during the entire trial than the no fat group. The Jersey no fat group consumed larger amounts of grain during the milk feeding period than the 1% fat group. These differences were not statistically significant. With the exception of the Jersey outside group from the fourth to the seventh week, only little difference can be observed between grain consumption of the 1% fat and no fat groups (Figure 18). The most rapid increases in grain consumption occurred just before or after weaning at the sixth week in all Holstein groups and at the seventh week in the Jersey groups.

The differences in hay consumption from 7 to 42 days were not statistically significant except for breeds. The Holsteins earlier and larger hay consumption than the Jerseys is shown in Tables 21 and

22. The 1% fat groups of both breeds held a slight lead over the no fat groups during most of the entire trial (Figure 19). Differences in hay consumption between the Holstein inside and outside groups were small. The differences in total hay consumption by the Jersey outside groups are clearly shown in Figure 20. The differences were larger in the Jersey groups than the Holstein groups.

Incidence of sickness and diarrhea was a problem in all groups. Incidence of sickness was lower in the Holstein groups than the Jersey groups. The ration appeared to have little effect on diarrhea. The Holsteins had six and four cases, respectively, in the no fat and 1% fat groups. The Jerseys had five cases of diarrhea in each of the 1% fat and no fat groups. A comparison of the inside and outside pens indicated more trouble among the Jerseys than Holsteins when housed outside. The Jersey calves were susceptible to respiratory ailments. Two Jersey calves died of probable pneumonia and complications. One Jersey calf housed inside died of diarrhea and probable pneumonia. There were no deaths in the Holstein groups. The Holstein inside and outside groups had six and four calves, respectively, notable for diarrhea. The Jersey groups had four and six calves, respectively, notable for diarrhea in the inside and outside groups. The inclusion of 15% soya flour in the milk replacer may have partly attributed to the high incidence of diarrhea. Studies by Noller, et al. (70) have shown that young calves cannot digest vegetable ingredients as well as milk proteins. Thus more scouring would be expected when the milk replacer contains vegetable ingredients.

A comparison of feeding 1% fat in a milk replacer vs. a minumum-fat milk replacer under the conditions of this study indicated there is no definite or significant advantage in supplementing 1% fat in the milk replacer. Though studies (43, 44) have shown the calf's dietary need for fat, the amount required for the young calf to make normal gains has not been determined. The results of this study and other studies (27) indicate that only a very small amount of fat is needed in the calf's ration.

A comparison of inside and outside pens indicated no great advantage of one over the other. Location of the calves had no significant effect upon growth or appetite. The health and well being of the Holstein calves in both locations were about equal. The outside location for the Jersey calves appeared to be conducive to respiratory ailments and sickness. On the basis of the results of this study, and under normal conditions, it would seem more feasible to house calves, especially Jersey calves, inside.

CHAPTER VI

SUMMARY

Three experiments were conducted to determine more efficient and economical methods of calf raising. Experiment I was conducted to determine the effects of feeding 10, 15, and 20% of milk solids at 15% of body weight upon the growth, feed intake and well being of the calf. Experiment II was conducted to determine the comparative effect of feeding 10, 15, and 20% solids at 15, 10, 7.5% of body weight, respectively, upon the growth, appetite, and gastrointestinal disturbances of calves. Experiment III was directed to compare a minimum-fat milk replacer with one supplemented with 1% fat, and inside pens versus outside pens.

Highly concentrated milks containing up to 20% total milk solids and fed at 15% of body weight were tolerated by calves without any noticeably detrimental effects. Average daily gains for calves fed 10, 15, and 20% solids were 1.56, 1.59, and 1.53 lb., respectively. The 10 and 15% groups made the most economical gains of the three groups. The total amount of hay and grain consumed by all groups was practically the same. Incidence of diarrhea was not severe in any of the groups.

Experiment II demonstrated that heavy milk feeding up to 15% of the body weight does not promote gastrointestinal trouble. The amount of feed consumed by all groups was practically the same with the exception of hay consumption by the 7.5% group. Hay consumption for the 15, 10, and 7.5% groups was 100.5, 106.1, and 86.6 lb., respectively.

Average daily gains for the respective groups were 1.13, 1.19, and 1.09 lb.. Incidence of scours was low and generally divided among all groups.

Experiment III indicated that there is no significant advantage in supplementing a fat-extracted milk replacement with 1% fat or housing calves in outside pens. The total and average daily gains of the various groups are presented in Tables 13 and 14. The differences in weight gains during the milk feeding period were not statistically significant due to treatment. Differences due to breed were statistically significant for weight gains and hay consumption. The differences in feed consumption among the groups within the breeds were not statistically significant.

The location of the calves had no significant effect upon growth or appetite. The Jersey calves were not able to tolerate the outside pens as well as Holstein calves. Two Jersey calves in outside pens and one Jersey calf housed inside died of diarrhea and probable pneumonia. Incidence of diarrhea was high and generally divided among all groups.

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