COTTONSEED MEAL VERSUS LINSEED OIL MEAL AS THE PRINCIPAL SOURCE OF PROTEIN FOR REPRODUCTION AND LACTATION OF DAIRY HEIFERS

THESIS FOR DEGREE OF M. S.

LANE A. MOORE

1929

PLACE IN RETURN BOX to remove this checkout from your record.
TO AVOID FINES return on or before date due.
MAY BE RECALLED with earlier due date if requested.

DATE DUE	DATE DUE	DATE DUE

COTTONSEED MEAL versus LINSEED OIL MEAL AS THE PRINCIPAL SOURCE OF PROTEIN FOR REPRODUCTION AND LACTATION OF DAIRY HEIFERS.

THESIS FOR DEGREE OF M.S.

Lane A. Moore

1929

THESIS

ACKNOWLEDGMENTS

The author of this thesis wishes to acknowledge the assistance of Mr. C. F. Huffman, Research Assistant in Dairying in carrying out this experiment and the kindly criticism given in preparing this manuscript.

He also wishes to express his gratitude to Professor E. L. Anthony, Head of the Dairy Husbandry Department for his kindly criticism in preparing this manuscript.

The author also wishes to acknowledge his appreciation of the aid given by Dr. E. D. Devereaux of the Department of Bacteriology in carrying out bacterial counts of the udders of the animals on this experiment.

Likewise the author wishes to express his appreciation to Dr. C. S. Robinson of the Experimental Chemistry Department for his aid given in making Iron Analyses in determining the rate of food passage.

I

II

TABLE OF CONTENTS

Page

INTRODUCTION

One of the chief causes of low production and unproditable returns in dairying is a lack of suffieient protein in the ration. Home grown feeds are high in energy and low in protein. It is therefore necessary to purchase a high protein concentrate in order to properly balance home grown feeds for dairy cattle. Efficient sources of this necessary protein are found in cottonseed meal and linseed oil meal.

Cottonseed meal athough it furnishes the cheapest source of protein is not recommended for use in very large amounts. If fed heavily it is thought to produce injury. Cottonseed meal injury has been attributed to beri beri, pyrophasphoric acid, bacteria and molds, betaine and choline, iron deficiency, protein decomposition products, acidosis, gossypol and lack of a factor or factors carried by hay. A lack of a factor or factors carried by hay seems very probalbe in view of thefact that cottonseed meal is a product of the Southern States where cottonseed hulls have been used as a roughage which lack a factor or factors carried by good quality hay. Linseed oil meal on the other hand, a Northern product, has not produced injury because in the North a good quality roughage has been fed.

This investigation is an attempt to determine whether cottonseed meal compared to linseed oil meal could be fed as the principal source of protein for proper growth, reproduction and lactation of dairy cattle with a good quality hay.

cie

tin

feed

prot

chem

is r

reco

cow

rat

pro

eff

Pro

the

are

tai

Mil

co

REVIEW OF LITERATURE AND GENERAL DISCUSSION

Home grown feeds are generally low in protein. Sufficient protein in the ration of dairy cattle is often a limiting factor in growth and milk production. Hence home grown feeds should frequently be supplemented by the use of a high protein concentrate. Cottonseed meal usually furnishes the cheapest available source of a high protein concentrate but is not heartily recommended by all authorities. It is seldom recommended for calves and only in small amounts for lactating cows.

NEED OF PROTEIN IN THE RATION

Proteins or feeds high in protein are needed in the ration for proper growth, maintenance or weight, and milk production. Sufficient amounts are necessary for the efficient utilization of all the nutrients of the ration. Protein or protein feeds also are high in phosphorous and therefore assist in making up mineral deficiencies. Proteins are specifically needed for the amino acids which they contain.

General Need

Milk

Van Slyke (1) quotes the average protein content of cows milk as 3.2 per cent. Therefore a cow producing 40 pounds of milk daily would be producing 1.28 pounds of protein per day. Since the animal body is unable to build up protein to any great extent from carbohydrates or fats, it is therefore apparent that the cow needs considerable protein in the ration for milk production.

Haecker (2) working with some 20 head of animals each year for a period of 8 years, concluded that under ordinary conditions, the ration of a cow should contain 1.5 units of crude protein to one unit of protein produced in the milk.

Hills (3) in trials covering 14 years in which a large number of animals were used, found that the low protein ration which he was using containing 9.76 per cent digestible crude protein was inadequate in respect to its digestible protein content in that it did not enable a cow to produce a full yield of milk.

Ellett and Holdaway (4) working with a small number of cows in comparing narrow and wide rations found that those cows on the wide ration with nutritive ratio, 1:11, decreased in milk flow, at first rapidly and later more slowly.

Savage (5) after two years study, concluded that the Haecker standard for crude protein requirement for milk production should be increased by 35 per cent.

Converse (6) got a 16 per cent increase in milk yield by increasing the protein 20 per cent and the total digestible nutrients 10 per cent over the Haecker standard using 5 cows for 3 thirty-day periods.

Fraser and Hayden (7) in an investigation used two lots of 9 cows each for 131 days. Lot I fed a ration with a nutritive ratio of 1:6, produced 12,553 pounds more of milk than Lot II fed a ration with a nutritive ratio of 1:11. Lot I consumed 54.59 pounds of total digestible nutrients and Lot II consumed 71.91 pounds of total digestible nutrients for each 100 pounds of milk produced. The cows on this experiment were given what they would consume.

Maintenance and Growth

Hills (3) found that a ration containing 9.76 digestible crude protein was inadequate in its digestible protein content in that it did not enable cows to maintain live weight.

Ellett and Holdaway (4) found that those cows on a wide ration, that had a nutritive ratio of 1:11, lost flesh rapidly.

Proper Utilization of Nutrients

Ellett and Holdaway (4) noted the low digestion coefficients on a ration with a wide nutritive ratio of 1:11.

Armsby (8) explains the lowered digestibility of nutrients where protein is limited in comparison to the carbohydrates, in the following manner. The excess of carbohydrates causes an increase in nitrogeneous excretion products in the feces which accounts for the apparent lowered digestibility of the protein part of the ration.

of t

rune

Ther

upon

upon

nitro

insol

diges

Repro

Bohle

of th

A Ho

to 2

stru

prot

This

exte

whic

Phos

It

The lowered digestibility of the carbohydrate part of the ration is due to the fact that the organisms of the rumen have an excess of soluble carbohydrates to act upon. Therefore the more insoluble carbohydrates are not acted upon so that they are left for the digestive juices to act upon and therefore may be excreted. The addition of nitrogenous material stimulates bacterial action upon the insoluble starches, leaving less to be acted upon by the digestive juices.

Reproduction

In a study of the protein necessary for reproduction, Eckles (9) found that the withdrawal of nutrients for growth of the foetus could not be measured on a dry matter basis. A Holstein calf at birth contains as much dry matter as 200 to 275 pounds of Holstein milk.

Hills (3) concludes from 14 records that foetal construction makes a small noticeable draft upon the digestible protein intake to a daily usage of from 0.05 to 0.1 pound. This may amount to 10 per cent of the entire protein intake extending over the entire gestation period, the large part of which, however, comes during the latter part of gestation.

Phosphorus

From an examination of a table compiled by Forbes (10) it is especially noticeable that feeds high in protein carry

a high per cent of phosphorous. Proteins or protein feeds must therefore assist in correcting a phosphorous deficiency in dairy cattle rations.

Reed and Huffman (11) recommended the use of protein concentrates as a source of phosphorous in Michigan dairy rations.

It is apparent from the review of literature that protein or feeds high in protein are essential for the maintenance of weight, milk, production, and reproduction. They also prevent waste of nutrients and furnish a source of phosphorus. The need of protein for milk production appears to be of the greatest importance in the nutrition of dairy cattle.

Amino Acids Required in the Ration

As previously stated, proteins are needed specifically for the amino acids which they contain. The efficiency of some proteins is limited, unless supplemented by other sources of proteins. This is due to a deficiency of certain amino acids which cannot be synthesized by the animal organism.

Osborn and Mendel (12) make this statement: "Obviously the relative values of the different proteins in nutrition are based upon their content of these special amino acids which cannot be synthesized in the animal body and which are indispensable for certain distinct, as yet not clearly defined processes which we express as maintenance and repair".

Hart and Humphry (13) in a study of the efficiency of the proteins of milk, corn and wheat found that the quality of the protein is an important factor in maintenance and milk production. They concluded that the mammary gland will not compensate for deficiencies in protein structure.

In connection with the ability of animals to make up these deficiencies of amino acids, Mathews (14) states: "While it appears that animal protoplasm has in general the same chemical properties as plants, there is no doubt that this power of manufacture of amino acids which is so noteworthy a property of plant life is reduced certainly to a very subordinate power in the animal, for it appears necessary to supply most animals with ready made amino acids".

Apparently some proteins are more valuable than others depending on their essential amino acids content. It therefore seems wise to inquire into the content of amino acids carried by Linseed Oil Meal and Cottonseed Meal. However, before such a study can be of value it is necessary to know what amino acids are necessary. Consequently, a brief review and discussion of the necessary amino acids will be made.

Hawk and Bergeim (15) believe that lysine, tryptophane, cystine and tyrosine are absolutely essential for normal development, while hitidine and proline may also be necessary. The remaining amino acids so far as known are not essential.

Tryptophane

Osborne and Mendel (12) reported that tryptophane was one of the limiting amino acids of casein for proper growth.

Sure (16) found that rats could not synthesize tyrptophane from alanine and indole. He also found that tryptophane was the primary growth-limiting factor in the protein of corn.

Mitchell (17) working with mice on rations composed of isolated amino acids found that mice survived longer if tryptophane was included as one of the amino acids.

Jones, Gersdorff and Moeller (18) noted the high tryptophane content of the proteins of oil seeds.

Ackroyd and Hopkins (19) working with rats observed that rations deficient in tryptophane resulted in a marked loss in body weight.

Lysine

According to Lusk (20) lysine is present in proteins of animal origin. He also pointed out that zein the principal protein of corn, is deficient in lysine. Lusk also stated that lysine is the only amino acid with a straight chain which does not form glucose.

Hart, Nelson and Pitz (21) presented evidence which indicated that the mammary gland cannot synthesize lysine and that this amino acid is not dispensible for normal maintenance.

Buckner, Nollau and Kastle (22) using chicks got better growth on a diet supposed to be high in lysine than with one somewhat low in this amino acid. The grain mixtures used in this work were rather complicated.

However, Osborne and Mendel (23) corborated the work of Buckner, Nollau and Kastle. These investigators working with chicks concluded that chickens as well as rats require lysine for normal growth.

McGinty, Lewis and Marvel (24) working with rats on a gliadin ration which was low in lysine found that several amino and hydroxy derivitatives of caproic acid would not replace lysine. Good growth was made when the gliadin ration was supplemented with lysine or with the inactive d l - lysine.

Osborne and Mendel (25) found that the addition of lysine to a ration containing 9 per cent of the protein edestein improved the growth of rats.

Geiling (26) found that lysine did not appear to be necessary for maintenance of adult mice.

Osborne and Mendel (12) reported that lysine was one of the amino acids necessary for proper growth on a ration consisting of zein as the source of protein.

Tyrosine

Since tyrosine is a cyclic compound, it is reasonable to suppose that the animal body cannot synthesize it. However, very little direct work has been done with this amino acid.

Aberbalden (27) demonstrated that tyrosine was necessary for satisfactory nutrition.

Sure (28) working with rats concluded that tyrosine was one of thelimiting factors of growth with a ration containing 9 per cent lactalabumin as the only source of protein.

Lightbody and Kenyon (29) reported that the growth of rats for a 12 week period on a diet extremely low in tyrosine, was independent of the tyrosine content of the food.

Cystine

Osborne and Mendel (30) found that the additinn of cystine to a diet in which casein was fed at a low level as the sole source of protein, promoted more adequate growth than a ration of casein alone.

Geiling (26) working with mice reported that cystine appeared to be necessary for the maintenance of adult mice.

Sherman and Merrill (31) observed that rats fed on whole milk powder diluted five times its weight with starch and supplemented with yeast grew more rapidly when cystine was added.

Lewis (32) found that the addition of cystine to the diet of dogs on a low protein diet of beef heart diminished the loss of nitrogen from the body. This is interpreted to be the result of a specific demand for cystine for metabolic purposes.

Later Lewis (33) reported the same results when casein was used as the source of protein.

The work of Sherman and Woods (34) showed that cystine aided in the growth of rats on an otherwise adequate ration in which whole milk powder was fed at a low level.

Muldoon, Shiple and Sherwin (35) found that dogs were not able to synthesize cystine or cysteine under stress of brombezene poisioning even though an inorganic form of sulphur was furnished.

Johns and Finks (36) stated that cystine was necessary for proper growth from the protein phaseolin.

Arginine and Histidine

These two amino acids are considered together because they are similar in chemical structure and were considered as inter changeable in animal metabolism by some of the earlier investigators.

Ackroyd and Hopkins (19) using rats reported that when arginine and histidine were removed from the diet of rats which had previously received a complete amino acid mixture, resluted in a rapid loss of body weight. When either arginine or histidine were restored to the ration there was no loss of weight. It was suggested that the body has the ability to convert arginine into histidine and visa versa.

Rose and Cox (37) using rats as a ration of hydrolyzed

casein fr
extracted
gave an
This sho
of the d
the hist
take pla
not mut

La
that ar
purine

I
histidi
ment o
defini

Prolin

indisp
organ

indis
trans

amino
hest
or f

casein from which the arginine and histidine had been extracted, found that the addition of histidine invariably gave an immediate resumption of growth at a normal rate. This showed that histidine is an indispensable component of the diet. However, when arginine was substituted for the histidine in the ration, resumption of growth did not take place which indicated that histidine and arginine are not mutually interchangeable in metabolism.

Later Rose and Cook (38) presented evidence to show that arginine and hestidine are not interchangeable in purine metabolism.

It is apparent from recent investigations that histidine is an essential amino acid. However, the requirement of the animal organism for arginine has not been definitely determined.

Proline

Aberhalden (39) suggests that proline is not an indispensible amino acid in maintenance and that the organism may be able to synthesize it from glutamic acid.

Sure (40) presents evidence which shows proline is indispensable for growth and that the rat is unable to transform pyrolidone carboxylic acid into proline.

It appears from the review of literature that the amino acids, tyrosine, tryptophane, lysine, cystine, and hestidine are absolutely essential for maintenance of weight or for proper growth.

Arginine and proline are probably essential.

Although the field has been fairly well covered as to the essential nature of the amino acids just discussed, one is left somewhat amiss as to what amino acids are necessary for milk production. Since milk protein is supposed to be a fairly complete protein food, one is led to wonder somewhat if the amino acids necessary for growth and maintenance are sufficient for milk production.

COTTONSEED MEAL versus LINSEED OIL MEAL AS A SOURCE OF PROTEIN

In studying the value of a feed which is new or not commonly used, it is a common procedure to compare it with some feed of similar nature in common use. Since linseed oil meal is a feed of high protein content which is commonly fed it is used as a basis for ascertaining the value of cottonseed meal as a source of protein.

Cottonseed Meal

Cottonseed meal is a high protein feed containing 37 per cent (41) digestible protein. It contains many amino acids which give it a high biological value. Many feeding experiments have been conducted with this product. It is manufactured from the delinted cottonseed as follows.(42)

Manufacture of Cottonseed Products

At the crude oil mill, the cottonseed is first run

through revolving screens which separate out the larger pieces of trash mixed with it, then passed over shaking sieves and magnets, and through cyclone cleaners, to get rid of the sand, nails, and dust. Next the seeds are fed into the delinters, where the little short cotton hairs which the gins failed to remove are taken off, compacted into a felt, and rolled out like cotton batting, ready for the mattress maker or gun-cotton manufacture. From the last of these delinters the seed goes to the hullers, which break the hard outer coat or hull and liberate the soft oil containing meats. To separate the hulls and meats as thoroughly as possible, the material as it comes from the hullers is run over shaking screens. The hulls are passed through a second and sometimes a third huller, and then through additional separators until they come out practically free from any of the valuable oil-bearing interior portion. The meats when nearly freed from the hulls are ground through a series of three or more heavy steel rolls, and finally carried into storage bins over the pressroom.

In expressing most of the edible oil abroad several grades are frequently made by a repressing of the same batch of raw material. Cottonseed, however, in the United States, at least, is pressed only once, and when hydraulic presses are used it is always heated or cooked before pressing. The cooking is done in a shallow, steam-jacketed pan equipped

with a m
the mea
many mil
the coo
the coo
The
in the
hydraul
plates
fittin
a seri
other,
One a
meats
fille
as it
press
comes
meal
ther
most

Whic
in s
slab
Cake

with a mechanical stirrer, which, as it revolves, mixes the meats thoroughly and prevents uneven cooking. In many mills a second pan, called a subheater, similar to the cooker and installed just below it, serves to hold the cooked batch until the presses are ready for it.

The type of press most commonly used in this country in the production of cottonseed oil is the steel box-frame hydraulic. It consists of a series of horizontal steel plates set one above the other, and provided with closely fitting steel sides so that the whole machine is really a series of steel boxes without ends piled one upon the other, the lowest box resting upon a hydraulic piston. One after another all the boxes are charged with cooked meats wrapped in heavy press cloths until the press is filled. The compressed air is then turned on, and the oil as it is squeezed out flows down over the sides of the press and through troughs to the settling cistern. Asit comes from the press the dark red oil contains some fine meal. Before being pumped or shipped to the refinery, therefore, it is held in settling tanks or cisterns until most of the finer particles have settled out.

The residue in the steel boxes, the cooked meats from which the oil has been pressed, are taken from the machine in slabs and go on the market as cottonseed cake. These slabs may be cracked and the material sold as "cracked Cake" used chiefly in range cattle feeding; or it may be

broken into smaller pieces and sold as "pea size" cake, used in range sheep feeding. The finer particles are sold as "screenings". The slabs are, also ground and the product sold as cottonseed meal.

An increasing amount of crude cottonseed oil is made in mills equipped with a type of continuous working press known as the expeller. The expeller is built somewhat on the principle of the ordinary meat grinder, and is simply an interrupted screw revolving inside of slotted steel barrel. The ground seed enters through a hopper at one end of the barrel, is pressed along toward the opposite end, and finally discharged around a cone, which can be set in or out of the outlet orifice, to give any desired pressure. Squeezed from the seeds by the pressure of the screw, the oil runs out through the small slits in the barrel, and after settling, or better, filtering through a filter press, is ready for shipment to the refinery. The residue after the oil is pressed out is sold on the market as "whole pressed cotton seed" or "cold pressed cotton seed".

Amino Acids

A complete analysis of the essential amino acids of cottonseed meal does not seem to be available.

Osborne and Voorhees (43) were among the early investigators to report any work pertaining to the proteins of cottonseed meal. They reported a yield of 15.3 per cent globulin from the air dried oil-free product, with which they worked. This, however, constituted only 42.3 per cent of the total nitrogen. of the product studied, so that globulin is probably not the only protein present in cottonseed meal.

Aberhalden and Rostoski (44) determined the mono-amino acids of the "edestin" of cottonseed meal calculated for dry, ash free, "edestin" which were as follows:

	Percent
Glycocoll	1.2
Alanine	4.5
Amino valerianic acid	present
Proline	2.3
Glutamic acid	17.2
Aspartic acid	2.9
Phenylalanin	3.9
Serin	0.4
Tyrosine	2.3
Tryptophane	present

Nevens (45) made a study of the basic amino acids found in cottonseed meal. He analyzed for the following amino acids expressed in percentage of the total nitrogen in the sample.

	Percent
Arginine N	18.736
Cystine N	0.906
Histidine N	7.397
Lysine N	3.807

Nitrogen expressed in percentage of the feeding stuff.

	Percent
Arginine N	1.2733
Cystine N	0.0616
Histidine N	0.5027
Lysine N	0.2588

Hamilton, Nevens and Grindly (46) report the following analysis: (Expressed as percent of the total nitrogen)

	C.S.M. Per cent	Alfalfa Per cent	Corn Per cent	Oats Percent
Arginine N	18.7	8.0	8.73	11.65
Cystine N	0.943	0.991	1.07	0.944
Histidine N	7.171	3.93	4.83	5.80
Lysine N	4.21	4.43	2.2	2.84

Expressed as percent of the feed

	C.S.M. Per cent	Alfalfa Per cent	Corn Per cent	Oats Per cent
Arginine N	1.27	0.210	0.1228	0.196
Cystine N	0.0641	0.026	0.0151	0.016
Histidine N	0.4873	0.103	0.068	0.97
Lysine N	0.286	0.117	0.031	0.048

Nollan (47) gave the analysis of the following feeding stuffs.

Expressed as percent of the total nitrogen

	C.S.M. Per cent	Oats Per cent	Tankage Per cent	Soy Beans Per cent
Arginine N	12.77	11.42	12.34	15.92
Cystine N	2.74	4.48	2.46	1.52
Histidine N	7.57	9.58	2.18	2.6
Lysine N	1.94	0.00	2.50	7.02

Jones and Conska (48) isolated two globulins from cottonseed meal the 1 and b globulins from a sodium chloride extract which yielded 2.59 and 16 percent, respectively. The material used for extraction was 74 per cent of the original meal, and the percent of nitrogen extracted by the method used was only 39 percent of the total nitrogen.

Apparently all those amino acids listed as essential, tyrosine, tryptophane, lysine, cystine and histidine with possibly arginine and proline, have been mentioned as present in varying quantities in cottonseed meal.

The arginine, cystine, histidine and lysine content of cottonseed meal as analyzed by the different investigators check fairly well. Nollau (47) reported a lower lysine and higher cystine content than the other investigators. It will also be noted that arginine, cystine, histidine, and lysine content of cottonseed meal compares quite favorably with the amino acid content of the other feeding stuffs tabulated.

Although cottonseed meal appears to be quite a complete source of the essential amino acids the true value as a source of protein should be further demonstrated by animal experimentations.

Feeding Experiments

Rats. Gallup (49) using rats investigated the digestibility of cottonseed meal treated in various ways, and fed at different levels in order to get the effect of varying the protein intake upon the digestibility. The results by the Bergeim (50) method are as follows:

Nature of Food	Per Cent of Ration	Average Digestibiliyy	No.of trials
Cottonseed meal	25	61.2	3
" "	44	71.5	2
" " autoclaved	25	50.2	3
" " "	45	64.4	2
" " extracted	31.2	73.6	2
" " "	51.8	81.2	2
" " " and gossypol	31.2	70.7	2
" " gossypol	51.8	75.4	2
Autoclaved seeds	40	64.0	1
" "	66	66.7	2

It will be noted from examination of this data, that in every case the digestibility of the protein was the highest where the larger per cent protein was fed. The average digestibility of cottonseed meal varied 10.3 per cent at the two levels fed. Cooking lowered the digestibility, as shown by the fact that the cottonseed meal which is cooked during the process of manufacture and the autoclaved cottonseed meal had a lower digestibility than the extracted cottonseeds. The presence of gossypol, a toxic principle found in cottonseed meal, did not lower the digestibility.

Jones and Waterman (51) found that the addition of one per cent gossypol to the weight of protein being used in Vitro experimentation, slowed up the action of pepsin and trypsin on the globulin of cottonseed meal.

Nevens (52) obtained 66 percent as the average utilization of the proteins of cottonseed meal for growth using three rats for two periods each. He also noted a supplementing effect in metabolism where alfalfa hay and cottonseed meal were fed together.

Osborne and Mendel (53) obtained satisfactory growth with cottonseed globulin as the only source of protein. Satisfactory growth occurred where cottonseed meal was fed as the sole source of protein at a 15 per cent level and also when cottonseed flour was fed to furnish protein at an 18 percent level. Good growth also occurred at a 9 per cent protein level from cottonseed meal, and even considerable growth occurred at a six per cent level. No toxic effect was noticed by feeding either the cottonseed meal or cottonseed flour.

McCollum and Simmonds (54) reported that cottonseed flour fed as the only source of protein so as to furnish 6 per cent protein in a ration consisting of agar agar, dextrin, butterfat and a salt mixture was sufficient for maintenance of weight.

Richardson and Green (55), (56) carried on quite an extensive investigation with rats using cottonseed flour as the sole source of protein. They were able to keep rats alive from 400 to 565 days with cottonseed flour in the diet as the only source of protein. A ration containing 50 per cent cottonseed flour, protein free milk and butterfat was sufficient for normal growth and development and for reproduction to the third generation. No better growth was obtained but more frequent reproduction with lower mortality occurred by the addition of 5 per cent casein to this diet. The above ration contained approximately 25 per cent protein since the cottonseed flour used contained 51.19 per cent protein. A ration of 50 per cent cottonseed flour witn 5 per cent casein and butterfat without additional minerals supported normal growth and reproduction through the second generation although the second generation did not grow normally on this diet.

Rats which received 50 per cent cottonseed flour as the sole source of protein, minerals and vitamines gained and maintained body weight for 135 days. The addition of butterfat improved the latter ration. No toxic effect was apparent in feeding from 45 to 50 per cent cottonseed flour through four successive generations or during 565 days of the life of one individual.

Later Richardson and Green (57) found that an extract of cottonseed flour fed at the rate to correspond to 50 per cent cottonseed flour in the ration contained sufficient water soluble accessory factors for normal growth. They also reported that cottonseed flour contained a fat soluble accessory factory found in butter fat in that the fat soluble extract of cottonseed flour fed at a very high level took the place of butterfat in the ration.

A ration containing cottonseed flour as the source of protein fed at an18 per cent level induced almost normal growth in the male and better than average growth in the female with fairly normal reproduction, although high mortality occurred among the second generation. Normal growth did not occur at a 9 per cent level of protein and very little growth at 6 per cent level. At a 4 per cent level the rats lost in weight at first and then successfully maintained their weight for 50 days.

The digestibility of cottonseed meal for rats averages approximately 65 per cent. The proteins appear quite complete since they will support growth and reproduction through the third generation when fed as the sole source of protein and will maintain weight fairly well when fed so as to furnish only 6 per cent protein in the ration.

Dogs. Osborne and Mendel (58) determined the nitrogen balance of three dogs fed a diet consisting of 50 per cent cottonseed flour with sugar and lard furnishing the remaining part of the ration. The results of nitrogen utilization were as follows:

Dog 5 - 72.6 per cent
Dog 6 - 67.2 " "
Dog 7 - 74.9 " "

Humans. Rather (59) ran seven digestion experiments on men, three of which were with cottonseed meal, two with cottonseed flour, and two with meat. The digestibility of the protein of cottonseed meal averaged 77.6 per cent and

that of cottonseed flour 78.4 per cent as compared with 96.6 per cent for the protein of meat.

Sheep. Skinner and King (60) found that a ration consisting of cottonseed meal, shelled corn and timothy hay was superior to a ration of shelled corn and timothy hay for fattening lambs.

Jones and Dickson (61) reported that 80-pound lambs can be fed more than one-half pound cottonseed meal daily for a 70-day period with cottonseed hulls without any noticeable ill effects.

Gray and Ridgway (62) fed 65 ewes through the winter on a ration of cottonseed meal and hulls with no ill effects except in one case where blindness occurred. The ewes were fed this ration from 63 to 210 days.

Poultry. Osborne and Mendel (23) found that for poultry, cottonseed flour was a suitable supplement for the proteins of corn gluten.

Phillips (63) reports feeding experiments with chickens in comparing the feeding value of cottonseed meal and butter milk. Thirty birds were placed in each lot with the following rations:

	Cottonseed meal Lot	Lot on Standard Ration
Grain	10 lbs. corn	10 lbs. corn
	10 lbs. wheat	10 lbs. wheat
	5 lbs. oats	5 lbs. oats
Mash	5 lbs. bran	5 lbs. bran
	5 lbs. shorts	5 lbs. shorts
	5.3 lbs. cottonseed meal	50 lbs. butter milk

Average eggs produced per hen for one year 55.69	Average eggs produced per hen for one year 166.87
Total feed consumed 50.24 lbs.	Total feed consumed 63.1 lbs

They concluded that cottonseed meal was worthless for poultry since the production on cottonseed meal was only approximately one-third as much as when buttermilk was fed. No effect upon the fertility of the eggs from these two lots was noted, but the hatchability was less in the case of the lot receiving cottonseed meal.

Evidently, in this investigation the reason for the lower egg production in the case of the cottonseed meal lot was probably due to a considerable lower feed consumption. Therefore, the cottonseed meal ration may have beenless palatable.

The New Mexico Station (64) reports the following data in comparing cottonseed meal and meat scrap as a source of protein in an experiment run for six months with twelve birds in each lot.

Pen No.	Bran	Alfalfa Meal	Cottonseed Meal	Meat Scrap
25	3.75	3.75	none	2.5
26	2.5	2.5	5.0	none
29	3.75	3.75	2.5	none
28	4.5	4.5	1.0	none
27	5.0	5.0	none	none

Results

Pen No.	Eggs Produced	Nutrients Consumed per hen lbs.	Per Cent Nutrients used for edible eggs produced
25	1221	36.78	28.96
26	1336	32.237	37.07
29	1159	32.766	32.30
28	1021	30.075	31.15
27	1138	19.935	51.75

It can be noted that pen 26 recieving 50 per cent of the mash ration as cottonseed meal produced the most eggs and utilized the nutrients consumed for edible eggs produced most efficiently.

Evidently, cottonseed meal proved a very good source of protein in this experiment.

Clayton (65) presented data to show that cottonseed meal comprising as much as 11 per cent and 22 per cent of the mash ration of chickens was more efficient for egg production than meat scrap fed at the same level of protein. He also reported data which indicates that cottonseed meal is good for fattening broilers when it comprises 25 per cent or less, of the mash feed.

Morrison (66) fed beef scrap and cottonseed meal at the same level in the mash of two lots of hens for six months. He found that the cottonseed meal lot produced the most eggs. Morrison concluded that cottonseed meal used as the chief source of protein is palatable to fowls, and will produce eggs when fed judiciously.

Hartwell and Lichtenthaeler (67) compared cottonseed meal with beef scrap. These investigators found as a feed for fattening chicks that there was very little difference in the gains of the chicks. However, they point out that cottonseed meal is always consumed less readily than beef scrap.

Thompson (69) presents data which tends to show that the addition of a mineral mixture composed of bone meal, calcium carbonate and salt is beneficial to mashes where cottonseed meal is used.

Thompson (68) reported that where a ration com posed of a grain ration of oats and milo and a mash composed of 50 per cent ground oats and 25 per cent bran was fed to hens, it caused the appearance of "cottonseed meal spots" in about 8 per cent of the eggs produced.

The "cottonseed meal spot" in an egg is described as a brown spot with a reddish tinge varying from the size of a pin point to one-fourth of an inch in diameter. This spot floats on the surface of the yolk and is readily seen when the egg is candled. Fertility and hatchability of the eggs were not effected. The health of the hens receiving this ration remained unchanged.

Cottonseed meal can be placed in the mash for consumption by chickens in amounts from 10 per cent to 50 per cent without any apparent ill effects upon health. The factor which limits its use in some cases seems to be the lack of palatability.

<u>Swine.</u> Curtis and Carson (70) in 1892 reported that cottonseed meal fed to hogs would cause death in six weeks. They also reported that raw cottonseed, roasted seed, boiled cottonseed meal and boiled seed produced the same effect, although boiling seemed to lessen the apparent toxic effect. They described the effects as follows: "The first sign of sickness, appearing in from six to eight weeks after cottonseed meal is added to the ration, is a moping dullness of the animal with loss of appetite and tendency to lie apart. Within the course of 12 to 36 hours, often within shorter time, the animal becomes restless; staggering in his gait; breathing labored and spasmodic; bare skin showing reddish inflammation; sight defective and both nervous and muscular systems feeble and abnormal in action. The fatal cases all show - "thumps" - spasmodic breathing and in many instances the animal will turn in one direction only. Those pigs, which do not die, become stunted and do not grow".

Emery (71) placed two pigs on experiment which had been fed a ration of skim milk. One pig was placed on a ration of cottonseed meal and wheat bran, while the other received a ration of corn meal and bran. The pig which received the cottonseed meal andbran weighed 88 pounds at the beginning of the experiment and after 103 days weighed 145 pounds, with a failing appetite. The pig receiving the corn meal and bran ration weighed 91 pounds when started and 171 pounds at the end of the experimant.

Dinwiddie (72) reported that three pigs died in 38 days after receiving a ration of one part cottonseed meal and three parts corn chops. Each pig at the time of death had consumed 23 pounds of cottonseed meal. The addition of turnips to the above ration had little beneficial effect. A substitution of bran in place of corn chops proved beneficial. Pigs on a check ration of bran one part and corn chops three parts grew normally. A sow fed 1.3 pounds of cottonseed meal per day during the last 80 days of the gestation period gave birth to three healthy pigs.

Burtis and Malone (73) fed weanling pigs in small pens a ration of one-fifth cottonseed meal and four-fifths corn meal. One-fourth to one-half of the pigs died in from five to seven weeks. In cases where cottonseed meal was replaced after two or three weeks with corn for two or three weeks and this alternating method of feeding continued, the pigs grew normally.

Georgeson (74) placed one lot of pigs on a ration of one-fourth cottonseed meal and three-fourths corn meal, and another lot on one-half cottonseed meal and one-half corn meal. The results were equally disastrous, the pigs of both lots dying within three to eight weeks, the larger ones being the more resistant. In all cases, post mortem examination revealed severe inflammation and congestion of the intestines, lungs, and heart. The authors state, however, that cottonseed meal produces very rapid gain in both pigs and large hogs if the feed is changed before symptoms appear.

Goldberg and Maynard (75) reported that nine pigs out of a lot of twelve died within eight to twelve weeks on a ration of 60 per cent corn meal, 10 per cent wheat middlings, 25 per cent cottonseed meal and 5 per cent molasses with a mineral mixture ad libitum. The pigs weighed from 30 to 50 pounds each when placed on experiment.

Barnett and Goodell (76) successfully fed three hogs for a period of 28 days on a ration of two parts corn and one part cottonseed meal. The hogs consumed an average of 2.3 pounds of cottonseed meal daily, with an average gain of 1.67 pounds per day.

Warren and Williams (77) fed three lots of pigs for 120 days on the following ration:

Lot I

Milo chops 8 parts, C.S.M. 1 part Av. daily gain 0.86 lbs.

Lot II

Milo chops 8 parts, Tankage 6 parts.Av.daily gain 1.13 lbs.

Lot III

Milo chops 8 parts, C.S.M. 5 parts,Tankage 3 parts

Av. daily gain 0.99 lbs.

The pigs in Lot I could not be induced to consume as much feed as the pigs in the other lots. One pig in Lot I died on the 70th day, apparently from cottonseed meal injury. A lack of palatability was the reason for the smaller gains when cottonseed meal was fed.

It is reported from the Texas Station (78) that five

brood sows, receiving a ration containing 15 per cent cottonseed meal stay in good condition and produce as many pigs as do tankage fed sows, but the pigs do not start to grow quite as rapidly as do the tankage fed pigs. The following statement is made: "We have not had any toxic condition with brood sows on pasture where they received a ration containing 15 per cent cottonseed meal and the sows farrow as large litters as do the tankage fed sows". They also note that pigs when fed free choice with a self feeder made good gains and showed no toxic effects when allowed oat pasture, whereas under dry lot or unfavorable pasture conditions the pigs will eat too much meal.

Apparently, cottonseed meal even in small amounts is quite toxic when fed to swine for a very long period of time. Cottonseed meal can, however, be used to advantage for a short period. Pasture, apparently, exerts some influence in neutralizing the bad effects of cottonseed meal.

Horses and Mules. Bell and Williams (79) fed a grain ration of oats, bran and cottonseed meal with oat hay as roughage to nine work horses, while seven of their team mates received a ration of oats and bran with oat hay as a roughage. The amount of cottonseed meal fed varied considerably, most of the animals refusing to eat more than two pounds daily although one consumed three pounds per day. One pound per day per 1000 pounds live weight proved to be the most satisfactory quantity to feed. Mares which were fed cottonseed meal during the period of pregnancy showed no ill effects from its consumption, nor were any ill effects noticeable on the colts when foaled. The feeding of cottonseed meal did not prevent the mares from becoming pregnant. One mare on this experiment died after receiving three pounds of cottonseed meal daily for 46 days. Post mortem examination disclosed an inflamed condition of the stomach and intestines. The indications in this case were that death was due to the effects of cottonseed meal on the system. The effects were not noticeable until too late to prevent the loss of the animal. These investigators also noted that the mares thrived better and consumed their ration containing cottonseed meal more satisfactorily after they were turned on grass.

Burkett (80) after conducting numerous investigations on the types of rations best suited for use in North Carolina, concluded that two pounds of cottonseed meal as a part of the daily ration could be fed to horses and mules with satisfactory results.

Curtis (81) after completing several experiments on feeding cottonseed meal to horses and mules, concluded that two pounds may be successfully supplemented in the ration without any harmful effects. However, if more than two pounds daily were placed in the ration, the feed would be refused after some time.

Templeton (82) carried on some quite extensive investigations on supplementing cottonseed meal in the ration of working mules. In one experiment, four lots of five mules each were used. Lots I and II were turned out to pasture, whereas Lots III and IV were kept in a dry lot during the times they were not being worked. The mules in Lots I and II were paired in teams and those in Lots III and IV likewise. The rations fed Lots I and II were reversed after 150 days and continued for an additional 150 days. The rations of Lots III and IV were likewise reversed. Mules in Lot I received a ration of 10.26 pounds ear corn, three pounds oats, one pound cottonseed meal and 15 pounds of Johnson grass hay per 1000 pounds live weight. The mules in Lot II received a ration of 16 pounds of ear corn and 15 pounds of Johnson grass hay per 1000 pounds live weight. For the first 150 days, Lot I gained an average of 60 pounds and Lot II gained an average of 76 pounds per mule. With the rations reversed, Lot I gained an average of 69 pounds and Lot II gained an average of 45 pounds per mule. Both rations were consumed with apparent relish although the animals gained less on the cottonseed meal ration which contained 1.5 pounds less of total digestible nutrients.

Lot III received a ration of 11.4 pounds of ear corn, 1.1 pound cottonseed meal, and 10 pounds of Johnson grass hay per 1000 pounds live weight, whereas Lot IV received a ration of 13.7 pounds of ear corn and 12 pounds of Johnson grass hay per 1000 pounds live weight. Lot III lost an average of 4 pounds and Lot IV gained an average of 4 pounds per mule. With the rations reversed, Lot III gained an average

of 7 pounds and Lot IV lost an average of 14 pounds per mule although the animals lost some weight on the cottonseed meal ration which contained 2 pounds less of total digestible nutrients. Six mules refused to consume more than 1.1 poundof cottonseed meal per 1000 pounds live weight, while four took to the ration readily and would have consumed more had it been offered. Apparently the oats fed Lot I and II or the pasture played some part in getting the animals to consume the cottonseed mealmore readily than in case of Lot III and IV. The health, spirit and endurance of work and heat were the same when fed the ration of ear corn as the sole concentrate as when fed the ration containing the cottoneed meal or the ration with cottonseed meal and oats.

Gayle and Lloyd (83) wintered five mares weighing 900 pounds each on a ration of two pounds of corn and cob meal, two pounds cottonseed meal, eight pounds silage, and ten pounds of Johnson grass hay with no ill effects.

Seventeen mares averaging 1100 pounds were wintered on a daily ration of 5.6 pounds of ear corn, 1 pound of cottonseed meal, 8 pounds of silage and 10 pounds of Johnson grass hay with an average gain in weight of 50 pounds.

Five colts were fed for 150 days on a daily ration of 0.5 pound corn and cob meal, 1 pound cottonseed meal, 8 pounds silage and 5 pounds of Johnson grass hay.

Twenty-four colts were successfully fed for 150 days on a daily ration of 1 pound cottonseed meal in three different lots, receiving other different ingredients. Nine yearling colts were fed 1.75 pounds of cottonseed meal daily for 150 days with no ill effects. Thirty two-year-old mules were successfully fed 2 pounds of cottonseed meal in their ration for 120 days.

It appears from the foregoing investigations that one to two pounds daily of cottonseed meal can be used as a supplement in a ration for horses and mules. Three pounds evidently produced bad effects where oat hay was used as roughage. Pasture in one case seemed to play some part in making cottonseed meal more palatable while in another case oats and pasture was a factor.

Cattle. Fraps (84) reports the digestibility of the protein of cottonseed meal for steers and sheep as 88.4 per cent.

Rusk and Snapp (85) report that for steers cottonseed meal excelled either ground or whole soy beans as a protein supplement to a ration of shelled corn, corn silage and alfalfa hay. This test was run for 200 days.

Goodell (86) fed two lots of 8 steers each for 140 days. Lot I received a daily ration of 5.8 pounds of cottonseed meal and 78.17 pounds of silage which contained 18.37 pounds of total digestible nutrients. The average daily gain was 1.9 pounds. Lot II received a daily ration of 11.6 pounds of velvet beans and pod meal and 72.03 pounds of silage which contained 21.19 pounds of total digestible nutrients. The average daily gain was 1.59 pounds.

In three other lots of steers, each animal consumed 6.29 pounds of cottonseed meal per day for a period of 108 days with no ill effects. Each lot received a different type of silage.

Templeton and Goodell (87) successfully fed 120 steers an average of 5.24 pounds of cottonseed meal in experiments covering four years with an average of 114 days in each feeding period.

Emery and Kilgore (88) in 1895 fed four steers large amounts of cottonseed meal with no percepti ble effect on the health of the steers. Steer number one fed 92 days, consumed an average of 92 pounds of cottonseed meal, 17.2 pounds cottonseed hulls, gained 150 pounds per day. Steer number two fed for 92 days, consumed 18 pounds cottonseed meal and 15.6 pounds cottonseed hulls per day, gained 155 pounds. Steer number three fed for 135 days, consumed an average of 9.6 pounds cottonseed meal and 14.1 pound cottonseed hulls daily gained 185 pounds. Steer number four which was fed for 135 days, consumed an average of 8.3 pounds cottonseed meal and 12.4 pounds cottonseed hulls daily, gained 240 pounds.

Gully (89) after considerable work using a large number of animals, recommends the use of cottonseed meal and cottonseed hulls for fattening cattle.

Captain Wright (90) fed 2,000 head of steers a ration of 8 pounds cottonseed meal and 25 pounds cottonseed hulls with hay once per week. The steers varied in weight between

850 and 950 pounds when the feeding period started, and when sold weighed between 1141 and 1690 pounds. The average gain for one month was 75 pounds. Three animals died. The cause of death was attributed to pleuro pneumonia.

Forst and Varley (91) attempted to produce mastitis by feeding cottonseed meal for a six month period. They began feeding at the rate of 6 quarts of cottonseed meal per day, and gradually increased to 10 quarts per day. Ten quarts of cottonseed meal weighs approximately 15 pounds. Hay was used as roughage. At the end of the period the animal failed to show any ill effects.

McNutt (92) placed on experiment two lots of calves ranging in age from five to ten months, with six animals in each lot. Lot I received a grain mixture of corn, oats, and wheat bran. Lot II received a grain mixture of cottonseed meal, oats and wheat bran. Each lot received the same amount of corn silage and hay. In Lot II four calves under ten months of age made no gain for the first two months, and appeared unthrifty. The other two calves in this lot which were ten months of age made good gains. The calves in Lot I gained normally. The results tend to show that cottonseed meal should not be fed to calves under ten months of age. The quality of hay used in this experiment was not mentioned. This same investigator fed a bull calf cottonseed meal with skim milk. At first one-fourth pound was fed, and the amount was gradually increased until the calf received one and one-half pounds daily. The calf died 71 days after the feeding of cottonseed meal had started.

Emery (71) reported that three calves which were fed cottonseed meal, skim milk and hay died at 60 days of age. One ate sand while another had convulsions. The cause of death in two of the calves was thought to be due to the cottonseed meal which was fed.

Rust (93) reports observing peculiar toxic symptoms in draft oxen which were receiving two pounds of cottonseed meal per day. He describes the condition as follows: "Edematous swelling appeared at the extremities, the appetite being undisturbed. In later stages weakness of the hind quarters appeared and in single animals disturbances of equilibrium. Four of of fifteen of the affected oxen showed disturbances of vision. Apparently, they became completely blind as was evidenced by their grouping gait and colliding with other animals and surrounding objects. Examination of the eyes revealed no special lesions except marked protrusion of the eye ball and abnormal enlargement of the pupil. The most severly affected animals were slaughtered and the remainder recovered after the administration of laxatives and alteration of the diet including discontinuance of the use of cottonseed meal.

Gautier and Larsen (94) report having recorded a number of poisoning cases of calves directly traceable to the cottonseed meal eaten.

Dinwiddie and Short (95) fed two 400-pound Jersey steers a ration of co ttonseed meal and cottonseed hulls. The cottonseed meal was fed at the rate of 2 pounds a day at the beginning and increased to four pounds during the second month. After 70 days from the time the experiment started there was a loss of appetite, and a loss of weight. The gait of the animals was unsteady and reeling. The defect of locomotion appearing in all four limbs. Blindness occurred, and one animal died. The erythrocyte count of the animal which died was 3,400,000 per cubic mm with the hemoglobin at 50 per cent.

Moore (96) placed three lots of heifers on experiment with five animals in each lot. A summary of feed consumed and milk produced for the first 180 weeks was as follows: Average daily per cow.

Grain

	C.S.M.	Wheat Bran	L.O.M.	Corn Chops	Rice Bran
Lot I	4.86	1.62		0.04	0.08
Lot II		5.11	0.65	0.91	0.14
Lot III		3.51	0.40	0.86	0.16

Roughage

	Rice Polish	Hay	C.S. Hulls	Silage	Green Feed	Milk Produced
Lot I	0.06	9.18		2.92	2.79	13.7
Lot II	0.03	0.22	15.2	0.22	0.62	14.3
Lot III	0.05	6.01		6.09	3.19	11.7

The feed consumed and milk produced for the last 140 weeks ran practically the same as for the first 180 weeks.

Breeding data was given as follows:

	Times Bred	Calves Dropped	Months between calving
Lot I	56	22	14
Lot II	41	24	13
Lot III	29	24	12

There were 14 cases of garget in Lot I.

There was 1 case of garget in Lot II.

There were 2 slight cases of garget in Lot III.

In Lot I one cow lost two quarters of her udder and two cows lost one quarter.

In Lot II one cow lost one quarter of her udder.

Lot I had three cases of retained afterbirth.

Lot II had one case of abortion.

One calf was born dead in Lot I, and another was weak.

The investigators conclude from their results that the feeding of 5 pounds of cottonseed meal per day for any great length of time is injurious to the dairy cow causing inflammation of the udder, difficult breeding and retention of the afterbirth. Mention is not made as to whether the cows of each lot were kept together or separately.

Coombs and Curtis (97) carried on extensive investigations using cottonseed meal as the principal concentrate. Their results will be discussed fully in the latter part of this thesis.

Apparently cottonseed meal furnishes a good source of protein for dairy cattle but if fed in large quantities for a long period of time, it produces injurious effects.

Linseed Oil Meal

Linseed oil meal (old process) is a high protein feed containing 30.2 per cent (41-a) of digestible pro tein. Very little work has been reported upon its amino acid content. It is used and recommended as a feed for all classes of live stock.

Manufacture of Linseed Products

According to Henry and Morrison (41-b), linseed oil meal is the by-product of flaxseed from which the oil has been extracted. The oil is extracted by means of two processes, the "old process" and the "new process". Practically all the linseed oil meal used in the United States is manufactured by use of the "old process".

By the old process the flax seeds are subject to a heating, crushing and pressing process in the extraction of the oil.

By the new process the flax seeds are heated and crushed and the oil extracted by the use of naptha. The new process oil meal contains 3 per cent more crude protein but 2.9 per cent less oil. The protein is slightly less digestible by the new process and the feed as a whole is less palatable.

Amino Acids

No analytical work as to the amino acid content of linseed oil meal seems to be available.

Feeding Experiments

McCollum and Simmonds (54) working with rats, used a ration of 14.3 per cent flaxseed oil meal, 2 per cent agar agar, 75 per cent dextrin, 5 per cent butter fat and 3.7 per cent salts. This ration contains 5 per cent protein, all of which is derived from the flaxseed oil meal. Five of six rats in this lot lost weight steadily and died within three to four months. In a ration similar but containing 6 per cent total protein from the flaxseed oil meal, there was a slow decline in weight. A ration of 8 per cent flax seed protein just served to maintain body weight.

These investigators conclude that, when taken as the sole source of protein, the proteins of flaxseed are of distinctly lower value than are those of wheat, maize and oat kernels.

Little need be said concerning feeding experiments carried out using linseed oil meal. It has always proven of great value as a supplement to ration for most all types of livestock.

Henry and Morrison state (41-c): "Linseed oil meal is one of the most popular dairy feeds and is excellent for horses. It is one of the best protein-rich supplements for fattening. cattle and sheep, and gives good results with swine when fed in a proper combination, but it should not be fed as the only supplement to pigs not on pasture".

Bull (98) states: "Linseed cake or meal is one of the most valuable and useful by-products. It is not only very high in feeding value but unlike cottonseed cake meal, it is a safe and usually a profitable feed with any kind of animals."

Feeding Experiments where Cottonseed Meal and Linseed Oil Meal have been Compared Directly.

Rats. McCollum and Simmonds (54) found that it required 8 per cent flaxseed protein to maintain body weight in rats, whereas only 6 per cent cottonseed meal protein was required for maintenance of weight.

Bethke (99) fed two lots of six young rats each the following diets:

Lot I		Lot II	
Linseed oil meal	30	Cottonseed meal	24.2
Corn starch	59	Corn starch	64.8
Salt mixture	4	Salt mixture	4.0
Crisco	5	Crisco	5.0
Cod liver oil	2	Cod liver oil	2.0

Vitamin B was supplied by 0.5 gm. of Brewer's yeast fed separately to each animal daily. The test continued for 15 weeks.

	Food Intake	Protein Intake	Gain in 15 weeks	Gain per gram of protein
	Grams	Grams	Grams	Grams
Lot I average	1,110	113.4	151.0	1.32
Lot II "	1,175	119.7	150.9	1.26

This investigator reported that proteins of linseed and cottonseed meal were equally efficient for growth of the rat when it was fed on a 10 per cent protein basis. No difference in the behavior of appearance of the rats were observed.

Bethke also ran metabolism trials on rats with the nitrogen level at 2.7 per cent. The dietsused were practically identical with the above rations. An average digestibility of 85.68, and a biological value of 70.83 for the protein was obtained for linseed oil meal on six rats run on two trials each. The metabolism period lasted seven days. In like trials conducted for cottonseed meal the average digestibility and biological value of the protein was 83.57 per cent and 72.2 per cent, respectively.

Sheep. Carmichael (100) reports that a lot of forty wethers receiving a ration of five parts corn and one part cottonseed meal made greater gains than a lot receiving a ration of five parts corn and one part linseed oil meal. Clover and alfalfa hay were used as roughage.

Mumford (101) reports that for sheep a ration of shelled corn, linseed oil meal, and clover hay produced an average daily gain of 2.52 pounds, while a ration of shelled corn, cottonseed meal and clover hay produced an average daily gain of 2.42 pounds. There were twenty animals in each lot.

Poultry. Bethke (99) reports that for growing chicks cottonseed meal protein seems to be superiorto linseed oil meal protein. However, for more mature chicks there was little difference.

Swine. Bethke (99) fed three lots of five pigs each the following rations for 132 days:

	Lot I	Lot II	Lot III
Yellow corn	73	77.8	73
Linseed oil meal	25	C.S.M. 20.2	C.S.M. 25
Mineral	2	2	2
Average daily gain	0.82	0.46	0.52

One pig in Lot I died on the 120th day. Another one, toward the end of the experiment, was inclinded to go into convulsions when disturbed. In Lot III two pigs died, one on the 67th and the other on the 78th day. All lots were kept on dry lot. Young rats on identical rations reproduced on all three rations with a high mortality rate of the young. There was no discernable difference in growth between the two lots of rats.

Horses and Mules. Kennedy (102) fed one horse each of three teams on a ration of 77 parts corn, 15 parts oats and 8 parts oil meal. To the other horse of each pair of the three teams he fed a ration of 70 parts corn, 15 parts oats, and 6 parts cottonseed meal. Both lots received timothy hay as roughage. The feeding period lasted for 154 days, during which time the horses were worked 132 days. The lot receiving the linseed oil meal ration consumed 17.39 pounds of grain and 14.51 pounds of hay per day. The lot receiving the cottonseed meal ration consumed an average of 17.77 pounds of grain and 14.76 pounds of hay. The lot receiving oil meal gained 64 pounds while the lot receiving the cottonseed meal ration gained 83 pounds during the 154 days that the ration was fed. The authors state: "Cottonseed meal gave somewhat better results on the whole than oil meal. The ration containing it was fully as palatable and as efficient in maintaining weight and health of the horses, was less laxative and a little cheaper. The results indicate that a pound of protein in cottonseed meal was fully as efficient as the same amount of protein in oil meal."

Cattle. Kennedy and Marshall (103) in a steer feeding experiment fed two lots of steers, for a period of 94 days, a ration of 25 pounds of corn meal and 4 pounds of linseed oil meal per steer per day to one of the lots, and to another 25 pounds corn and cob meal and 2.5 pounds cottonseed meal per day. Wheat straw was used as a roughage. The animals in the lot fed cottonseed meal were suddenly affected, three of them dying, and the rest going blind and refusing to eat. A post mortem examination revealed the fact that the stomachs were greatly inflamed, being red and blue in color. The investigators state: "We can say without any hesitation that cottonseed meal can be fed with safety to fattening cattle when clover hay and shelled corn are used in connection with it."

Bethke (99) reports the following data obtained for two lots of seven beef calves each fed for a period of 280 days.

Average Daily Feed Consumption and Gain

Lot I	Lot II
6.72 pounds corn	6.04 pounds corn
0.71 pounds L.O.M.	0.64 pounds C.S.M.
4.12 pounds alfalfa	3.71 pounds alfalfa
4.86 pounds corn silage	4.41 pounds corn silage
1.7 pounds gain	1.66 pounds gain

The same amount of feed required per unit gain was slightly less for Lot II. No unfavorable effects were noticed in either lot.

Smith (104) fed two lots of steers for twenty weeks with ten animals in each lot. Both lots were fed 10 per cent of the grain mixture as either linseed oil meal or cottonseed meal. Corn was used for the remaining part of the grain mixture. Corn stover, was used as roughage. The lot receiving the linseed oil meal mixture made the larger gains, although the difference was small. The cattle consumed about eight pounds less of the cottonseed ration.

Garlock (105) relates a study of experimental results obtained in 27 trials conducted at the Missouri, Iowa, Kansas, Nebraska and Pennsylvania stations, in which cottonseed meal and linseed oil meal were compared as supplements to rations of fattening cattle. He found that in six tests the lots which were fed cottonseed meal made larger daily gains, and in 23 of the trials the ones which received linseed oil meal made the larger gains. The fact that in some trials cattle receiving cottonseed products as a supplement made larger daily gains than the ones fed linseed oil meal, and in other trials the lots fed linseed oil meal made larger daily gains than those receiving cottonseed meal indicates a considerable variation in the quality and palatability of these supplements.

Michels (106) fed a group of four cows for three 24-day periods. During periods I and III a ration was fed which consisted of 10 parts wheat bran, 10 parts cottonseed meal, 5 parts corn meal and 5 parts linseed oil meal. During the period II the grain ration differed in that 10 parts linseed oil meal were fed and only 5 parts cottonseed meal. Production during period II was 2,294 pounds milk and production during periods I and III was 2,331 pounds of milk. The cottonseed meal apparently gave slightly larger returns than the linseed oil meal. These investigators also fed cows a grain ration composed of one-third cottonseed meal during the month preceding calving, with no ill effects. The cows received a liberal amount of corn silage during the time these observations were made.

Hart and Humphrey (107) in making a study of the protein of gluten feed, oil meal, distillers grains and cottonseed meal for milk production as a supplement to the proteins of corn meal, corn silage, and clover hay found that the protein feeds under study were of practically equal value. The protein feeds in this investigation furnished 40 per cent of the protein ration. The total protein intake constituted about 12 per cent of the dry matter of the ration.

Later, however, Hart and Humphrey (108) found that the proteins of cottonseed meal were inferior to the protein of distillers grains, gluten feed, and oil meal with a ration of corn meal, alfalfa and corn silage. These investigators, however, did not explain why the per cent of digestibility was so low for all of the rations fed. It is apparent from these investigators that cottonseed meal and linseed oil meal are quite comparable as a source of protein formost animals. However, in some instances cottonseed meal seemed to possess poisonous properties. It has been shown to produce injury in swine, horses and cattle.

POISONOUS EFFECTS OF LINSEED OIL MEAL AND COTTONSEED MEAL

Since cottonseed meal has in some cases proved injurious to certain classes of live stock, a consideration as to the causes of such injury will be made.

Linseed Oil Meal

Almy and Robinson (109) reported that linseed oil meal when fed to trout proved injurious, which they concluded was due to hydrocyanic acid. The trout became blind; turned black, and died.

Henry and Morrison (41) state that there is an enzyme in flaxseed which may produce the poison prussic acid. This enzyme, however, is destroyed by the heating process in both methods of manufacture.

Cottonseed Meal Injury

Cottonseed meal injury has been attributed to several causes, namely, beriberi, pyrophosphoric acid, betaine and choline, bacteria and molds, iron deficiency, protein decomposition products, acidosis, gossypol and lack of dietary factor or factors carried by hay.

Beri Beri. Rommel and Veeder (110) produced what they termed beri beri in pigs by feeding a ration of nine parts steamed polished rice and one part tankage. They produced a similar disease in pigs fed five parts cottonseed meal and five parts corn meal which they attributed to a deficiency similar to beri beri in man.

However, Withers and Carruth (111) could not substantiate the work of Rommel and Veeder. Pigs to which they fed a ration of cottonseed meal supplemented with milk and green feed, died, whereas pigs lived on cottonseed kernels from which the gossypol had been extracted with ether.

Bechdel, Eckles, and Palmer (112) report that the requirement of the dairy calf for vitamin B is either small or this vitamin is synthesized by the animal since calves did not develope beri beri on a ration of corn gluten meal, commercial casein, cane sugar, rice, pearled hominy, corn starch, and dried sugar beet pulp.

Richardson and Green (57) found that cottonseed meal contained a considerable amount of water soluble vitamin.

Pyrophosphoric Acid. Crawford (113) reports that an extract of pyrophosphoric acid from cottonseed meal was toxic to rabbits. He concludes that the cause of cottonseed meal injury is due to a salt of pyrophosphoric acid.

Rather (114) found that the inorganic phosphorus contained in cottonseed meal was less than 5 per cent of the total phosphorus.

Anderson (115) presents evidence which tends to show that the extract used by Crawford was similar to phytic acid.

Withers and Ray (116) were unable to substantiate Crawford's results when they fed rabbits the extract used by Crawford at the same rate the animals would consume if fed cottonseed meal.

Wessles (117) was also unable to substantiate Crawford's results.

Betaine and Choline. Maxwell found (117) the proportions of choline and betaine in cottonseed meal was, choline 17.5 per cent and betaine 82.5 per cent.

Ritthausen and Weger (118) found betaine in the extract of cottonseed, but doubted if it existed as such in the seed. They thought that it was probably a decomposition product.

Bähm (119) obtained cholin from cottonseed.

Wethers and Frap (120) found 0.28 per cent of betaine and cholin in cottonseed meal. The proportions isolated were betaine 79 per cent and cholin 21 per cent.

No evidence is available to show that either betaine or choline form the toxicfactor in cottonseed meal.

Bacteria and Molds. Voelcker (121) observed that moldy and heated feeding cakes, when fed in large quantities, were injurious to cattle.

Koenig (122) reports that bacterial decomposition products of cottonseed meal are not poisonous.

Kopf (123) found several microorganisms in cottonseed meal, one of which (B. vernicosum) was poisonous.

Edgerton and Morris (124) reported that fermented cottonseed meal was less toxic to guinea pigs than unfermented meal. Sterilized meals, which were inoculated with several types of fungi which cause rot in cotton balls in the field, caused very little increase in toxicity when fed to guinea pigs.

Dinwiddie and Short (125) found that fermented meal was no more or less toxic than unfermented cottonseed meal.

It therefore, seems that the action of bacteria and molds upon cottonseed meal plays no part in its toxicity.

Iron Deficiency. McGowan and Crichton (126) attributed cottonseed meal injury to an iron deficiency. The pigs from sows which were fed cottonseed meal and several other types of meals, developed spasmodic breathing and were pale in color. The feeding of forty grams of iron oxide to the sows alleviated the condition. The hemoglobin of pigs from sows which were fed iron was 60 to 80 per cent, and the erythrocyte count was 4 to 6 million per cubic mm. of blood. Pigs from sows which did not receive iron had a hemoglobin reading below 50 per cent and an erythrocyte count below 3 million.

Dinwiddie and Short (95) noted an erythrocyte count of 3,400,000 in a steer which had been receiving a heavy cottonseed meal ration.

Roberts (127) reported that cottonseed meal had little effect upon lowering the per centage of hemoglobin or the number of erythrocytes in swine.

According to Withers and Brewster (128) iron acted as an antidote for cottonseed meal injury in rabbits.

Withers and Carruth (129) reported that iron salts had a beneficial action in preventing cottonseed meal injury in swine in that much larger quantities of meal were consumed, better gains made, and death postponed.

Gallup (130) concluded that iron salts delayed the effects of cottonseed meal injury.

Apparently, it is questionable whether or not cottonseed meal causes an anemic condition. It does, however, seem apparent that iron aids in preventing cottonseed meal injury.

<u>Protein Decomposition Products.</u> Bahnsen and Hutchins (131) state the following: "It is a universally recognized fact that toxins are produced in destructive tissue changes, and it is chemically accepted that such toxins, unless eliminated are capable of and prove to destroy the living organisms. In view of these considerations it is our opinion that fatal cottonseed meal feeding is a manefestation of perverted metabolism and is not due to any specific poison in cottonseed meal."

Friemann (132) says: "The symptoms of poisoning which result from feeding cottonseed meal are said to be due to ptomaines which have a neurin andmuscarin like action. The ptomaine substances are probably formed from the nitrogen components of the lecithen in the meal".

Dinwiddie and Short (125) state: "It may be noted finally that the ill effects from the feeding of cottonseed meal may be due to a prolonged absorption of poisonous products generated in the digestive tract by decomposition and putrefactive changes peculair to this feed".

Aaron (133) states: "In the breaking up of protein by the putrefactive process, a number of substances which have a toxic and injurious effect upnn the body are produced. The best known of these are skatol, indol, and phenol".

There seems to be no supporting evidence to the theory that cottonseed meal injury is due to protein decompostion products.

Acidosis. Forbes (10) reported the excess of acid over bases in cottonseed meal was equivalent to 7.7 cc of normal acid in 100 grams of cottonseed meal.

Wells and Ewing (134) found an excess equivalent of 8.21 cc of normal acid in cottonseed meal. However, work carried out by Wells and Ewing did not substantiate the theory of acidosis as a cause of cottonseed meal injury in swine.

Gossypol. Kuhlmann (135) in 1861 while attempting to recover fatty acids from the "degras" or "foots" of cottonseed oil purification found in the residue after distillation, a substance to which he gave the formula C 17 H24 O_4 and called it "cottonseed blue".

Marchlewski (136) in 1899 isolated a yellow substance from the "foots" of cottonseed oil which he called gossypol because of its phenolic properties. It was isolated as an acetate.

Withers and Carruth (137) in 1915 isolated a substance from cottonseed kernels similar to the substance isolated by Marchlewski.

Withers and Ray (138) reported having fed cottonseed meal to rabbits from which they had evidently extracted the gossypol with gasoline and ether. The extracted meal was much less toxic to rabbits than untreated meal.

Carruth (140) reported that raw kernels contained 0.67 gossypol. Cooking caused the ether soluble, and oil soluble gossypol to be changed to a substance no longer either oil or ether soluble. The substance is termed d-gossypol. A quantative and qualative method for determing the gossypol content of cottonseed meal is also reported.

Carruth (141) later reports the emperical formula of gossypol as $C_{30} H_{28} O_9$ or $C_{30} H_{30} O_9$. This investigator also reports that in the cooking process evidently the toxic substance gossypol is converted to a less toxic substance, d-gossypol. He reported that very little gossypol was found in samples of hot pressed meal.

Sherwood (142) analyzed the gossypol and d-gossypol content of forty North Carolina cottonseed meals. Of these, four were made by the open kettle method, twenty-two by the continuous cooker process, and four by the cold press or expeller process.

	Gossypol	D-gossypol
Expeller	0.02 to 0.102 per cent	0.335 to 0.505 per cent
Open kettle	0.021 to 0.15 per cent	0.544 to 0.963 per cent
Continuous cooker	0.007 to 0.228 per cent	0.633 to 1.076 per cent

Approximately 75 per cent of the gossypol present in the cottonseed kernels is, therefore, converted in the manufacturing process to d-gossypol which is less toxic.

Clarke (143) reported that the molecular fomula of gossypol was $C_{30} H_{30} O_8$. Also of the eight oxygen atoms in gossypol, two have been shown to be present in carbonyl groups, whereas the remaining six have been shown to be present as hydroxyl groups. Two of the hydroxyl groups behave differently from the remaining four, being much more acid and requiring drastic treatment for the hydrolysis of their acetyl derivitatives.

Later Clark (144) reported that rats receiving twenty mg. or more of gossypol per kilo of body weight injected into the intra peritoneal cavity died in from 20 to 13 days. Clark makes the following statements relative to gossypol: "The condition of gossypol, when cottonseeds are treated with heat, appears to change in form in the molecule, possibly due to oxidation or hydrolysis, however, d-gossypol has never been isolated. On the other hand, hot aniline extraction of cottonseed meal gives a crystalline material having the general appearance of di aniline gossypol. The substance has been considered a derivative of d-gossypol, known as aniline d-gossypol. Aniline d-gossypol and dianiline gossypol, which is obtained by condensing gossypol with aniline are identical. This evidence indicates that the gossypol molecule had undergone no chemical alteration such as oxidation or hydrolysis as suggested." He proposes that the gossypol, during the heating process, is brought into contact with the oil, protein, possibly condensing with free amino acids forming a substance similar to di-aniline gossypol. The material is thus rendered physiologically inert. The word "bound gossypol" is suggested instead of

"d- gossypol".

Gallup (145) reported that autoclaving cottonseed meal made cottonseed meal a safe feed for swine. Untreated cottonseed meal proved toxic even when supplemented with calcium carbonate yeast and butterfat. The same held true for albino rats.

Withers and Carruth (146) reported that raw cottonseed kernels containing about 0.6 per cent gossypol were highly toxic to rats, whereas ether extracted material proved non-toxic to rats. The extract proved toxic.

Edgerton and Morris (147) reported that heating cottonseed meal reduces its toxicity.

Schwartz and Alsberg (148) reported the gossypol content of some varieties of cottonseed meal as follows:

Trice 0.411 per cent

Lone Star 0.518 per cent

Durango 0.984 per cent

Egyptian 1.180 per cent

These investigators found a parallelism between the gossypol content of the seeds in toxicity for rats which received adequate diets. They also found that the cottonseed from the Atlantic Coast states contained more gossypol than that from the South Western states.

Schwartze and Alsberg (149) later reported that seeds from the South Eastern states were high in toxicity and those from the Pacific Coast states were still higher. They also reported a high correlation between the oil and the gossypol content. There was considerable variation in gossypol content within the same variety of cotton grown during different years. They concluded that weather, cultivation, and locality are probably greater factors than variety.

Edgerton and Morris (147) also noted variation in toxicity of the same variety grown on the same field, but during different years.

Osborne and Mendel (53), Richardson and Green (56), and Nevens (50) fed cottonseed flour to rats with no toxic effects.

Apparently, gossypol is toxic for pigs and rats. There is nodirect evidence that it is toxic for sheep, horses, or cattle. During the process of manufacture a large part of the gossypol is made less toxic. The gossypol content varies considerably according to locality and climatic conditions. This probably accounts for the variation in toxicity of some meals and for the different results obtained by the different investigators.

Lack of Dietary Factor or Factors Carried by Hay. Reed, Huffman and Addington (150) attributed the cause of cottonseed meal injury to lack of a factor or factors carried by good quality hay. These investigators were able to produce a condition identical with that caused by feeding cottonseed meal and commonly called cottonseed meal injury, by feeding corn, distiller's grain, and corn gluten to two male calves which received wheat straw as roughage, ad libetum.

Huffman and Robinson (151) were unable to raise calves on concentrates where roughage was not fed, even though a

large number of supplements were tried.

Davenport (152) and McCandlish (153) reported similar findings.

Wells and Ewing (134) produced cottonseed meal injury by feeding digester tankage which, they concluded, indicated that if cottonseed meal is fed in a restricted ration and in large quantities, the ration will injure and kill pigs even though it should contain no specific toxic substance.

McGowan and Crichton (126) produced in one case an injury in pigs by feeding Earth nut meal, middlings. Locust bean mealalso produced the same effect.

Combs and Curtis (97) placed on experiment five lots of five animals each, ranging in age from six months to one year, using the following rations:

Lot I Cottonseed meal
Cottonseed hulls

Lot II Cottonseed meal (1/2)
Crushed Corn (1/2)
Cottonseed hulls (1/2)

Lot III Cottonseed meal
Cottonseed hulls (1/2)
Corn Silage (1/2)

Lot IV Cottonseed meal
Copper sulphate solution
Cottonseed hulls

Lot V Cottonseed meal
Cottonseed hulls (1/3/)
Beet pulp (2/3)

Concentrates were fed at the rate of one pound daily per 100 pounds live weight.
Roughage was fed ad libetum.

All animals in Lot I died within 82 to 226 days after starting experiment.

In Lot II two animals died, in Lot III, one, and in Lot IV, two.

Blindness, weakness, abortion, dead, and weak calves occurred. The experiment was finally discontinued. It is, however, interesting to note that in Lot II none of the animals receiving corn silage died.

The work of Combs and Curtis (154) at the North Carolina Station was continued by several different investigators through the years 1922 to 1927 with rations similar to those above, similar results were obtained. In 1923, (155) the rations were supplemented with 5 to 10 per cent alfalfa in the form of meal, with the result that two living calves were produced. Spasms and convulsions did not occur, Other supplements, such as casein, yeast, butterfat, cod-liver oil, steamed bone meal, and precipitated chalk were reportedas being tried.

In 1924 (156) mineral salts added to the ration of cows whose roughage was cottonseed meal, hulls, and grain made up entirely of cottonseed meal, were of no benefit. Calves were born prematurely, and even though some gestation periods were normal, the calves were weak. The addition of small amounts of other supplements, which were described in this report as "certain other substances", proved to be

highly beneficial. The following statement is made: "Where cottonseed meal and hulls have been supplemented liberally with corn silage and cracked corn, the cows receiving this ration have not been able to give birth to normal calves and milk normally. But with the addition of small quantities of certain other substances to the rations, these cows have given normal calves and have milked well above the state average."

Calves could not be raised from the milk of the experimental cows, excepting where the cows were receiving a supplement.

In 1925, (157) a very interesting fact was mentioned as follows: "Approximately five years ago twenty head of cattle on heavy cottonseed meal feeding, kept on a lot of four acres of ground, produced apparently normal living calves. In this lot these cows had access to small amounts of grass which they kept clipped short. This herd was later moved to a small closely fenced lot where no green grass was obtained with the astonishing result that abortions, dead, underweight calves and living blind calves were obtained." It was noted that water soluble B, fat soluble A, and calcium showed beneficial results when all are supplied in the ration.

In 1926 (158) four lots of cows which were fed a concnetrate ration of from 50 to 100 per cent cottonseed meal with a good roughage have reproduced normally. Four groups of cows were placed on an experiment with wheat straw as roughage, and using the following concentrates in each of the four lots:

Lot I Cottonseed meal

Lot II Linseed oil meal

Lot III Peanut meal

Lot IV Soy bean meal

All animals received minerals.

In 1927 (159) the roughage was changed in the above lots to beet pulp and cottonseed hulls. All animals in all groups reacted similarly.

Two animals out of each lot died, and all out of Lot IV. The addition of cod liver oil alleviated the deficiency. symptoms of the remaining animals.

In another group of cows, those animals receiving the poorest quality of rough ge failed to respond as did those where alfalfa hay was used.

Wells and Ewing (160) conducted studies with pigs which indicated that an indequate diet produced cottonseed meal injury. Pigs were fed the following rations.

Feed fed in grams per kilo of body weight.

Pig I C.S.M. 25, starch 6, sugar 2.3^{o},skimmilk 5 cc.

Pig IV Gluten flour 125, starch 6, sugar 2.3^{o},skimmilk 5cc (died)

Pig V Digester tankage 18.5, starch 6, sugar 2.3^{o}, skimmilk 5cc (died)

Pig XI C.S.M. 22.5,starch 6, sugar 2.3^{o}, whole milk 70 cc. gained weight

Pig XII Gluten flour, 12.4, starch 6, sugar 2.3^{o}, whole milk 70 cc, gained weight

Pig I was removed from experiment in order to avoid death. The addition of whole milk appeared to make the ration more adequate.

The Texas Station (78) reported a beneficial effect of pasture when cottonseed meal was fed to brood sows.

Bell and Williams (79) reported that mares thrived better and consumed their ration of cottonseed meal more satisfactorily on pasture.

A lot of mules fed by Temperton (82) which were on pasture part time consumed their cottonseed meal ration more readily than a lot of mules which did not have access to pasture.

Frost and Varley (91) fed a cow approximately fifteen pounds of cottonseed meal per day for six months with hay as roughage with no ill effects.

Apparently, from the results of the above investigators, one would conclude that green pasture, butter fat, cod liver oil, and a good quality of roughage carries some factor which prevents cottonseed meal injury. This injury can also be produced by other concentrates, such as linseed oil meal, soy bean meal and peanut meal.

COSTIVE EFFECT OF COTTONSEED MEAL

Consistency of Feces

It is a common impression among dairymen and investigators that cottonseed meal is costive when fed to cattle in very large amounts and especially when fed without silage. Linseed oil meal on the other hand is considered laxative. According to Henry and Morrison (41-d) cottonseed meal is constipating and should be fed with laxative concentrates such as linseed oil meal, wheat bran or with succulent feeds

such as silage or roots.

McCandlish (161) stated that cottonseed meal has a constipating effect and so should be fed with such laxative feeds as linseed oil meal and bran. He also stated that it was excellent feed for cows on pasture as its constipating action counteracts the effect of washy grass.

Eckles (162) stated that cottonseed meal is somewhat constipating. He stated that cottonseed meal has a costive action.

However, Ewing and Wells (163) stated that cottonseed meal in small quantities seems to produce a normal feces, but when it was the sole ingredient of the ration, the bowel action became slightly laxative, probably due to the oil content.

Curits (164) reported that cottonseed meal is an excellent laxative for horses and for this reason it is desirable to feed with corn.

Jones (61) observed, in fattening tests for 90 days with lambs, a slight tendency toward laxativeness in most of the tests.

Wright (90) fed 2,000 head of cattle and noticed the manure becoming abnormally soft when feeding 8 pounds of cottonseed meal and 25 pounds of cottonseed hulls per day with hay once a week. If the manure became abnormally soft the hay was increased.

It is quite apparent that the evidence concernig the costive effect of cottonseed meal is conflicting.

Rate of Food Passage

Another possible means of studying the costive character of a ration is by means of the rate of food passage.

Reed, Huffman and Addington (150) obtained the rate of food passage by feeding sudan III to heifers fed cottonseed meal compared to linseed oil meal. The first and last appearance of the dye was determined by studying the filtered ether extract of the feces. All the dye passed through the heifers receiving linseed oil meal in 52 hours and 35 minutes. All the dye passed through the heifers receiving cottonseed meal in 48 hours and 20 minutes showing that cottonseed meal was not costive in comparison to linseed oil meal.

Fish (165) fed 6 grams of sudan III in 250 grams of butter and found the first appearance of the dye in the feces 16 to 17 hours after feeding and the last appearance from 48 to 92 hours.

Ewing and Smith (166) fed rubber discs to steers and slaughtered them. They concluded that with a normal ration the average specific time required for the passage of the feed residue probably varies between 72 and 84 hours.

EFFECT OF FEEDING COTTONSEED MEAL ON THE UDDER

It is a common impression among dairymen that cottonseed meal when fed heavily produces mastitis.

Moore (96) reported mastitis and loss of quarters of

cows fed a heavy cottonseed meal ration, whereas, little trouble occurred in another lot not receiving cottonseed meal in the ration. He did not state whether the animals of these lots were kept together or separately.

Forst and Varly (91) in an attempt to produce mastitis in a cow fed from 6 to 10 quarts of cottonseed meal per day for six months with no ill effects. This is approximately 9 to 15 pounds of cottonseed meal daily.

Copeland and Olson (167) working with normal cows reported that milk drawn from each quarter of the udder of 40 cows gave an average bacterial count of 1,541 per cc of milk. Extreme bacterial counts ranged from 0 to 347,000.

Harding and Wilson (168) observed from an examination of 1,230 samples of milk from the udder of 78 normal cows gave a count of 428 per cc of milk.

GENERAL DISCUSSION OF REVIEW OF LITERATURE

Linseed oil meal and cottonseed meal are concentrates high in protein. Protein is one of the necessary constituents of a dairy ration. Proteins are specifically needed for the amino acids which they contain. Cottonseed meal contains all the known essential amino acids. However, the amino acid content of linseed oil meal is not known.

In feeding experiments the proteins of cottonseed meal were very efficient. The proteins of linseed oil meal in feeding experiments were also efficient, although when fed at a low level the proteins of cottonseed meal were superior.

In feeding experiments where cottonseed meal and linseed oil meal have been compared directly, the proteins of both were about equal.

However, cottonseed meal produced injury in some cases when fed to hogs, horses and cattle. The most probable cause of this injury seems to be gossypol and a lack of a dietary factor or factors carried by hay. Since "cottonseed meal injury" has been produced by other concentrates than cottonseed meal it seems probable that for dairy cattle the cause of this injury is the lack of a factor or factors carried by hay.

EXPERIMENTAL WORK

Object

Cottonseed meal furnishes a cheap source of protein for dairy cattle rations. It has not been used extensively because it has seemed to produce injurious effects with several classes of livestock.

The object of this experiment is to find out if cottonseed meal can be fed to dairy cattle for growth, reproduction and lactation as the principal source of protein in an otherwise adequate ration.

In this study cottonseed meal has been compared to linseed oil meal since linseed oil meal is a much used and recommended source of protein for dairy cattle.

ORIGINAL PLAN OF EXPERIMENT

Procedure

Animals Used.

Previous History. The animals used in this experiment, G-1 to G-10 inclusive, are the same as those used by L. H. Addington as reported in his thesis for a Masters Degree in 1927 on "Cottonseed Meal as the Principal Source of Protein for Dairy Heifers". Theyconsist of ten healthy Holstein heifers divided into two lots of five animals each. They have received cottonseed meal and linseed oil meal respectively since three months of age. The female offspring of these animals will also be placed on experiment at birth in the same lots as their dams and continued in a manner similar to the dams, making the problem include the second generation. Male calves will be kept ninety days and then taken off the experiment.

The heifers in Lot I which includes the animals odd numbered, have received cottonseed meal as the principal source of protein. Those in Lot II which include the even numbered animals have received linseed oil meal as the principal source of protein.

These animals received linseed oil meal or cottonseed meal and skim milk to furnish the amount of protein necessary for growth according to the Armsby Standard from three to five months of age. After five months of age they received linseed oil meal or cottonseed meal sufficient to furnish the entire requirement for protein according to the Armsby Standard. They received all the silage and timothy hay they would consume since being placed on experiment. They were given sufficient corn in the ration to properly balance the required therms energy necessary, which were not furnished by the timothy hay, silage or either the cottonseed meal or linseed oil meal as the case happened to be.

The concentrate part of the ration was supplemented with two per cent steamed bone meal and one per cent salt.

The heifers were paired so as to be equal in as many respects as possible. In most cases the smaller animal of each pair was placed in Lot I so that this must be kept in mind in the interpretation of data.

No blindness, convulsions, stiffening of joints or any type of abnormality has been observed. Both groups made normal growth with cottonseed meal and linseed meal as the principal source of protein.

Age. The paired groups of heifers range in age from 12 to 20 months. The female offspring of these animals will be considered as placed on experiment at birth. The male offspring will be used on the experiment until ninety days of age.

Inheritance. A comparative chart and discussion of the inheritance of the animals will be furnished as evidence of the similarity in breeding of the animals.

Choice of Rations

Milk. The offspring of both lots will receive the mother's milk from the pail until forty-five days of age. From forty-five days of age to one hundred fifty days of age they will receive skim milk in amounts up to twelve pounds per day.

Grain. Lot I will receive sufficient co ttonseed meal to furnish all the protein necessary for growth, maintenance, and lactation. Lot II will receive linseed oil meal in similar amounts.

The requirements prior to parturation for both lots will be calculated according to the Armsby Feeding Standard.

After the first parturation the requirements for both lots will be calculated according to the Savage Standard. At any time when the cottonseed meal or linseed oil meal, silage, and timothy hay do not meet the requirements for therms energy as required by the Armsby Standard, or furnished the total digestible nutrietns as required by the Savage Standard, this deficiency will be supplied by ground corn.

The offspring of the animals of both lots will receive whole corn and oats until ninety days of age when they will receive the rations composed of the same feeds as their dams received after ninety days of age.

Roughage. A good quality of timothy hay, grade high No. 2 as to color and purity will be fed in whatever amounts the animals will consume. It will be the object to get the animals of both lots toconsume as much hay as possible. In

any case where bad effects of feeding either linseed oil meal or cottonseed meal are noticed, the amount of hay will be increased and silage reduced. The offspring of the animals of both lots will receive as much timothy hay as they will consume from time of birth.

Corn silage fed the main college dairy herd will be used. The animals in this experiment will be fed as much silage as they will clean up. However, the amount of silage fed will be sacrificed in order that the animals will consume all the hay deemed necessary. The offspring of the animals of both lots will receive silage after ninety days of age or as soon thereafter as the feeder in charge believes they will take it readily.

Minerals. Two per cent of special steamed bone meal and one per cent salt will be mixed with the cottonseed meal, linseed oil meal, and ground corn used.

Management.

Water. The animals will receive water once daily until parturation. After parturation they will be placed in stanchions furnished with drinking cups. During the latter part of the lactation period some of the animals in which the production is quite small will be returned to the method of watering used previous to parturation. During the dry period they will be watered as before parturation.

Shelter. Until parturation time the calves will be kept in the experimental barn. Calves will be kept in box stalls until they become large enough to be tied in modified Graves stalls. After parturation they will be sheltered in the main dairy barn of the College until the latter part of the lactation period.

Bedding. Wood shavings will be used throughout the experiment for bedding.

Care. While the animals are at the experimental barn they will be under the care of a competent feeder in charge of the experimental barn. While the animals are in the main dairy barn they will be under the care of the herdsman in charge.

Feeding Methods. While the animals are at the experimental barn they will be fed twice daily. Silage and grain will be fed in the morning and hay at night. During heavy milk production the animals will be kept at the main dairy barn where they will be fed grain according to the number of times they are milked per day. Silage will be fed twice daily and timothy once daily, at the night feeding.

Milking. After freshening all animals willbe milked three times daily for five months, after which they will be milked twice daily. While the animals are in the main dairy barn they will be milked by a DeLaval milking machine and stripped by hand. While at the experimental barn they will milked by hand. All animals will be dried up approximately sixty days before the time calculated for the following parturation.

Body weights to be used in Calculation of Rations. Rations to be fed each succeeding month will be calculated every calendar month and as near the first as possible. Up to the first parturation of the animals the weight used in calculating the ration to be fed will be that taken for three consecutive days at the beginning of each month. The adjudged theoretical gain for the ensuing month will also be added to the weight in the calculation in order that the animals will be receiving sufficient nutrients at the end of the calendar month. After calving the actual weight at the beginning of the calendar month will be used. The weight of milk to be used in the calculation will be the average of three to four days previous to the time the calculation is made plus five pounds in order to insure sufficient nutrients for the ensuing month.

Collection of Data

Reproduction Data.

Oestrum Periods. The dates of oestrum periods of all animals on this experiment will be noted.

Breeding Data. A complete record of all breeding dates will be kept.

Ease of Parturation. Note will be made of the ease or trouble with which parturation is accomplished by all animals at calving time.

Placenta. The placenta will be examined for any abnormal conditions by a competent pathologist of the Department of Bacteriology.

Recovery. Note will be made of the recovery of the animal from the effects of calving.

Udder. Observations of the udder at calving time will be made in order to detect any abnormality.

Colostrum. Samples of colostrum will be taken by a competent Bacteriologist of the Department of Bacteriology. The types of bacteria in the colostrum will be determined.

Offspring. Note will be made of the apparent strength of the calves immediately after being dropped. Observations will be made to determine whether or not the calf has normal vision. All calves will be weighed before sucking or as soon after birth as possible.

Lactation Period.

Milk. A complete daily milk record of each animal will be kept and summerized by thirty day periods. The milk records will start on the fourth day after calving. The milk will be weighed with a Chatillon spring scale.

Butter Fat. A test by the Babcock method for the per cent of butter fat in each animal's milk will be made every month from a composite sample of two days milk. The butter fat produced will be calculated according to thirty day periods and placed in table form.

Feed Records.

Feed Consumed. A daily record of all feed consumed will be kept. This will be summed up by thirty day periods and placed in table form.

Nutrients Required. The nutrients required by thirty day periods for growth, maintenance, and milk production will be calculated according to the two feeding standards being used, and placed in table form. The average weight to be used for figuring nutrients required for each thirty day period will be calculated from the monthly weight records. The average daily production in pounds for the periods will be used in calculating the nutrients required.

Nutrients Consumed. The nutrients consumed will be calculated from the average daily consumption of each thirty day period. This willbe placed in table form for the purpose of comparison.

Observations.

Weight. All animals willbe weighed every ten days until fifteen months of age, after which they will be weighed every thirty days for three consecutive days. Graphs of growth in weight will be prepared of all animals arranged in pairs and compared to the Eckles Normal.

Height at Withers. Measurements of the height at withers will be taken every calendar month. Graphs will be prepared of all animals arranged in pairs showing the height at withers compared to Eckles Normal.

Consistency of Feces. Observations of the hardness and softness of the feces of both lots of animals will be made each month since cottonseed meal is supposed to be costive.

Rate of Food Passage. An Attempt will be made to measure the length of time required for food to pass through the digestive tract of the two lots of animals since cottonseed meal is supposed to be somewhat costive and linseed oil meal laxative.

Bacterial Flora of the Udder. Since cottonseed meal is believed to cause udder trouble, a study of the udder flora of the two lots of animals will be made.

Condition of Coat. Condition of the coat of the animals in both lots will be observed each month.

Length of Hair. Observations of thelength of hair for both lots will be made each month by measuring with a small pair of calipers. The hair will be taken from the right side in the triangular space between the hip bone and last rib.

Double Thickness of Hide. The double thickness of hide of all animals will be measured each month with a small pair of calipers. The measurement will be taken from the middle of the length of the last rib on the right side.

Looseness and Pliability of Hide. Observations of the pliability of the hide will be made each month by means of feeling and stretching the hide covering the ribs.

Health. Observation will be made each month of the general health of the animals of each lot.

Appetite. Observations will be made each month of the appetite of each animal.

Condition of Flesh. Observations will be made each month as to the flesh carried by each animal.

Lice. Observations will be made each month for the presence of lice.

Shedding. Observations will be made each month for the amount of shedding.

Blindness. Note will be made of any blindness which may occur during the course of the experiment.

Blood Counts. Erythrocyte and Leucocyte counts will be made of cows and calves at calving time. Other counts will be made on the cows at 120 and 270 days after calving.

Blood Tests. All animals will be bled each month for abortion tests. These tests will be made by the Department of Bacteriology.

Photographs. Photographs will be taken of cows and calves at calving time, of calves ninety days and fifteen months of age.

PROCEDURE

Animals Used

The animals used in this experiment were as planned, except that twelve other herd animals were used in an experiment for testing the difference in consistency of feces between cottonseed meal and linseed oil meal.

Eight heifer calves of the second generation were also placed on this experiment. The numbers given these heifers are as follows: G-1's calf, G-11; G-2's calf, G-12, G-5's calf, G-13; G-6's calf, G-14; G-7's calf, G-15; G-10's calf G-16; G-8's calf, G-17; and G-4's calf, G-18. No experimen-

tal data relative to G-17 and G-18 is given because they are only a few months old. The heifers were placed in the same lot as the dams. It so happens that all odd numbers are in Lot I and all even numbers in Lot II.

Age

The age of the animals used in this experiment was as planned.

Inheritance.

The similarity of inheritance of the animals used in this experiment is very close as given in Table XXXI. Eight of the animals, G-3 to G-10 inclusive, were sired by the same bull. Animal G-1 and the dam of G-10 were also sired by the same bull. The dams of G-3, G-4, G-5 and G-6 were sired by the same bull as well as the dams of G-7, G-8, and G-9. Animals G-7 and G-8 are twins. The milk records of the dams of the animals used varied from 7,343 pounds to 9,440 pounds.

Choice of Rations

Milk

Milk was fed to calves as planned except those calves from animals calving the second time were not fed the mother's milk for the first 45 days. This proceedure was discontinued since no ill effects were noted from the first calving.

Grain.

Grain was fed as planned.

Roughage

Roughage was fed as planned.

Minerals.

Minerals were fed as planned.

Management

Water

Was was supplied as planned.

Shelter

Animals were sheltered as planned.

Bedding

Wood shavings were used as planned.

Care

Animals were cared for as planned.

Feeding Methods

Feeding methods were carried out as planned except that while animals were in the main dairy barn they were fed timothy hay twice a day to induce them to consume more hay.

Milking.

Milking was carried out as planned.

Body weights used in Calculation of Rations.

Body weights ... used in the calculation of the ration were figured as planned.

EXPERIMENTAL RESULTS

Reproduction Record

Lot I Cottonseed Meal

Animal No. G-1

Observations to first calving

	Date	Age	Oestrous Cycle	
Born	11-13-25			
Placed on experiment		118 days		
1st oestrum period	10-16-26	337 "		
2nd " "	12- 3-26	385 "	48 days	
3rd " "	1-13-27	426 "	41 "	
4th " "	2- 3-27	447 "	21 "	Bred
5th " "	2-21-27	465 "	18 "	"
Calved	11-23-27	740 "		

Observations at calving time

(a) Ease of Parturation

This animal had little trouble calving except that it was necessary to pull the calf because of its large size. The presentation was normal.

(b) Placenta.

Placenta came away in four hours. Approximately one-half of the placenta in the non-gravite horn came away with the maternal cotyledons still intact. Therewere also a few inter placental areas of attachment but this is also quite normally found in first calf heifers. The placenta was very healthy.

(c) Recovery

This animal recovered in a very normal way from the effects of calving.

(d) Udder

The udder was much softer than normally found in heifers. There was very little hardness, congestion or swelling of the udder.

(e) Colostrum

Quarters one and four showed some blood, staphloccus, albus and a Bacillus Abortus like organism.

(f) Offspring

The calf (female) was very strong and active. It was able to get up for the first milk. No blindness observed. Weight 90 pounds.

Observations first to second calving.

	Date	Age	Oestrous Cycle	
1st oestrum period	1-21-28	799 days		
2nd " "	3- 2-28	840 "	41 days	Bred
Examined	2-29-28			

Uterus normal, ovaries did not seem to be active.

Examined	5-19-28			Pregnant
Calved	11-28-28	1111 days		

Observations at calving time

(a) Ease of Parturation

Calved about two hours after labor started. It was necessary to pull the calf.

(b) Placenta

The placenta was not expelled immediately. Some of it was retained until the sixth day after two treatments with

oil. Two days after she had supposedly cleaned some very bloody and putrid material was passed which appeared to be some more of the placenta. Condition healthy.

(c) Recovery

This animal remained strong and healthy but continued to discharge material from the vagina for about 70 days.

(d) Udder

Udder did not harden up in the usual manner and did not get very large in size.

(e) Colostrum

Straphloccus in all four quarters.

(f) Offspring

The calf (male) was strong and active at birth. However the calf died after 48 hours due to Bacillus Coli infection which was prevalent in the experimental herd at that time. The calf was injected immediately after delivery with anti white scour serum. The dam was washed off with pinol solution before she was placed in the west room of the experimental barn to calve where no cows had calved before. No blindness observed. Weight 87 pounds. Time carried 271 days.

Post Mortem Examination. Drs. Scholl and Meyer.

Subcutaneous Tissues. Negative

Arrangement of Organs. Normal

Peritoneum, Spleen and Pancreas. Negative

Stomach and Intestines. The abomasum contained abundant rather yellow curd and fluid which was very sour smelling.

There was congestion of the mucosa and considerable excess mucus. The intestine contained some yellow fluid and showed considerable congestion.

Liver and Lungs. Showed some congestion and some hemorrhage.

Diagnosis. Septicemia

Observations second to third calving.

	Date	Age	Oestrous Cycle	
1st oestrum period	1-26-29	1170		
2nd " "	3-29-29	1232	62 days	Bred

Animal G-3

Observations to first calving.

	Date	Age	Oestrous Cycle	
Born	1-10-26			
Placed on experiment	4-10-26	90 days		
1st oestrum period	3-16-27	430 "		
2nd " "	4-3-27	448 "	18 days	Bred
Calved	12-31-27	720 "		

Observations at calving time

(a) East of Parturation.

This animal had little trouble calving although it was necessary to pull the calf. Normal presentation.

(b) Placenta.

The placenta came away of its own accord in from four to five hours. Condition - not examined.

(c) Recovery

This animal recovered in a normal manner.

(d) Udder

The udder appeared to swell up in the usual way although the hardness did not disappear until the twentieth day after calving.

(e) Colostrum

Straphloccus and Streptoccus in left front quarter and Straphloccus in left rear quarter.

(f) Offspring.

The calf (a male) was strong and active. It appeared to be normal in every way. No blindness observed. Weight 87 pounds. Time carried 272 days.

Observations from first to second calving.

	Date	Age	Oestrous Cycle	
1st oestrum period	1-28-28	748 days		
2nd " "	2-17-28	768 "	20 days	
3rd " "	3-8-28	788 "	20 "	
4th " "	3-27-28	807 "	19 "	Bred
Examined	7-9-28			Pregnant
Calved	12-27-28	1082 "		

Observations at calving time.

(a) Ease of Parturation

Posterior presentation so that it was necessary to pull the calf.

(b) Placenta.

Placenta came away in about three hours after calving. Condition - healthy.

(c) Recovery.

This animal continued to discharge considerably for about sixty days after calving as shown by abnormal excretions from the vagina.

(d) Udder.

Udder had considerable congestion but did not seem to be abnormal otherwise.

(e) Colostrum.

Sample not obtained.

(f) Offspring.

The calf (female) was strong and normal at birth. No blindness observed. Weight 82 pounds. Time carried 275 days.

Observations from second to third calving.

	Date	Age	Oestrous Cycle	
1st oestrum period	3-12-29	1166 days		Bred

Animal G-5

Observations to first calving.

	Date	Age	Oestrous Cycle	
Born	1-31-26			
Placed on experiment	5-1-26	89 days		
1st oestrum period	2-20-27	385 "		
2nd " "	4-1-27	425 "	40 days	
3rd " "	1-24-28	455 "	20 "	Bred
Calved	1-24-28	722 "		

Observations at calving time.

(a) Ease of Parturation.

It was necessary to pull the calf. Normal presentation.

(b) Placenta.

Placenta came away in four hours. Condition - healthy. On each of three or four placental areas there were six to twelve villi which were calcified.

(c) Recovery.

Recovered in a normal way after calving.

(d) Udder.

Udder contained the usual congestion commonly observed among heifers. The hardness disappeared by the fourth day.

(e) Colostrum.

No sample taken.

(f) Offspring.

The calf (female) was normal and active. This calf had an exceptionally slick appearance. It appeared to have a lot of oil in the coat of hair. No blindness observed. Weight 87 pounds. Time carried 277 days.

Observations from first to second calving.

	Date	Age	Oestrous Cycle	
1st oestrum period	2-10-28	739 days		
2nd " "	3-10-28	768 "	29 days	
3rd " "	4-21-28	810 "	42 "	Bred
4th " "	5-31-28	850 "	40 "	"
Examined	12-1-28			Pregnant
Calved	3-5-29	1127 "		

Observations at calving time.

(a) Ease of Parturation.

Calved some time during the night. Apparently normal.

(b) Placenta.

Passed placenta during the night. Condition - normal.

(c) Recovery.

Recovered in a normal manner. Showed some discharge for about two weeks.

(d) Udder.

Had a little congestion but no more than normal for a freshening cow.

(e) Colostrum.

Left hind quarter was gargety. Straphloccus in right front quarter. Streptoccus in right rear and left front quarters.

(f) Offspring.

The calf (male) was strong and able to get the first milk. Normal. No blindness observed. Weight 95 pounds. Time carried 278 days.

Animal G-7.

Observations to first calving.

	Date	Age	Oestrous Cycle	
Born	5-21-26			
Placed on experiment	8-18-26	89 days		
1 st oestrum period	8-3-27	439 "		
2nd " "	8-24-27	460 "	21 days	Bred
Calved	5-21-28	730 "		

Observations at calving time.

(a) Ease of Parturation.

It was necessary to pull the calf. A normal presentation.

(b) Placenta.

The placenta came away in five hours. Condition was very healthy.

(c) Recovery.

Recovered normally from the effects of calving.

(d) Udder.

The udder was congested the usual amount for a freshening cow.

(e) Colostrum.

No organisms identified.

(f) Offspring.

The calf (female) was quite small but was strong and normal in every way. Was able to get the first milk without aid. No blindness observed. Weight 63 pounds. Time carried 270 days.

Observations from first to second calving.

	Date	Age	Oestrous Cycle	
1st oestrum period	8-13-28	814 days		
2nd " "	9-4-28	836 "	22 days	
3rd " "	11-27-28	920 "	84 "	Bred
Examined	2-2-29			Pregnant

Animal G-9

Observations to first calving

	Date	Age	Oestrous Cycle	
Born	9-3-26			
Placed on experiment	12-6-26	94 days		
1st oestrum period	10-31-27	425 "		
2nd " "	1-1-28	485 "	60 days	Bred
Examined	3-23-28			Pregnant
Calved	10-2-28	760 "		

Observations at calving time.

(a) Ease of Parturation.

Calved in a normal manner.

(b) Placenta.

Passed placenta in four and one-half hours.

Condition - healthy.

(c) Recovery.

Recovered in a normal way. Showed some discharge for a short period after calving.

(d) Udder.

Udder seemed quite hard and swollen but the swelling disappeared in 20 days.

(e) Colostrum.

No sample taken.

(f) Offspring.

The calf (female) seemed normal in every way at birth and was able to get up and get the first milk. However, the calf died in 48 hours after birth evidently from Bacillus

Coli infection. No blindness observed. Weight 75 pounds. Time carried 275 days.

Post Mortem Examination.

Subcutaneous Tissues and Arrangement of Organs. Normal

Peritoneum. Slight congestion.

Spleen and Pancreas. Negative.

Stomach and Intestines. The abomasum contains some rather sour smelling curded milk, some grey material and much mucus. The small intestines shows considerable congestion, espedially in the lower part.

Liver. Negative, except for some evidence of degenerative changes.

Kidneys. Negative, except for some congestion of the medullae.

Urinary Bladder and Genital Organs. Negative.

Pleura and Lungs. The pariental pleura showed marked congestion and numerous hemorrhages. There was much fibrinous exudate present and much adhesion noted. Pleurisy was very general. On the right side, all the opical, cardiac and azygous lobes showed late gray state of hepatization. Some small necrotic areas were noted. The anterior third of the diaphragmatic lobe was very similar. The rest of this lobe showed only a small part of open tissue, the bulk showed hepatization in the red and early gray stages. It had the appearance of a broncho-pneumonia. On the left side, all the apical and cardiac lobes showed solidification, in the gray stage. A small part of the diaphragmatic lobe showed

gray hepatization with necrotic foci. Several rather large areas of red hepatization were also noted.

Perecardium and Heart. Negative

Diagnosis - Pleuro Pneumonia.

Observations from first to second calving.

	Date	Age	Oestrous Cycle
1st oestrum period	2-3-29	884 days	
2nd " "	3-1-29	913 "	29 days

Lot II Linseed Oil Meal

Animal G-2

Observations to first calving.

	Date	Age	Oestrous Cycle	
Born	11-12-25			
Placed on experiment	3-11-26	119 days		
1st oestrum period	6-21-26	221 "		
2nd " "	7-14-26	244 "	23 days	
3rd " "	8-20-26	281 "	37 "	
4th " "	9-7- 26	299 "	18 "	
5th " "	9-27-26	319 "	20 "	
6th " "	11- 4-26	357 "	38 "	
7th " "	11-23-26	376 "	19 "	
8th " "	12-11-26	394 "	18 "	
9th " "	12-29-26	412 "	18 "	
10th " "	1-17-27	431 "	19 "	
11th " "	2-22-27	467 "	36 "	Bred
12th " "	3-19-27	492 "	25 "	

Examined	5-26-27		Pregnant
Calved	11-26-27	744 days	

Observations at calving time.

(a) Ease of Parturation.

This heifer had little trouble calving except that it was necessary to pull the calf because of its large size and the dam being only a heifer. It was necessary to push the calf back at time of parturation and get one front foot started out which was bent back at presentation.

(b) Placenta.

Cleaned within four hours. Condition - healthy.

(c) Recovery.

Recovered in normal manner.

(d) Udder.

The udder appeared to be normal at calving time. The usual swelling and hardness was present but disappeared by the end of the fifth day.

(e) Colostrum.

Bacillus Coli in right and left hind quarters.

(f) Offspring.

The calf (female) was strong and active at birth. No blindness observed. Weight 92 pounds. Time carried 277 days.

Observations first to second calving.

	Date	Age	Oestrous Cycle	
1st oestrum period	No date noted			
2nd " "	2-9-28	819 days		
3rd " "	2-20-28	830 "	11 days	Bred
4th " "	3- 2-28	841 "	11 "	
5th " "	4-6- 28	875 "	35 "	

6th oestrum period	4-29-28	890 days	14 days	Bred
Examined	7- 9-28			Pregnant
Calved	11-22-28	1106 "		

Observations at calving time.

(a) East of Parturation.

This animal calved without assistance. The calf was found in the gutter in the morning.

(b) Placenta.

Placenta came away in about three hours. Condition - normal. There were two cotyledons in the dorsal cervical region which presented no healthy villi, all being short tufted and of a grayish opaque color.

(c) Recovery

Recovered in a normal manner.

(d) Udder

The udder showed very little congestion. It softened up after milking began.

(e) Colostrum.

No microorganisms found.

(f) Offspring.

The calf (male) was very strong at birth. Obtained colostrum. No blindness observed. This calf died at 48 hours of age due to Bacillus Coli infection. G-9's, G-1's and one herd calf died from this infection in the same manner at about the same time. This calf was injected three hours after birth with anti white scour serum. Weight 88 pounds. Time carried 276 days.

Post Mortem Examination by Drs. Sholl and Meyer, of the Department of Animal Pathology.

There was some evidence of degenerative change in the liver. The kidneys showed congestion and some evidence of cloudy swelling. There was some curdled milk in the abomasum and the mucosa showed congestion and numerous small hemorrhages. The lungs showed marked congestion and numerous small hemorrhages. No pneumonia was noted. There were many subepicardial hemorrhages.over the heart.

Cultures. B. Coli was cultured from the liver.

Diagnosis. B. Coli septicemia.

Observations from second to third calving.

	Date	Age	Oestrous Cycle	
1st oestrum period	12-17-28	1131 days		
2nd " "	1-18-29	1163 "	32 days	
3rd " "	3- 5-29	1209 "	46 "	Bred

Animal G-4.

Observations to first calving.

	Date	Age	Oestrous Cycle	
Born	12-28-25			
Placed on experiment	3-31-26	93 days		
1st oestrum period	2- 8-27	407 "		
2nd " "	3-18-27	445 "	38 days	
3rd " "	4- 4-27	462 "	17 "	Bred
4th " "	4-23-27	481 "	19 "	"
5th " "	5-12-27	500 "	19 "	"
Calved	2-12-28	776 "		

Observations at calving time.

(a) Ease of Parturation.

It was necessary to pull the calf. Normal presentation.

(b) Placenta.

Placenta came away in about four hours. Condition-healthy.

(c) Recovery.

This animal recovered in a very normal way.

(d) Udder.

The udder showed considerable congestion but could not be considered abnormal. The swelling seemed to extend all along the abdominal wall. This condition disappeared by the eighteenth day.

(e) Colostrum.

Streptoccus was isolated from the left rear quarter.

(f) Offspring.

The calf (male) was fairly active at birth. It was able to get on its feet andnurse. This calf was not quite as lively as it should have been. No blindness observed. Weight 79 pounds. Time carried 276 days.

Observations from first to second calving.

	Date	Age	Oestrous Cycle	
1st oestrum period	3-15-28	808 days		
2nd " "	4- 6-28	830 "	22 days	
3rd " "	4-28-28	852 "	22 "	
4th " "	5-19-28	873 "	21 "	Bred
5th " "	7- 2-28	917 "	24 "	"

Examined	12-1-28	
Calved	4-15-29	1204 days

Observations at calving time.

(a) Ease of Parturation.

It was necessary to pull the calf. Normal presentation.

(b) Placenta.

Placenta came away in about seven to eight hours.

Condition - healthy.

(c) Udder.

The udder contained some hardness but not more than normal.

(e) Colostrum.

Incompleted.

(f) Offspring.

The calf (female) was very strong and active at birth. No blindness observed. Weight 81 pounds. Time carried 287 days.

Animal G-6

Observations to first calving.

	Date	Age	Oestrous Cycle	
Born	4-16-26			
Placed on experiment	7-19-26	94 days		
1st oestrum period	6-4-27	414 "		
2nd " "	6-25-27	435 "	21 days	
3rd " "	7- 8-27	448 "	13 "	
4th " "	7-15-27	732 "	7 "	Bred
Calved	4-18-28	732 "		

[illegible]

Observations at calving time.

(a) Ease of Parturation.

It was necessary to pull the calf. Normal presentation.

(b) Placenta.

The placenta came away before morning, the animal having calved some time during the night. Condition of placenta was normal.

(c) Recovery.

This cow recovered in a normal way and was active immediately after calving.

(d) Udder.

The udder contained considerable swelling. The swelling extended forward along the underline. The hardness disappeared in ten days.

(e) Colostrum.

Streptococcus in all four quarters.

(f) Offspring.

Calf (female) was normal and very lively. No blindness observed. Weight 79 pounds. Time carried 277 days.

Observations from first calving to second calving.

	Date	Age	Oestrous Cycle	
1st oestrum period	5-17-28	764 days		
2nd " "	6- 6-28	781 "	20 days	
3rd " "	6-26-28	801 "	20 "	
4th " "	8-11-28	847 "	46 "	Bred
5th " "	10-15-28	912 "	65 "	"
6th " "	11-14-28	942 "	30 "	"
Examined	2- 2 -29			Pregnant.

Animal G-8

Observations to first calving.

	Date	Age	Oestrous cycle	
Born	5-21-26			
Placed on experiment	8-18-26	89 days		
1st oestrum period	7-25-27	430 "		
2nd " "	8-15-27	451 "	21 days	Bred
Calved	5-18-28	727 "		

Observations at calving time.

(a) Ease of Parturation.

It was necessary to pull the calf. A normal presentation except that one foot was bent back so that it was necessary to push the calf back in order to get the other foot started.

(b) Placenta.

The placenta came away in five hours. Condition - normal. Only the gravid horn was examined. Absolutely no indications of disease.

(c) Recovery.

Recovered in a normal manner from the effects of calving.

(d) Udder.

The udder contained the usual congestion common to heifers with some swelling along the underline.

(e) Colostrum.

Streptococcus found in the right hind quarter.

(f) Offspring.

The calf (male) was strong at birth. No blindness observed. Weight 80 pounds. Time carried 276 days.

Observations from first calving to second calving.

	Date	Age	Oestrous Cycle	
1st oestrum period	8-5-28	806 days		
2nd " "	11-26-28	919 "	113 days	Bred
3rd " "	1-21-28	975 "	56 "	"

Animal G-10.

Observations to first calving.

	Date	Age	Oestrous Cycle	
Born	10-5-26			
Placed on experiment	1-5-27	92 days		
1st oestrum period	2-13-28	493 "		Bred
2nd " "	3-4-28	513 "	20 days	"
3rd " "	3-20-28	529 "	16 "	"
4th " "	5-8-28	578 "	49 "	"
Examined	7-9-28	640 "		Pregnant
Calved	12-9-28	794 "		

Observations at calving time.

(a) Ease of Parturation.

It was necessary to pull the calf. However, it offered very little resistance.

(b) Placenta.

The placenta was expelled about three hours after calving. The condition was healthy.

(c) Recovery.

Recovered normally.

(d) Udder.

The udder was not exceptionally hard or inflamed.

(e) Colostrum.

No sample taken.

(f) Offspring.

The calf (female) was normal and active at birth. The calf was injected three hours after calving with anti white scour serum and removed from the dam twelve hours after calving to be raised by the Udahl system. No blindness observed. Weight 88 pounds. Time carried 281 days.

Observations from first to second calving.

	Date	Age	Oestrous Cycle	
1st oestrum period	12-20-28	805 days		
2nd " "	1-22-29	838 "		
3rd " "	2-11-29	858 "	20 days	
4th " "	3-25-29	900 "		Bred

Discussion of Reproduction.

The reproduction records of both lots is summarized in Tables XXXI and XXXII. One calf in Lot I was quite small which was probably due to inheritance since the calf's dam was also the smallest animal in both lots. The weights of the calves from Lot I compare favorably with those in Lot II.

The loss of three calves, two in Lot I and one in Lot II can in no way be attributed to the effects of the rations upon the dams since the calves were strong and active at birth. Apparently a very virulent type of Bacillus Coli was present in the herd at the time these calves were affected.

The heavy feeding of cottonseed meal has not caused difficult breeding nor retention of placentas.

There was apparently little difference in favor of either lot from the standpoint of reproduction.

Lactation Records

Milk.

Milk records for all animals by thirty-day periods will be found in Tables XVIII to XXX, inclusive. Animals G-1 to G-5 inclusive have completed the first lactation. The total milk produced the first lactation period by animals G-1, G-3 and G-5 in Lot I, fed cottonseed meal was 9,958, 10,286 and 10,897 pounds of milk respectively. While animals G-2 and G-4 in Lot II fed linseed oil meal produced 6,340 and 12,102 pounds of milk respectively. Animals G-1 to G-8 inclusive have completed ten months. The ten months milk records of the cows in Lot I fed cottonseed meal and the cows in Lot II fed linseed oil meal is as follows:

Lot I	Pounds of milk for 10 months	Lot II	Pounds of milk for 10 months
G-1	9,846	G-2	6,340
G-3	10,231	G-4	11,088
G-5	10,099	G-6	7,854
G-7	7,529	G-8	9,240

Butterfat.

The butterfat produced by thirty-day periods will be found in Tables XVIII to XXX inclusive. The ten months butterfat production of the animals in Lot I fed cottonseed meal and in Lot II fed linseed oil meal is as follows:

Lot I		Lot II	
Pounds of butterfat for 10 months		Pounds of butterfat for 10 months	
G-1	313.3	G-2	235.7
G-3	359.6	G-4	407.6
G-5	346.0	G-6	273.4
G-7	277.1	G-8	329.6

The average percent of butter fat in the milk of Lot I was 3.43 per cent, and for Lot II 3.6 per cent.

Discussion of Lactation Records

One animal, G-2 in Lot II, proved to be a rather low producer. She produced only 6,340 pounds of milk and did not milk a full ten months. This low production is probably due to inheritance. Two animals in Lot I and one in Lot II made better than 10,000 pounds of milk for the first lactation.

There is apparently little difference between the two groups from the standpoint of milk and butter fat production, although Lot I which received cottonseed meal has a slight advantage.

Feed Records

Feed Consumed.

A complete record of feed consumed by thirty-day periods by all animals in this experiment is contained in Tables I to XXX inclusive.

Feed consumed by all animals to calving is found in Table I to XVII inclusive.

Feed consumed by all animals from first to second calving is included in Tables XVIII to XXVII inclusive. Tables XXVIII to XXX inclusive includes feed consumed by three animals which have calved the second time.

Nutrients Required

Nutrients required will be found in the same tables as those in which feed consumption is tabulated.

Nutrients Consumed

Nutrients consumed will likewise be found in the same tables as those in which feed consumed is tabulated.

Discussion of Feed Records

An examination of the tables shows that animal G-1 consumed an average of 7.1 pounds of cottonseed meal daily during the first lactation. Animal G-3 consumed 7.4 pounds. Animal G-5 consumed 7.3 pounds. These amounts of cottonseed meal are several times more than the average feeder would use to supplement a ration.

The feeding of such large amounts of cottonseed meal is not in harmony with the common opinion that not more than two to three pounds should be fed to dairy cattle.

Excess protein consumed by both groups is approximately 50 per cent more than the requirements for the Savage Standard.

Observations

Weight.

The growth in weight of the two lots of animals up to first calving is shown in Graphs I to XVII inclusive. The growth in weight of each pair is compared to Eckles Normal.

In every case the animal in the lot fed cottonseed meal weighed less than the paired animal in the linseed oil meal lot. It must be remembered that in every case the smaller animal of each pair was placed in the cottonseed meal lot. All the first original animals, G-1 to G-10 inclusive, are, however, above Eckles Normal from 18 months of age to calving time.

Animals G-11 to G-12 and G-14 are also above Eckles Normal. The remaining animals, G-13, G-15 and G-16 are below Eckles Normal although most of the other animals were also below Eckles Normal at this age. Table XXXIV shows the growth in weight of G-1 to G-10 inclusive by six month periods up to 36 months of age compared to Eckles Normal at 30-months of age.

Apparently there was little difference in growth by weight between the two lots of animals. However, there was a slight difference in favor of Lot II.

Height of Withers.

The growth in height at withers of the two lots of animals up to first calving is shown in Graphs I to VIII inclusive. The growth in height at withers of each pair is compared to Eckles Normal. Practically all animals of the original group except G-7 were normal in height at withers at first calving.

Table XXXIV shows the growth in height of withers of animals G-1 to G-10 inclusive by six months periods to 36 months of age.

Apparently there was little difference between the two lots in growth in height at withers, although the animals in Lot I[1] may have a slight advantage which may be explained on the basis of individual variation.

Consistency of Feces.

No previous attempt has been made experimentally to study the costive or laxative effect of cottonseed meal.

Consequently, an attempt was made to compare the effect of cottonseed meal and linseed oil meal upon the consistency of feces by feeding various amounts of each with and without silage.

It was thought that the consistency of the feces should be measured by some mechanical means in order to avoid personal prejudice and variation in judgment. Consequently, the following mechanical method was used.

The feces samples were taken immediately after evacuation and as near the same hour each day as possible. The samples were placed in a six inch evaporating dish and pressed down just sufficiently so as not to allow any open air spaces. (See Plates I and II) The feces were then leveled off even with the edges of the dish with a smooth stick. A wooden ball approximately three inches in diameter with graduations about its circumference was gently placed in the middle of the dish. Each graduation was called a degree which read from 15 to 45 degrees. A 500 gram weight was placed on top of the ball, which was flattened. The distance which the ball pressed into the feces was determined by the graduation of degrees on the on the ball. In other words, the softer the feces, the farther the ball sank and the greater the reading in degrees and visa versa.

Using the method as described, the consistency of fecés of 4 groups of animals was determined. The consistency of feces of animals G-1, G-3 and G-5 in Lot I and animals G-2, G-4 and G-6 was determined for a 10-day period. The observations were taken during a period of heavy milk production and consequently the animals were being fed cottonseed meal and linseed oil meal quite heavily. They were 24 to 30 months of age. The results are shown in Table XXXV and Graph IX. The animals in Lot I received 7.8 pounds to 9 pounds of cottonseed meal and the animals in Lot II received 6 to 12.6 pounds of linseed oil meal daily. The results show very little difference in the consistency of feces of the two groups.

The consistency of feces of animals G-7 and G-9 of Lot I, and G-8 and G-10 of Lot II was determined for a 10-day period. These animals had not yet freshened and were receiving 2.4 pounds of cottonseed meal and 3 pounds of linseed oil meal daily. The results are shown in Table XXXVI and Graph X.

The results secured in the first two groups of animals indicated that there was practically no difference in the consistency of feces of cattle fed on cottonseed meal or linseed oil meal along with silage and timothy hay. Since succulent feed, such as silage, is regarded as having a laxative effect, six mature cows were placed on an experiment to determine the effect of feeding cottonseed meal and linseed oil meal without silage.

A group of cows were divided into two lots of three animals each. The cows in both groups received 4.5 pounds of ground corn, 4.5 pounds ground oats each, and all the timothy hay which they would clean up in addition to the protein concentrate.

The animals in Lot I, numbers 158, 179 and 150, received in addition, nine pounds of cottonseed meal daily, while those in Lot II, numbers 225, 226 and 217, received nine pounds each of linseed oil meal daily. A seven day preliminary period was allowed, during which time the silage was replaced by timothy hay. The consistency of the feces excreted by the groups was determined daily for six days, after which the animals in Lot I were fed nine pounds of linseed oil meal and those in Lot II were fed nine pounds of cottonseed meal daily. Two days were allowed for the change from cottonseed meal to linseed oil meal and vice versa. The consistency of the feces from both groups was then observed daily for six days.

The effect of these feeds on the consistency of the feces is shown in Table XXXVII and Graph XI. It is apparent that there is but little difference between the consistency of feces of animals fed cottonseed meal and linseed oil meal. It is also of interest to note in Table XXXVII that the change from cottonseed meal to linseed oil meal and vice versa failed to produce a disturbance in the digestive tract. These animals

were not accustomed to having cottonseed meal in their ration.

The results obtained in the first and third groups of animals indicated that the heavy feeding of cottonseed meal did not affect the consistency of feces any more than the heavy feeding of linseed oil meal. However, there was a possibility that the heavy feeding of cottonseed meal caused an irritation in the digestivetract which resulted in a soft feces. In order todetermine the effect on the consistency of feces of feeding a small amount of cottonseed meal and linseed oil meal without silage, six animals were placed on experiment.

The cattle in Lot I, numbers 202, 194 and 1-B were fed two pounds of cottonseed meal, three pounds of corn and oats daily with timothy hay for roughage. The cattle in Lot II, numbers 153, 173 and 2-B received two pounds of linseed oil meal in addition to three pounds of corn and oats daily with timothy hay.

A seven day preliminary feeding period was allowed, after which, the consistency of feces was determined daily for eight days. Animals in Lot I were then fed two pounds of linseed oil meal in place of cottonseed meal, and those in Lot II were fed two pounds of cottonseed meal in place of two pounds of linseed oil meal. These changes were made in one day. Observations were made daily on the feces for eight days thereafter. The results are shown in Table XXXVIII and Graph XII.

The method of judging the consistency of feces by physical appearance depends largely on the judgment of the investigator. The use of a wooden ball with graduations to measure the depth into which the ball sinks into different feces when a 500 gram weight is placed on it is a superior method of measuring the consistency of various feces.

Heifers which were raised on cottonseed meal as the principal source of protein from three months of age have excreted, for more than two years, feces which are just as soft as those excreted by animals raised on linseed oil meal for the same period. In this investigation, the amount of cottonseed meal or linseed oil meal did not affect the consistency of the feces.

When silage was left out of the ration and cottonseed meal and linseed oil meal were fed at the rate of nine pounds per day, no difference could be shown in the consistency of the feces. A sudden change from cottonseed meal to linseed oil meal feeding, and vice versa, had no apparent effect on the consistency of the feces. Cows which were fed only two pounds of cottonseed meal or two pounds of linseed oil meal daily excreted feces of about the same consistency. Apparently the levels at which cottonseed meal was fed in these rations had no effect on the consistency of feces.

Rate of Food Passage.

To measure the rate of food passage in cattle it is necessary to feed some substance and detect its first and last appareance in the feces. It is therefore necessary to

find some substance which the animal does not digest or absorb and one which does not affect the digestive system.

Ferric oxide was considered suitable for this purpose because it is very insoluble, and because there is such a small amount of iron in the feed which cattle consume, so that any raise in the amount of iron in the feces could easily be detected by chemical analysis.

The animals used in this experiment were G-5 and G-7 in Lot I and G-4 and G-6 in Lot II. Animals G-5 and G-7 received 2.3 pounds of cottonseed meal per day and G-4 and G-6 received 3 pounds of linseed oil meal per day. They also received whatever silage and timothy hay they would clean up. These animals were from 20 to 24 months of age when this experiment was run.

One hundred grams of ferric oxide was fed in the morning mixed with the grain and silage. Samples of the feces were collected and the time of passage noted. These collections continued for approximately 70 hours after the iron oxide was fed.

Analysis for the iron content of the feces are shown in Table XXXIX.

The first appearance in the feces of the ingested iron oxide of animals G-5 and G-7 in the lot fed cottonseed meal was 11 hours and 45 minutes, and 11 hours and 30 minutes, respectively. The iron first appeared in the feces of animals G-4 and G-6 fed linseed oil meal in 12 hours and 30 minutes and 12 hours, respectively.

The iron excretion reached the peak in animals G-5 and G-7 in 25 hours and 30 minutes, and 24 hours and 45 minutes respectively, after the iron oxide was fed. In Lot II the peak of excretion occurred in animal G-4 31 hours and 10 minutes and in G-6 31 hours after being fed.

Samples evidently were not taken for a sufficient length of time to measure the complete lag since considerable iron remained in the feces after 70 hours. The lag, however, was considerably longer than that obtained by Reed and Huffman and Addington (150).

It seems quite apparent from this investigation that cottonseed meal is not costive in comparison to linseed oil meal. The results tend to show that cottonseed meal is more laxative than linseed oil meal. However, insufficient numbers of animals were used to warrent a very definite conclusion.

Bacterial Flora of the Udder

Bacteria in milk from each animal in both lots was determined over a period of six months. Samples were taken for three consecutive days each month at the evening milking. The milk of each animal was drawn into a sterile tube in approximately equal amounts from each quarter.

One cc of milk was then pippetted in 9 cc of sterle physiological salt solution. One cc of this dilution was then plated in duplicate using nutrient agar. Plates were incubated for 48 hours at room temperature and then incubated for 48 hours at 37^{o} centigrade. Results are shown in Table XL.

Apparently all bacterial counts were within a normal range with the exception of one animal, G-3 in Lot I, which had a rather high count. An examination of themilk from the separate quarters revealed a high count in one quarter. However, this cow has never shown any signs of mastitis. The animals in both lots have been free from this disease although animals of the experimental herd have had mastitis.

Tests for the reduction of Methylene blue were also run for two months as shown in Table XLI.. It was apparent that the type of organisms present in the udder flora of the animals used in this investigation did not affect the keeping qualities of the milk, so that these tests were discontinued.

Condition of Coat.

Observations on the coat were made as planned. Results with the original ten animals of this experiment are shown in Table XLII.. In Lot I the observations "sleek" was made 39 times; "very sleek" 9 times; "fairly sleek" 65 times; "fairly rough" 35 times and "rough" nine times. In Lot II "sleek" was observed 28 times; "very sleek" 3 times; "fairly sleek" 66 times; "fairly rough" 39 times and "rough" 9 times. Apparently there is little difference between the two groups in this respect.

Length of Hair.

Observations on length of hair were made as planned. Results of these observations are shown in Table XLIII. There appears to be little difference between the two lots in this respect.

Double Thickness of Hide.

Linseed oil meal is used extensively by showmen to produce

a thin loose hide. Observations on double thickness of hide were made as planned. Results of these observations are shown in Table XLIV . There appears to be little discernable difference between the two lots in this respect.

Looseness and Pliability of Hide.

Linseed oil meal is used quite extensively by showmen as a part of the fitting ration for the purpose of making the hide loose and pliable. Observations on looseness and pliability of hide were made as planned. Results of these observations are shown in Table XLV .

Little difference can be discerned between the two lots in this respect.

Health.

Observations were made of the health of the animals as planned. All animals remained in good health throughout the experiment. The health of G-1 and G-9 in Lot I was noted, as fair, instead of good at several observation times. The health of G-4 in Lot II was also observed as fair for three observations. The reason for such observations was because the animals were milking very heavy.

Appetite.

The appetite of all animals remained normal at all times, although occassionally an animal refused feed which occurs among normal cattle.

Condition of Flesh.

Observations of the candition of flesh were made as planned. Results are tabulated in Table XLVI . There was very little difference between the two lots.

Lice

Observations for the presence of lice were made as planned. Lice were found in a few cases during certain seasons of the year. The lice were not prevalent in one lot any more than in the other.

Shedding.

Observations for the shedding of hair was made as planned. Results of these observations are shown in Table XLVIII. No particular difference could be noted in either group.

Blindness.

No blindness was observed. in either group.

Blood Counts.

Erythrocyte and leucycyte counts were made by the standard method of counting. The results are shown in Tables XLIX and L.

Apparently all animals remained normal in their erythrocyte count. However, the leucycyte count seemed to run high in a great many cases of both lots. This condition will be investigated further.

Hemoglobin.

Hemoglobin content of the blood was also checked each month by use of the Tallquist Hemoglobin scale. The results are shown in Table LI. The results show that none of the animals of either group were below normal.

Blood Tests

Blood samples were taken each month for abortion tests.

All animals remained negative throughout this experiment.

Photographs

Photographs were taken of cows and calves at freshening to show the strength and size of both cows and calves. Plates III to XXXVII. Photographs were also taken of the calves at 90 days of age to show grwoth and health. Photographs of all heifers were taken at 15 months of age.

GENERAL DISCUSSION OF EXPERIMENTAL RESULTS

Cottonseed meal and linseed meal were compared by feeding two lots of animals. Linseed oil meal was used as a standard of comparison against cottonseed meal since linseed oil meal is considered as a good safe source of protein. Cottonseed meal is considered as a good source of protein but not a safe feed to use in large amounts or for long periods of time.

In this experiment cottonseed meal was compared to linseed oil meal starting with heifer calves at 90 days of age and continuing through lactation. The ration was supplemented with corn, silage, a good quality timothy hay, bone meal and salt. Whole ground corn was also fed at various times as a source of energy.

The growth, reproduction and lactation of the two groups were about equal when the factor of inheritance was taken into consideration. Both lots consumed approximately 50 per cent more protein than was required by the Savage Standard.

Cottonseed meal has been considered as a costive feed. In measuring the consistency of feces and rate of food passage these investigations do not confirm the idea that cottonseed meal is costive. The method used in determining the rate of food passage indicates that the lag of food is longer than previously reported by other investigators.

Cottonseed meal is believed to cause mastitis. No mastitis was noted in either lot and bacterial counts of the udder flora revealed normal counts for the cows in both lots with the exception of one animal in Lot I. This condition, however, often occurs in normal cattle not affected with mastitis. In observations which were made upon the condition of coat, looseness and pliability of hide, health, appetite, condition of flesh, lice and shedding, no particular difference could be ascertained between the two groups. In measuring the length of hair and double thickness of hide, there was no difference between the two lots.

Erythocyte counts were made which revealed that all animals remained normal. The leucocyte count seemed to be abnormally high in both lots. This condition may be associated with heavy feeding of concentrates and should be investigated further.

There was no manifestation of cottonseed meal injury in any of the animals at any time during this investigation. Cottonseed meal was fed in amounts to furnish all the required protein in the form of cottonseed meal. Two and four tenths pounds were fed up to first calving. As much as 11.7 pounds were fed to one animal for a short period of time. Three of the animals in Lot I consumed an average of from 7.1 to 7.4 pounds of cottonseed meal daily from first to second calving with no ill effects.

The symptoms of cottonseed meal injury have been produced by some investigators by feeding concentrates other than cottonseed meal. This would seem to eliminate the factor gossypol as a cause of cottonseed meal injury to cattle.

Apparently "cottonseed meal injury" in cattle is due to a lack of factor or factors carried by hay. A good quality hay was fed throughout this experiment.

SUMMARY

1. Cottonseed meal when compared to linseed oil meal furnished a good source of protein for growth, reproduction and lactation.

2. As much as 7.1 to 7.4 pounds average daily of cottonseed meal were fed on an adequate rati n through the first lactation with no apparent injury.

3. Cottonseed meal injury is probably due to a lack of factor or factors carried by hay.

4. Cottonseed mealdid not prove costive to dairy cattle when compared to linseed oil meal in rations with and without corn silage.

5. The heavy feeding of cottonseed meal to dairy cows did not produce mastitis.

6. There was no appreciable difference in the effect of cottonseed meal and linseed oil meal upon the condition of coat, length of hair, double thickness of hide, looseness and pliability of flesh, and shedding.

7. The heavy feeding of cottonseed meal had no effect on the erythocyte count or per cent of Hemoglobin of the blood of dairy cattle.

BIBLIOGRAPHY

1. Van Slyke, Lucius L.

1927. Modern Methods of Testing Milk and Milk Products. pp.16. Orange Judd Publishing Co., Inc., New York, Publisher.

2. Haecker, T. L.

1914. Investigations in Milk Production. University of Minnesota Agr'l. Exp. Sta. Bulletin 140.

3. Hills, J. L.

1922. The Maintenance Requirements of Dairy Cattle. Vermont Agr'l. Exp. Sta. Bul. 226.

4. Ellett, W. B., and Holdaway, C. W.

1920. The Effects of High Protein and High Energy Rations in Feeding Dairy Cows.
Virginia Polytechnic Institute. Va. Agr'l. Exp. Sta. Technical Bul. 20.

5. Savage, B. E.

1912. A study of Feeding Standards for Milk Production. Cornell University, Agr'l. Exp. Sta. Bul. 323.

6. Converse, H. T.

1926. The Effect of Milk Production of Feeding More Than Eckles and Savage Requirements.
Jour. Dairy Sci., Vol. IX, pp. 338-406.

7. Fraser, W. J., and Hayden, C. S.

1912. Balanced versus Unbalanced Rations for Dairy Cows. Univ. of Ill. Agr'l. Exp. Sta. Bul. 159.

8. Armsby, H. P.

1917. The Nutrition of Farm Animals, pp. 620.

The MacMillan Co., New York, Publishers.

9. Eckles, C. H.

1916. The Nutrition Required to Develop the Bovine Foetus.

Univ. of Mo. Research Bul. 26.

10. Forbes, E. B., and Beegle, F. M.

Organic and Mineral Analysis of Foods.

Ohio Agr'l. Exp. Sta. Bul. 255, pp. 226.

11. Reed, O. E., and Huffman, C. F.

1928. Dairy Cattle Need Phosphorus in Ration.

Mich. Agr'l. Exp. Sta. Quarterly Bul. Vol. 10,

No. 4, pp. 152, (May 1928).

12. Osborne, T. B., and Mendel, L. B.

1914. Amino Acids in Nutrition and Growth.

Jour. Biol. Chem., Vol. 17, pp. 325-349.

13. Hart, E. B., and Humphrey, G. C.

1915. Quality of Proteins for Milk Production.

Jour. Biol. Chem., Vol. 21, pp. 239-253.

14. Mathews, A. P.

1925. Physiological Chemistry, pp. 194.

William Wood and Co., New York, Publishers.

15. Hawk, P. B., and Bergeim, Olaf.

1926. Practical Physiological Chemistry, pp. 126.

P. Blakiston's Son and Company, 1012 Walnut

Street, Philadelphia, Publishers.

16. Sure, B.

1925. Amino Acids in Nutrition. - IX, The Role of Alanine and Indol in the Synthesis of Tryptophane by the Animal Organism.

Am. Jour. Physiol., Vol. 72, pp. 260-263.

17. Mitchell, H. H.

1916. Feeding Experiments on the Substitution of Protein by Definite Mixtures of Isolated Amino Acids.

Jour. Biol. Chem., Vol. 26, pp. 231-261.

18. Jones, D. B., Gersdorff, C.F.F., and Moelter, O.

1924. The Tryptophane and Cystine Content of Various Proteins.

Jour. Biol. Chem. Vol. 62, pp. 183-195.

19. Ackroyd, H. and Hopkins, G. F.

1916. XLV. Feeding Experiments with Deficiencies in the Amino Acid Supply: Arginine and Histidine as Possible Precursors of Purines.

Bio Chemical Jour., Vol. 10, pp. 551-576.

20. Lusk, Graham.

1928. The Science of Nutrition, pp. 244.

W.B. Saunders Company, Philadelphia, Pub.

21. Hart, E. B., Nelson, V.E., and Pitz, W.

1918. Synthetic Capacity of the Mammary Gland.

Jour. Biol. Chem., Vol. 36, pp. 291-300.

22. Buckner, G. D., Nollau, E. H., and Kastle, J. H.

1916. The Feeding of Young Chicks on Grain Mixtures of High and Low Lysine Content.

Am. Jour. Physiol., Vol. 39, p. 162.

23. Osborne, T. B., and Mendel, L. B.

1916. The Effect of the Amino Acid Content of the Diet on the Growth of Chickens.
Jour. Biol. Chem. Vol. 26, pp. 293-300.

24. McGinty, D. A., Lewis, H. B., and Marvel, G. S.

1924. Amino Acid Synthesis in the Animal Organism. The Availability of Some Caproic Acid Derivatives for the Synthesis of Lysine.
Jour. Biol. Chem. Vol. 62, p. 75-92.

25. Osborne, T. B., and Mendell, L. B.

1914. Nutritive Properties of the Proteins of the Maize Kernel.
Jour. Biol. Chem. Vol. 18, pp. 1-16.

26. Geiling, E. M. K.

1917. The Nutritive Value of the Diamino Acids Occurring in Proteins for the Maintenance of Adult Mice.
Jour. Biol. Chem., Vol. 31, pp. 173-199.

27. Aberhalden, E.

1913. Weitere Versuche Über die Sunthetischen Fähigkeiten des Organismus des Hund.
Zeit f physiol. Chem. Lxxxiii 444, cited by McCollum, E. V.
The Newer Knowledge of Nutrition, p. 61.
MacMillan Company, New York, Publishers.

28. Sure, B.

Amino Acids in Nutrition.

II. The Nutritive Value of Lactalbumin; Cystine and Tyrosine as Growth Limiting Factors in That Protein.

Jour. Biol. Chem., Vol. 43, pp. 457-468.

29. Lightbody, H. D., and Kenyon, M. B.

1928. Feeding Experiments with a Diet Low in Tyrosine.

Jour. Biol. Chem., Vol. 80, p. 149-153.

30. Osborne, T. B., Mendel, L. B.

1915. Nutritive Value of Proteins in Growth.

Jour. Biol. Chem. Vol. 20, pp. 351-378.

31. Sherman, H. C., and Merrill, A. T.

1925. Cystine in the Nutrition of the Growing Rat.

Jour. Biol. Chem., Vol. 63, pp. 331-337.

32. Lewis, H. B.

1917. The Metabolism of Sulphur. II. The Influence of Small Amounts of Cystine on the Balance of Nitrogen in Dogs Maintained on a Low Protein Diet.

Jour. Biol. Chem., Vol. 31, pp. 363-370.

33. Lewis. H. B.

1920. The Nutrition of Sulphur. III. The Relation Between the Cystine Content of Proteins and Their Efficiency in the Maintenance of Nitrogenous Equilibrium in Dogs.

Jour. Biol. Chem., Vol. 42, pp. 289-296.

34. Sherman, H. C., and Woods, E.

1925. The Determination of Cystine by means of Feeding Experiments.

Jour. Biol. Chem.,Vol. 66, pp. 29-36.

35. Muldoon, J. A., Shiple, C. J., and Sherwin, C.P.

1924. Synthesis of Amino Acids in the Animal Organism. III. Concerning the Synthesis of Cystine in the Body of the Dog.

Jour. Biol. Chem. Vol. 59, pp. 675-681.

36. Johns, C..O., and Finks, A. J.

Studies in Nutrition; II. The Role of Cystine in Nutrition Experiments with the Proteins of Navy Beans. Phaseolus Vulgaris.

Jour. Biol. Chem. Vol. 41, pp. 379-389.

37. Rose, W. C., and Cox, G. J.

1924. The Relation of Arginine and Histidine to Growth.

Jour. Biol. Chem., Vol. 61, pp. 747-773.

38. Rose, W. C., and Cook, K. G.

1925. The Relation of Histidine and Arginine to Creative and Purine Metabolism.

Jour. Biol. Chem., Vol. 64, pp. 325.

39. Aberhalden, E.

1912. Zetschr F. physiol. LXXVII, p. 27., cited by Osborne T. B., and Mendel, L. B.

Jour. Biol. Chem., Vol. 17, pp. 326.

40. Sure, B.

1924. Amino Acids in Nutrition. VIII Proline is Indispensable for Growth.
Jour. Biol. Chem., Vol. 59, pp. 577-586.

41. Henry, W. A., and Morrison, F. B.

1927. Feeds and Feeding. (41-a, p. 730) (41-b,p.177) (41-c, p. 178) (41-d, p. 364).
The Henry-Morrison Company, Madison, Wisconsin, Publishers.

42. Ward, A. L.

1927. Manufacture of Cottonseed Products.
Educational Service; Cottonseed Products Association. Dallas, Texas.

43. Osborne, T. B., and Voorhees, C. G.

1894. The Proteids of Cottonseed Meal.
Jour. Am. Chem. Soc., Vol. 16, pp. 778-785.

44. Aberhalden, E., and Rostoski, O.

1905. Zeit physiol. Chem. XLIV, p. 265.
Cited by Nevens, W. B. Jour. Dairy Sci., Vol. IV, p. 376, 1921.

45. Nevens, W. B.

1921. The Proteins of Cottonseed Meal.
Jour. Dairy Sci., Vol. 4, p. 375-401.

46. Hamilton, T. S., Nevens, W.B., and Grindly, H. S.

1921. The Quanitative Determination of Amino Acids of Feeds.
Jour. Biol. Chem. Vol. 48, p. 249-272.

47. Nollau, E. H.

1915. The Amino-acid Content of Certain Commercial Feeding Stuffs and other Sources of Protein. Jour. Biol. Chem., Vol. 21, pp. 611-614.

48. Jones, D. B., and Csonka., F. A.

1925. Proteins of the Cotton Seed. Jour. Biol. Chem., Vol. 64, p. 673-683.

49. Gallup, W. D.

1928. The Digestibility of the Proteins of Some Cottonseed Meal Products. Jour. Biol. Chem., Vol. 76, p. 43-53.

50. Bergeim., Olaf.

1926. IV. A method for the Study of Food Utilization or Digestibility. Jour. Biol. Chem., Vol. 70, p. 29-33.

51. Jones, D. B., and Waterman, H. C.

1923. Studies on the Digestion of Proteins in Vitro IV on the Digestibility of the Cottonseed Globulin and the Effect of Gossypol upon Peptic and Tryptic Digestion of Proteins. Jour. Biol. Chem., Vol. 56, p. 501-511.

52. Nevens, W. B.

1921 The Proteins of Cottonseed Meal. II The Nutritive Value. Jour. Dairy Sci., Vol. IX, pp. 552, 589.

53. Osborne, T. B., and Mendel, L. B.

1917. The Uses of Cottonseed as Food.

Jour. Biol. Chem., Vol. 29, p. 289-317.

54. McCallum, E. V., and Simmonds, N.

1916. The Values of Some Seed Proteins for Maintenance.

Jour. Biol. Chem., Vol. 32, p. 347-368.

55. Richardson, A. E., and Green, H. S.

1916. Nutrition Investigations upon Cottonseed Meal I.

Jour. Biol. Chem. Vol. 25, p. 307-318.

56. Richardson, A. E., and Green, H. S.

1916. Nutrition Investigations upon Cottonseed Meal II.

Jour. Biol. Chem., Vol. 30, p. 243-258.

57. Richardson, A. E., and Green, H. S.

1917. Nutrition Investigations upon Cottonseed Meal.

Jour. Biol. Chem., Vol. 31, p. 379-389.

58. Mendel, L. B., and Fine, M. S.

1912. Studies in Nutrition V. The Utilization of the Proteins of Cottonseed.

Jour. Biol. Chem. Vol. 11, p. 1-3.

59. Rather, J. B.

1913. Digestion Experiments on Men with Cottonseed Meal.

Texas Agr'l. Exp. Sta., Bul. 163.

60. Skinner, J. H., and King, J. G.

1912. Fattening Western Lambs.

Purdue University Indiana Agr'l. Exp. Sta.

Bul. 162, p. 694-701.

61. Jones, J. M., and Dickson, R. F.
1928. Grain Sorghums versus Corn and Fattening Lambs.
Texas Agr'l. Exp. Sta., Bul. 379.

62. Gray, D. T., and Ridgway, J. W.
1909. Feeding Cottonseed Meal to Pregnant Ewes.
Alabama Polytechnical Institute, Alabama Exp.
Sta. Bul. 148.

63. Phillips, A. G.
1919. Feeding Experiments with Leghorns.
Purdue University Agr'l. Exp. Sta. Bul. 227.

64. New Mexico Station Report.
1918-1919. Poultry. pp. 21-24.

65. Clayton, E. P.
1916. Cottonseed Meal, A. Good Feed for Laying Hens.
Miss. Agr'l. Exp. Sta. Bul. 175.

66. Morrison, J. K.
1913. Cottonseed Meal as a Feed for Laying Hens.
Miss. Agr'l. Exp. Sta. Bul. 162.

67. Hartwell, B. L., and Lichtenthaeler, R. A.
1914. The Availability of the Nitrogen of Cottonseed
Meal and of Beef Scrap for Chicks.
R. I. Exp. Sta., Bul. 156.

68. Thompson.
1924-1926. Cottonseed Meal.
Okla. Sta. Report. Biennial Report, pp. 52-54.

69. Thompson, R. B.

1918. Poultry Feeding Experiment.

New Mexico College of Agriculture and Mechanic Arts. Bul. 117.

70. Curtis, G. W. and Carson, J. W.

1892. Effect of Cottonseed and Cottonseed Meal in Feeding Hogs.

Texas Agr'l. Exp. Sta., Bul. 21.

71. Emery, F. E.

1894. Feeding Trials with Animals.

N. C. Agr'l. Exp. Sta., Bul. 109.

72. Dinwiddie, R. R.

1903. Pig Feeding Experiments with Cottonseed Meal.

Ark. Agr'l. Exp. Sta. Bul. 76.

73. Burtis, F. C., and Malone, J. S.

1901. Feeding Cottonseed Meal to Hogs.

Okla. Agr'l. Exp. Sta. Bul. 51.

74. Georgeson, C. C.

1895. Pig Feeding Experiments with Corn, Wheat, Kafir, Corn and Cottonseed.

Kansas Agr'l. Exp. Sta., Bul. 53.

75. Goldberg, S. A., and Maynard, L. A.

1922-1923. Studies in Cottonseed Poisoning.

I The Pathological Tissue Changes Resulting From Continuous Feeding of Cottonseed Meal.

Am. Vet. Med. Ass'n., Vol. 62, p. 450-457.

76. Barnett, E., and Goodell, C. J.

1923. Grazing and Feeding Trials with Hogs.

Miss. Agr'l. Exp. Sta. Bul. 218, p. 17.

77. Warren, G. R., and Williams, D. W.

1923. Swine Feeding Experiments. II Exp. III Cottonseed and Cottonseed Meal for Fattening Pigs.

Texas Agr'l. Exp. Sta. Bul. 305, p. 25-27.

78. Fortieth Annual Report.

1927. Cottonseed Meal for Maintaining, Growing and Fattening Hogs.

Texas. Agr'l. Exp. Sta., p. 71.

79. Bell, G. A., and Williams, J. O.

1920. Cottonseed Meal for Horses.

U. S. Dept. of Agr'l. Bul. 929.

80. Burkett, C. W.

1903. Feeding Farm Horses and Mules.

N. C. Agr'l. Exp. Sta. Bul. 189.

81. Curtis, R. S.

1911. Cottonseed Meal Feeding Experiments with Mules and Horses.

N. C. Agr'l. Exp. Sta., Bul. 215.

82. Templeton, G. S.

1927. Mule Feeding Experiments.

Miss. Agr'l. Exp. Sta., Bul. 244, p. 1-16.

83. Gayle, H. K., and Lloyd, E. R.

1916. The Economy of Mule Production is in the South, and Method of Management.

Miss. Agr'l. Exp. Sta., Bul. 176.

84. Fraps, G. S.

1910. Cottonseed Meal as Human Food.

Texas Agr'l. Exp. Sta., Bul. 128.

85. Rusk, H. P. and Snapp, R. R.

1929. Exp. Sta. Record.

Vol. 60, no. 3, p. 254.

86. Goodell, C. J.

1924. Steer Feeding Experiments.

Miss. Agr'l. Exp. Sta., Bul. 222.

87. Templeton, G. S., and Goodell, C. J.

1927. Steer Feeding Experiments and Actuary.

Miss. Agr'l. Exp. Sta., Bul. 242.

88. Emery, E. E., and Kilgore, B. W.

1895. Cottonseed Hulls and Meal for Beef Production.

N. C. Agr'l. Exp. Sta., Bul. 118.

89. Gully, F. A.

1889. Feeding Experiment.

Texas, Agr'l. Exp. Sta., Bul. 6.

90. Wright, Capt.

1889. Ark., Agr'l. Exp. Sta. Bul. 9.

91. Frost and Varley.

1922-1923. Cited by Goldberg, S. A., and Maynard, L. A.

Am. Vet. Med. Ass'n., Vol. 62, p. 455.

92. McNutt, J. C.

1911. Report of Division of Dairy Husbandry.

N. C. Agr'l. Exp. Sta., Annual Report, Vol. 34, p.33.

93. Rust.

1905. Poisoning by Cottonseed Meal.

(Wröffentl, Johres, Vet. Ber. Lurärzte.

Preuss 6 (1905) pt. 2, pp 35-36. Publ. (1908).

Exp. Sta. Record, Vol. 21, p. 788, (1909)

94. Gautier, D., and Larsen, C. F.

1895-1896. Poisoning of Calves by Cottonseed Meal

Landmandsblade, 28 (1895) p. 128-130.

Exp. Sta. Record, Vol. 7, p. 252.

95. Dinwiddie, R. R. and Short, A. K.

1911. Cottonseed Poisoning of Live Stock.

Ar. Agr'l. Sta. Bul. 108.

96. Moore, J. S.

1914. I Feeding Cottonseed Meal and Hulls.to Dairy Cows.

Miss. Agr'l. Exp. Sta. Bul. 174, p. 1-10.

97. Coombs, S., and Curtis, R. S.

1921. The Effect of Cottonseed Meal upon the Growth and Reproduction of Cows.

Jour. Dairy Sci. Vol. IV, p. 334-342.

98. Bull, S.

1917. The Principles of Feeding Farm Animals, p. 207.

The MacMillan Company, New York, Publishers.

99. Bethke, R. M., and Bohstedt, G.

1928. The Comparative Nutritive Value of the Proteins of Linseed Meal and Cottonseed Meal in Different Animals.

Jour. Agr'l. Res., Vol. 36, p. 855-871.

100. Carmichael, B. E.

1906. Fattening Range Lambs.

Ohio Bul. 174.

101. Mumford, F. B., Trowbridge, E. A., Hackendorn, H.

1913. Rations for Fattening Western Yearling Sheep.

Missouri Bul. 115.

102. Kennedy, W. J., Robbins, E. T., and Kildee, H. H.

1910. The Value of Corn, Oil Meal, Cottonseed Meal, and Gluten Feed in Work Horse Rations.

Iowa Exp. Sta., Bul. 109.

103. Kennedy, W. J., and Marshall, F. R.

1902. Condimental Foods (Stock Foods), The By-Products of Corn, Flaxseed, and Cottonseed and Dried Blood; Their Value when Fed in Conjunction with Corn for the Economical Production of Beef.

Iowa Agr'l. Exp. Sta., Bul. 66.

104. Smith, H. R.

1907. Economic Rations in Beef Productions.

Univ. of Nebr. Agr'l. Exp. Sta., Bul. 100.

105. Garlock, H. M.

1927. Cottonseed Meal, Cold Pressed Cake, and Linseed Oil Meal in Rations for Fattening Cattle.

Missouri Agr'l. Exp. Sta., Circular 153.

106. Michels, John.

1910. Feeding Experiments with Cows and Calves.

N. C. Agr'l. Exp. Sta. Bul. 213, p. 94-97.

107. Hart, E. B., and Humphrey, C. C.

1917. The Relation of the Quality of Proteins to Milk Production - III.
Jour. Biol. Chem. XXXI, p. 445-460.

108. Hart, E. B., and Humphrey, C. C.
The Relation of the Quality of Proteins to Milk Production - IV.
Jour. Biol. Chem. Vol. XXXV, p. 367-383.

109. Almy, L. H., and Robinson, R. K.
1920. Toxic Action of Ingested Linseed Meal on Trout.
Jour. Biol. Chem., Vol. 43, p. 97-111.

110. Rommel, G. M., and Vedder, E. B.
1915. Beriberi and Cottonseed Poisoning in Pigs.
Jour. of Agr'l. Research, Vol. V, p. 489.

111. Withers, W. A., and Carruth, F. E.
1918. Gossypol, the Toxic Substance in Cottonseed.
Jour. Agr'l. Research, Vol. XII, p. 83-101.

112. Bechdel, S. I., Eckles, C. H., and Palmer, L. S.
1926. The Vitamin B Requirement of the Calf.
Jour. Dairy Sci. Vol. IX, p. 409-438.

113. Crawford, A. C.
1910. Editorial.
Exp. Sta. Record, Vol. XXII, p. 503.

114. Rather, J. B.
1912. The Forms of Phosphorus in Cottonseed Meal.
Texas Agr'l. Exp. Sta., Bul. 146.

115. Anderson, R. J.
1912. The Organic Phosphoric Acid of Cottonseed Meal.
Jour. Biol. Chem. Vol. XIII, P. 311.

116. Withers, W. A., and Ray, B. J.

1913. Studies in Cottonseed Meal Intoxication I. Pyrophosphoric Acid.
Jour. Biol. Chem., Vol. XIV, p. 53.

117. Maxwell, W.

1891. Nitrogenous Bases present in Cotton Seed.
Am. Chem. Jour. Vol. XIII, p. 469.

118. Ritthausen and Weger.

1884. J. Prakt Chem. 30, p. 32.
U. S. Exp. Sta. Bul. 33, p. 96.

119. Böhm

1881. Address before the Scientific Society of Marburg.
U. S. Exp. Sta., Bul. 33, p. 96.

120. Withers, W. A., and Fraps, G. S.

1901. The Composition of Cottonseed Meal.
N. C. Agr'l. Exp. Sta., Bul. 179

121. Voelcker, Dr. Augustus.

1873. On the Characterisitics of Pure and Mixed Linseed Cakes.
Jour. Royal Agr'l. Society of Eng., Vol. IX, Part I, p. 43.

122. Koenig, J.

1901. Contribution to the Subject of the Decomposition of Feeding Stuffs and Foods by Microrganisms which attack Fat.
Part I, Ztschr. Untersuch, Nahr, U. Genussmtl 4, 1901, 16, p. 721.
Ibid, part 4. Ibid 6, 103, 5, 193;
Ibid, part 5, Ibid 9, 105, 5, 13;
Ibid, part 6, Ibid 11, 106, 4, 177.
Cited by Ewing and Wells.
George Exp. Sta. Bul. 119, p. 37, (1916).

123. Zopf.

1892. Zur Kenntnis der Organism des Amerikaneschen Baumwallsaatmahl Betrag Aus Kryp. Lab. Univ. Hall e.
Cited by Ewing and Wells (1916)
Georgia Exp. Sta. Bul. 119, p. 37.

124. Edgerton, C. W., and Morris, H.

1912. Some Studies of Cottonseed Meal Poisoning.
Louisiana Agr'l. Exp. Sta. Bul. 134.

125. Dinwiddie, R. R., and Short, A. K.

1911. Cottonseed Poisoning of Live Stock.
Ark. Agr'l. Exp. Sta. Bul. 108.

126. McGowan, J. P. and Crichton, A.

1924. Cottonseed Meal Poisoning.
Biochemical Journal, p. 273-282.

127. Roberts, G. A.

1913-1914. Report of the Division of Vet. Medicine.
N. C. Agr'l. Exp. Sta., Biennial Report.

128. Withers, W. A., and Brewster, J. F.

1913. Studies on Cottonseed Meal Toxicity II Iron as an Antidote.

Jour. Biol. Chem. Vol. XV, p. 161-166.

129. Withers, W. A., and Carruth, F. E.

1917. Iron as an Antidote to Cottonseed Meal Injury.

Jour. Biol. Chem., Vol. 32, p. 245, 257.

130. Gallup, U. D.

1928. The Value of Iron Salts in Counteracting the Toxic Effects of Gossypol.

Jour. Biol. Chem. Vol. 77, p. 437.

131. Bahnsen, P. F., and Hutchens.

1916. Georgia Exp. Sta. Bul. 119, p. 55.

132. Friemann, F.

1909. Investigations of Cottonseed Meal with Reference to its Toxic Action.

Untersuchugen uber Baumwollsomemehl mit Berucksichtgung Seiner Toxichschen Neukung - Inaug Diss., Univ. Bern. p. 43.

Abstract from Exp. Sta. Record, Vol. 32, p. 80.

133. Aaron, C. D.

1927. Diseases of the Digestive Organs, p. 689.

Lea and Febiger, Philadelphia, Publisher.

134. Wells, C. A., and Wing, P. V.

Acidosis and Cottonseed Meal Injury.

Georgia Agr'l. Exp. Sta. Bul. 119, p. 35-64.

135. Kuhlmann, F.

1918. Cited by Carruth, F. E.

Jour. Am. Chem. Soc., Vol. 40, p. 643.

136. Marchlewski, L.

1899. Gossypol, A Constituent of Cottonseed.

Jour. Prakt. Chem., Vol. 60, p. 84-90.

Abst. in Exp. Sta. Record VII, p. 50.

137. Withers, W. A. and Carruth, F. E.

1915. Gossypol, A Toxic Substance in Cottonseed.

A Preliminary Note.

Science, Vol. 41, p. 324.

138. Withers, W. A., and Ray, B. J.

1912. A Method for the Removal of the Toxic Properties from Cottonseed Meal. A Preliminary Report.

Science, Vol. 36, p. 31.

139. McCollum, E. V., Simmonds, N, and Petz, W.

1916. The Distribution in Plants of the Fat Soluble A, The Dietary Essential of Butter Fat.

American Jour. of Physiology, Vol. 41, No. 3, p.362.

140. Carruth, F. E.

1917. Methods for Approximating the Relative Toxicity of Cottonseed Products.

Jour. Biol. Chem., Vol. 32, p. 89-90.

141. Carruth, F. E.

1918. Contribution to the Chemistry of Gossypol. The Toxic Principle of Cottonseed.

Jour. Am. Chem. Soc., Vol. 40, p. 647-663.

142. Sherwood, F. W.

1926. Studies on Gossypol: The Gossypol and D-Gossypol Content of Some North Carolina Cottonseed Meals.

Jour. Agr'l. Research, Vol. 32, p. 793-800.

143. Clark, E. P.

1927. Studies on Gossypol.

I The Preparation, Purification and Some of the Properties of Gossypol. The Toxic Principle of Cottonseed.

Jour. Biol. Chem., Vol. p. 725-739.

144. Clark, E. P.

1928. The Composition and Toxic Effects of Gossypol.

Reprint from Aug. and Sept. Issues of Oil and Fat Industries.

145. Gallup. W. D.

1926. Eliminating the Toxicity of Cottonseed Meal.

Jour. Dairy Science, Vol. IX, p. 359-373.

146. Withers, W. A., and Carruth, F. E.

1918. Gossypol, The Toxic Substance in Cottonseed.

Jour. Agr'l. Research, Vol. XII, p. 83-101.

147. Edgerton, C. W., and Morris, H.

1912. Cottonseed Meal Poisoning.

L. A. Bul. 134.

148. Schwartze, E. W., and Alsberg, C. L.

1924. Relation between Toxicity of Cottonseed and its Gossypol Content.

Jour. Agr. Res. Vol. 28, p. 173-198.

149. Schwartze, E. W., and Alsberg, C. L.
1923. Quantative Variation of Gossypol and its Relation to the Oil Content. of Cottonseed. Jour. Agr. Res., Vol. 25, no. 7, p. 285-295.

150. Reed, O. E., Huffman, C. F., and Addington, L. H.
1928. Cottonseed Meal as a Feed for Dairy Calves. Jour. Dairy Sci., Vol. 11, p. 488-513.

151. Huffman, C. F., and Robinson, C. S.
1926. Studies on the Chemical Composition of Beef Blood III The Blood Picture of Calves on a Sole Diet of Milk or of Milk with the Addition of Various Supplements. Jour. Biol. Chem., Vol. 69, p. 101-112.

152. Davenport, E. V.
1897. On the Importance of the Physiological Requirements of the Animal Body: Results of an Attempt to Grow Cattle without Coarse Food. Ill. Agr'l. Exp. Sta., Bul. 46, p. 362-371.

153. McCandlish, A. C.
1923. Studies in the Growth and Nutrition of Dairy Calves. Jour. Dairy Sci., Vol. 6, p. 54.

154. Forty-fifth Annual Report.
1922 North Carolina Agr'l. Exp. Sta., p. 44-47.

155. Forty-sixth Annual Report.
1923. North Carolina Agr'l. Exp. Sta., p 63.

156. Forty-seventh Annual Report.

1924. North Carolina Agr'l. Exp. Sta., p. 55-56.

157. Forty-eighth Annual Report.

1925. North Carolina Agr'l. Exp. Sta., p. 23.

158. Forty-ninth Annual Report.

1926. North Carolina Agr'l. Exp. Sta., p. 32-35.

159. Fiftieth Annual Report.

1927. North Carolina Agr'l. Exp. Sta., p. 42-48.

160. Wells, C. A., and Ewing, P. V.

1916. Cottonseed Meal as an Incomplete Food.

Jour. Biol. Chem., Vol. 27, p. 15-25.

161. McCandlish, A. C.

1922. The Feeding of Dairy Cattle, p. 155.

John Wiley and Sons, Inc., New York, Publishers.

162. Eckles, C. H.

1924. Dairy Cattle and Milk Production, p. 330.

The MacMillan Company, New York, Publishers.

163. Eweing, P V., and Wells, C. A.

1915. The Associative Digestibility of Corn Silage, Cottonseed Meal and Starch in Steer Rations.

Georgia Agr'l. Exp. Sta., Bul. 115.

164. Curtis, R. S.

1911. Feeding Cottonseed Meal to Draft Animals.

North Carolina Agr'l. Exp. Sta., Bul. 216.

165. Fish, P. A.

1923. The Rate of Passage of Material Through the Digestive Tract.

Cornell Veterinarian, April, 1923.

166. Ewing P., and Smith, F. H.

1927. A Study of the Rate of Passage of Food Residue through the Digestive Tract and Its Influence on Digestion.

Jour. Agr'l. Research, Vol. V, No. 10, p. 55-63.

167. Copeland, L., and Olson, T. M.

1926. The Bacterial Flora of Normal Cows Udder.

South Dakota Agr'l. Exp. Sta., Bul. 218.

168. Harding, H. A., and Wilson, J. K.

1913. A Study of the Udder Flora of Cows.

New York Agr'l. Exp. Sta., Geneva Tech. Bul. 27.

APPENDIX

TABLE I Animal G-1

Feed Consumed by 30 day Periods from 90 days of age to First Calving. Average Daily Requirements and Consumption of Digestive Protein and Energy according to the Armsby Standard.

Age for period	Av. body wt.	Skim milk	Feed Consumed C.S.M.	Feed Consumed Corn	Silage	Timothy	Nutrients Required Digestible Protein	Nutrients Required Energy	Nutrients Consumed Protein C.S.M.	Nutrients Consumed Total Prot.	Nutrients Consumed Excess Prot.	Energy
Days	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Therms	Lbs.	Lbs.	Per Ct.	Therms
118	266	360	18.8	22.4	108	70	0.69	4.06	0.67*	0.83	20.9	4.51
148	303.5	360	56.8	2.4	147	108	0.73	4.28	0.75*	0.97	32.8	4.96
178	340		63.8	0.0	204	134	0.76	4.54	0.78	0.99	29.9	4.98
208	383.5		66.0	6.0	210	151	0.79	4.95	0.81	1.06	33.9	4.49
238	426		69.0	6.0	234	198	0.81	5.33	0.85	1.15	42.6	6.43
268	468.5		69.0	8.9	280	252	0.82	5.70	0.85	1.23	49.4	7.50
298	512.5		70.9	9.0	316.5	270	0.84	6.08	0.85	1.26	50.6	7.95
328	557.5		72.0	9.0	325.5	270	0.85	6.46	0.89	1.30	53.1	8.11
358	591		72.0	9.0	350	270	0.85	6.73	0.89	1.31	54.2	8.23
388	631		72.0	9.0	390	270	0.85	7.05	0.89	1.32	55.8	8.44
418	669.5		72.0	9.0	428	270	0.85	7.36	0.89	1.34	57.4	8.65
448	730		72.0	9.0	450	270	0.85	7.78	0.89	1.35	58.4	8.76
578	750		72.0	9.0	450	270	0.85	7.90	0.89	1.35	58.4	8.76
508	790		72.0	9.0	450	270	0.85	8.13	0.89	1.35	58.4	8.76
538	818		72.0	9.0	467	270	0.85	8.31	0.89	1.35	59.2	8.85
568	855		72.0	9.0	502	270	0.85	8.53	0.89	1.37	61.0	9.08
598	916		72.0	9.0	496	270	0.85	8.90	0.89	1.36	60.2	9.00
628	971		72.0	9.0	450	270	0.85	9.23	0.89	1.35	58.4	8.76
658	1001		72.0	9.0	462	270	0.85	9.41	0.89	1.35	58.9	8.82
688	1025		72.0	9.0	509	270	0.85	9.55	0.89	1.37	61.0	9.08
718**	1041		103.2	7.5	494	250	0.85	9.65	1.26	1.71	100.9	9.59

* Plus protein in skim milk.
** Last period 26 days.

TABLE II Animal G-2

Feed Consumed by 30 day Periods from 90 days of age to First Calving. Average Daily Requirements and Consumption of Digestible Protein and Energy according to the Armsby Standard.

Age for period	Av. body wt.	Feed Consumed: Skim	Feed Consumed: L.O.M.	Feed Consumed: Corn	Feed Consumed: Silage	Feed Consumed: Timothy	Nutrients Required: Digestible Protein	Nutrients Required: Energy	Nutrients Consumed: Protein L.O.M.	Nutrients Consumed: Total Pro.	Nutrients Consumed: Excess Prot.	Nutrients Consumed: Energy
Days	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Therms	Lbs.	Lbs.	Per Ct.	Therms
119	326	360	31.4	1.2	138	100	0.75*	4.41	0.75*	0.90	19.7	4.79
149	374	24	75.6	4.0	185	112	0.78*	4.86	0.78*	0.97	24.1	5.04
179	414		82.9	0	204	134	0.80	5.23	0.82	1.03	27.5	5.42
209	467		86.8	6	210	141	0.82	5.68	0.88	1.11	34.9	5.97
239	514		87.0	6	244	198	0.84	6.09	0.88	1.18	40.6	6.96
269	554		89.9	2	282	252	0.85	6.43	0.91	1.27	49.2	7.90
299	611		90.0	0	319	261	0.85	6.89	0.91	1.28	51.0	8.10
329	650		90.0	0	319	270	0.85	7.20	0.91	1.29	52.1	8.22
359	688		90.0	0	350	270	0.85	7.50	0.91	1.32	54.8	8.56
389	734		90.0	0	390	270	0.85	7.80	0.91	1.32	55.2	8.61
419	779		90.0	0	428	270	0.85	8.07	0.91	1.33	56.5	8.82
449	837		90.0	0	450	270	0.85	8.42	0.91	1.34	57.8	8.92
479	851		90.0	0	450	270	0.85	8.53	0.91	1.34	57.8	8.92
509	895		90.0	0	450	270	0.85	8.77	0.91	1.34	57.8	8.92
539	943		90.0	0	467	270	0.85	9.06	0.91	1.35	58.6	9.02
569	977		90.0	0	502	270	0.85	9.26	0.91	1.36	60.3	9.24
599	1023		90.0	0	496	270	0.85	9.54	0.91	1.36	59.6	9.16
629	1073		90.0	0	450	270	0.85	9.84	0.91	1.34	57.8	8.92
659	1110		90.0	0	462	270	0.85	10.06	0.91	1.35	58.2	8.99
689	1150		90.0	0	509	270	0.85	10.30	0.91	1.36	60.3	9.24
719**	1174		90.0	0	534	270	0.85	10.44	0.91	1.37	61.4	9.37

* Plus protein in skim milk

** Last p riod 29 days

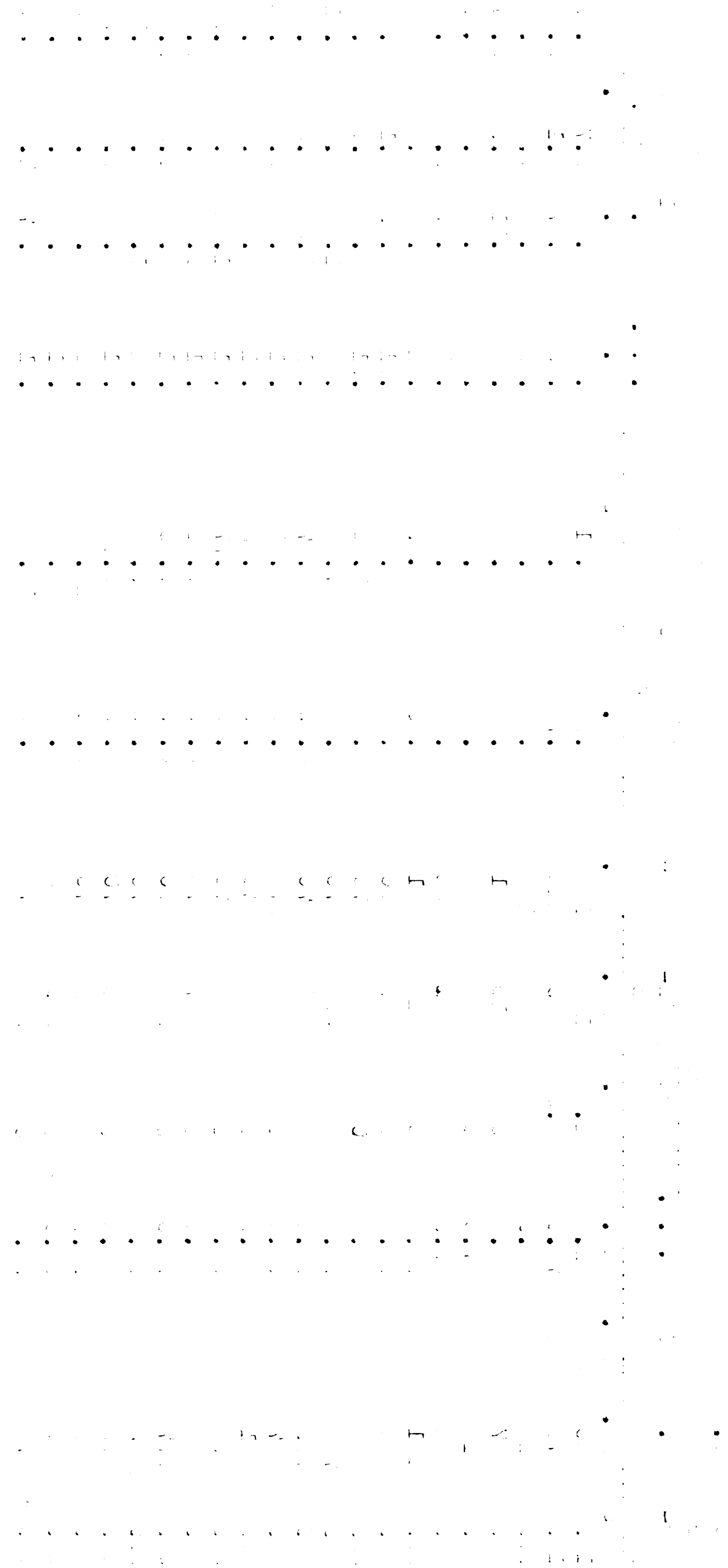


TABLE III Animal G-3

Feed Consumed by 30 day Periods from 90 days of age to First Calving. Average Daily Requirements and Consumption of Digestible Protein and Energy according to the Armsby Standard.

Age for period	Av. body wt.	Skim milk	Feed Consumed C.S.M.	Corn	Silage	Timothy	Nutrients Required Digestible Protein	Energy	Nutrients Consumed Protein C.S.M.	Total Prot.	Excess Prot.	Energy
Days	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Therms	Lbs.	Lbs.	Per Ct.	Therms
90	187	360	14.5	27	54	46	0.58	3.70	0.62*	0.75	29.1	3.89
120	237	360	17.7	30	125	104	0.65	3.93	0.65*	0.88	35.8	5.09
150	285		60.4	29	150	121	0.71	4.16	0.74	0.99	39.5	5.24
180	330		63.0	30	175	163	0.75	4.45	0.78	1.08	43.2	6.06
210	366		64.2	36	219	199	0.78	4.79	0.79	1.16	49.2	7.02
240	417		66.8	18.9	258	208	0.81	5.25	0.83	1.18	46.0	6.96
270	460		69.0	9	239	206	0.82	5.62	0.85	1.17	42.7	6.65
300	506		69.0	9	290	215	0.84	6.02	0.85	1.20	43.2	7.05
330	553		69.0	9	335	240	0.85	6.42	0.85	1.24	45.5	7.63
360	596		70.1	9	360	250	0.85	6.77	0.87	1.27	49.3	7.92
390	634		72.0	9	435	270	0.85	7.07	0.89	1.34	57.7	8.68
420	666		72.0	9	450	270	0.85	7.33	0.89	1.35	58.4	8.76
450	720		72.0	9	450	270	0.85	7.72	0.89	1.35	58.4	8.76
480	758		72.0	9	466	270	0.85	7.94	0.89	1.35	58.9	8.84
510	788		72.0	9	466	270	0.85	8.12	0.89	1.35	58.9	8.84
540	820		72.0	9	434	270	0.85	8.32	0.89	1.34	57.6	8.68
570	879		72.0	9	355	270	0.85	8.67	0.89	1.31	54.1	8.25
600	917		72.0	9	439	270	0.85	8.90	0.89	1.34	57.8	8.69
630	969		72.0	9	509	270	0.85	9.20	0.89	1.39	60.9	9.07
660	1025		72.0	9	524	270	0.85	9.55	0.89	1.37	61.5	9.15
690	1070		72.0	9	540	270	0.85	9.82	0.89	1.38	62.2	9.23
725**	1094		21.6	0	66	26	0.85	9.96	2.00	2.37	78.3	10.47

* Plus Protein in skim milk
** Last period 4 days.

TABLE IV Animal G-4

Feed Consumed by 30 day Periods from 90 days of age to First Calving. Average Daily Requirements and Consumption of Digestible Protein and Energy according to the Armsby Standard.

Age for period	Av. body wt.	Skim milk	Feed Consumed L.O.M.	Feed Consumed Corn	Silage	Timothy	Nutrients Required Digestible Protein	Nutrients Required Energy	Nutrients Consumed Protein L.O.M.	Nutrients Consumed Total Prot.	Nutrients Consumed Excess Prot.	Nutrients Consumed Energy
Days	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Therms	Lbs.	Lbs.	Per Ct.	Therms
93	227	360	19.8	29	71	46	0.63	3.88	0.63*	0.78	22.6	4.19
123	263	360	24.8	29	110	90	0.68	4.05	0.68*	0.89	30.2	5.19
153	317	21.5	74.6	29	150	120	0.74	4.36	0.78	1.03	38.9	5.69
183	363		80.0	30	165	143	0.78	4.76	0.82	1.10	41.3	6.20
213	406		82.9	30	199	192	0.80	5.16	0.83	1.17	46.6	7.11
243	450		84.9	21	248	210	0.82	5.54	0.86	1.21	48.2	7.45
273	501		87.0	0	270	210	0.63	5.97	0.88	1.19	42.3	7.02
303	538		87.9		280	207	0.85	6.30	0.88	1.19	40.5	7.07
333	578		90.0		320	237	0.85	6.62	0.91	1.26	48.4	7.77
363	624		90.0		355	240	0.85	6.99	0.91	1.28	50.1	7.99
393	675		90.0		402	270	0.85	7.39	0.91	1.35	59.2	8.67
423	722		90.0		435	261	0.85	7.73	0.91	1.33	56.1	8.72
453	757		90.0		450	270	0.85	7.94	0.91	1.37	61.3	8.92
483	807		90.0		457	270	0.85	8.24	0.91	1.37	61.5	8.96
513	831		90.0		466	270	0.85	8.39	0.91	1.38	62.0	9.00
543	840		90.0		360	261	0.85	8.44	0.91	1.30	52.8	8.32
573	880		78.0		334	247	0.85	8.68	0.79	1.15	35.7	7.64
603	925		90.0		398	270	0.85	8.95	0.91	1.35	59.1	8.65
633	976		90.0		490	270	0.85	9.26	0.91	1.39	63.0	9.13
663	1018		90.0		514	270	0.85	9.51	0.91	1.39	64.0	9.26
693	1057		90.0		540	270	0.85	9.74	0.91	1.40	65.2	9.40
723	1096		90.0		540	270	0.85	9.98	0.91	1.40	65.2	9.40
753**	1131		81.0	8	494	227	0.85	10.19	0.91	1.38	62.6	9.45

* Plus protein in skim milk.

** Last period 27 days

[illegible]

TABLE V Animal G-5

Feed Consumed by 30 day Periods from 90 days of age to First Calving. Average daily Requirements and Consumption of Digestible Protein and Energy according to the Armsby Standard.

Age for per-iod	Av. body wt.	Skim milk	Feed Consumed C.S.M.	Corn	Sil-age	Tim-othy	Nutrients Required Digestible Protein	Energy	Protein C.S.M.	Total Prot.	Nutrients Consumed Excess Prot.	Energy
Days	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Therms	Lbs.	Lbs.	Per Ct.	Therms
89	166	360	12.3	28	64	51	0.55	3.60	0.58*	0.66	19.4	3.17
119	208	360	15	28	88	88	0.61	3.80	0.62*	0.80	32.1	4.66
149	247	22	58	30	130	111	0.66	3.97	0.73	0.96	45.3	5.01
179	282		60	33.8	125	157	0.71	4.15	0.74	1.03	45.2	5.74
209	323		61.9	36	180	180	0.75	4.39	0.76	1.10	46.8	6.58
239	360		63.9	36	177	171	0.77	4.73	0.79	1.11	44.2	6.41
269	395		66.9	36	190	168	0.80	5.06	0.83	1.15	44.7	6.52
299	433		69	17.1	222	202	0.81	5.39	0.85	1.18	45.2	6.70
329	469		69	9	268	210	0.82	5.70	0.85	1.18	43.7	6.83
359	511		69	9	300	231	0.84	6.06	0.85	1.22	45.2	7.31
389	556		71.7	9	306	256	0.85	6.45	0.88	1.27	49.9	7.77
419	596		72	9	349	270	0.85	6.77	0.89	1.31	54.2	8.25
449	640		72	9	374	270	0.85	7.12	0.89	1.32	55.1	8.36
479	682		72	9	405	270	0.85	7.46	0.89	1.33	56.4	8.52
509	709		72	9	365	266	0.85	7.65	0.89	1.31	54.3	8.27
539	757		72	9	304	270	0.85	7.94	0.89	1.29	57.9	7.98
569	805		72	9	394	270	0.85	8.23	0.89	1.32	55.8	8.45
599	849		72	9	469	270	0.85	8.49	0.89	1.35	59.1	8.85
629	903		72	9	495	270	0.85	8.82	0.89	1.36	60.2	8.99
659	956		72	9	510	270	0.85	9.14	0.89	1.37	61.0	9.07
689	971		72	9	529	270	0.85	9.23	0.89	1.37	61.7	9.17
719**	990		19.2	1.4	106	41	0.85	9.34	0.85	1.16	37.0	6.61

* Plus protein in skim milk
** Lastperiod 8 days.

TABLE VI Animal G-6

Feed Consumed by 30 day Periods from 90 days of age to First Calving. Average Daily Requirements and Consumption of Digestible Protein and Energy according to the Armsby Standard.

Age for period	Av. body wt.	Feed Consumed: Skim milk	Feed Consumed: L.O.M.	Feed Consumed: Corn	Feed Consumed: Silage	Feed Consumed: Timothy	Nutrients Required: Digestible Protein	Nutrients Required: Energy	Protein L.O.M.	Nutrients Consumed: Total Prot.	Nutrients Consumed: Excess Prot.	Nutrients Consumed: Energy
Days	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Therms	Lbs.	Lbs.	Per Ct.	Therms
94	209	360	17.4	29	69	82	0.61	3.80	0.61*	0.79	29.2	4.622
124	259	360	23.6	29	134	131	0.68	4.03	0.67*	0.93	36.5	5.88
154	299.5		74.5	30	150	120	0.73	4.25	0.74	0.99	35.7	5.55
184	342.5		77.9	30	157	127	0.76	4.57	0.79	1.04	37.3	5.80
214	378		80.9	18	179	160	0.78	4.90	0.82	1.09	39.1	6.15
244	412.5		81.0		214	180	0.80	5.22	0.82	1.07	34.1	6.11
274	457		84.7		240	191	0.82	5.60	0.85	1.13	37.7	6.49
204	487		80.5		240	210	0.83	5.86	0.82	1.11	34.1	6.68
234	536		77.9		270	239	0.85	6.28	0.79	1.12	36.3	7.19
264	579		87.0		300	250	0.85	6.62	0.88	1.24	45.3	7.74
294	625.0		87.5		370	270	0.85	7.00	0.88	1.29	51.4	8.42
324	659		90.0		368	270	0.85	7.27	0.91	1.31	54.3	8.50
354	696		90.0		326	270	0.85	7.57	0.91	1.30	52.5	8.27
384	740		90.0		383	270	0.85	7.84	0.91	1.32	54.9	8.57
414	767		90.0		461	270	0.85	8.00	0.91	1.35	58.2	8.99
544	803		90.0		485	270	0.85	8.22	0.91	1.35	59.3	9.12
574	862		90.0		510	270	0.85	8.57	0.91	1.36	60.4	9.24
604	902		90.0		519	270	0.85	8.81	0.91	1.37	60.7	9.29
634	933		90.0		540	270	0.85	9.00	0.91	1.37	61.7	9.40
664	978		90.0		540	270	0.85	9.27	0.91	1.37	61.7	9.40
694	1027		90.0		540	282	0.85	9.56	0.91	1.39	63.1	9.57
724**	1091		48.0		234	150	0.85	9.95	1.12	1.62	90.0	10.45

* Plus protein in skim milk.

** Last priod 13 days.

TABLE VII Animal G-7

Feed Consumed by 30 day Periods from 90 days of age to First Calving. Average Daily Requirements and Consumption of Digestible Protein and Energy according to the Armsby Standard.

Age for per-iod	Av. body wt.	Feed Consumed					Nutrients Required		Nutrients Consumed			
		Skim milk	C.S.M.	Corn	Sil-age	Tim-othy	Digestible Protein	Energy	Protein C.S.M.	Total Prot.	Excess Prot.	Energy
Days	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Therms	Lbs.	Lbs.	Per Ct.	Therms
89	179	360	14	31.8	67	52	0.57	3.66	0.62*	0.77	35.5	4.17
119	225	360	15	33.0	99	92	0.63	3.87	0.62*	0.83	31.6	4.98
149	268	282	17.9	33.0	118	110	0.69	4.07	0.56	0.80	15.6	5.06
179	305		58.6	36.0	167	142	0.73	4.28	0.72	1.02	39.2	5.76
209	337		61.4	36.0	180	148	0.76	4.52	0.76	1.07	40.1	6.05
239	364		65.1	36.0	174	144	0.78	4.77	0.80	1.10	37.2	6.04
269	391		67.7	21.6	180	150	0.79	5.02	0.84	0.98	23.9	5.85
299	424		69.0	9.0	190	186	0.81	5.31	0.85	1.13	39.4	6.08
329	465		69	9	210	203	0.82	5.67	0.85	1.16	40.9	6.45
359	483		69.5	9	271	210	0.83	5.82	0.86	1.18	43.4	6.87
389	533		72	9	281	212	0.84	6.25	0.89	1.23	46.0	7.05
419	576		72	9	300	240	0.85	6.61	0.89	1.26	48.4	7.53
449	612		72	9	298	266	0.85	6.90	0.89	1.29	51.9	7.95
479	650		72	9	387	270	0.85	7.20	0.89	1.32	55.8	8.42
509	679		72	9	450	270	0.85	7.43	0.89	1.35	58.4	8.76
539	721		72	9	498	270	0.85	7.73	0.89	1.35	58.4	9.01
569	756		72	9	510	270	0.85	7.93	0.89	1.37	61.0	9.08
599	792		72	9	510	270	0.85	8.15	0.89	1.37	61.0	9.08
629	865		72	9	517	270	0.85	8.59	0.89	1.37	61.3	9.11
659	904		72	9	540	284	0.85	8.82	0.89	1.39	64.0	9.45
689	962		69.6	8.7	529	273	0.85	9.17	0.86	1.54	81.5	9.13
719**	975		38.4	4.8	228	96	0.85	9.25	0.89	1.29	51.8	8.96

* Plus protein in skim milk

** Last period 16 days.

TABLE VIII Animal G-8

Feed Consumed by 30 day Periods from 90 days of age to First Calving. Average Daily Requirements and Consumption of Digestible Protein and Energy according to the Armsby Standard.

Age for period	Av. body wt.	Skim milk	Feed Consumed L.O.M.	Feed Consumed Corn	Silage	Timothy	Nutrients Required Digestible Protein	Nutrients Required Energy	Protein L.O.M.	Nutrients Consumed Total Prot.	Nutrients Consumed Excess Prot.	Nutrients Consumed Energy
Days	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Therms	Lbs.	Lbs.	Per Ct.	Therms
89	186	360	16.8	28	66	52	0.58	3.70	0.60*	0.75	28.8	4.07
119	234	360	18.0	30	103	90	0.64	3.91	0.61*	0.82	27.4	4.94
149	274	270	23.8	30	117	101	0.70	4.10	0.56*	0.78	11.9	4.93
179	314		75.0	30	166	146	0.74	4.34	0.76	1.04	40.2	6.06
209	357		75.0	30	180	150	0.77	4.70	0.76	1.05	35.9	6.18
239	395		79.2	30	180	150	0.80	5.06	0.80	1.09	36.0	6.31
269	440		82.7	10	196	158	0.81	5.45	0.83	1.09	34.4	6.03
299	478		85.8		220	219	0.83	5.78	0.86	1.16	40.2	6.84
329	524		88.4		240	240	0.84	6.17	0.88	1.22	45.0	7.34
359	554		90		297	240	0.85	6.34	0.91	1.25	47.5	7.68
389	610		90		346	240	0.85	6.88	0.91	1.27	49.8	7.94
419	654		90		326	240	0.85	7.23	0.91	1.27	49.0	7.84
449	701		90		320	266	0.85	7.61	0.91	1.32	55.8	8.24
479	737		90		386	270	0.85	7.82	0.91	1.35	58.8	8.60
509	745		90		450	270	0.85	7.87	0.91	1.37	61.4	8.92
539	793		72		336	229	0.85	8.15	0.73	1.08	26.6	7.18
569	831		90		506	270	0.85	8.39	0.91	1.39	63.9	9.24
599	882		90		510	270	0.85	8.69	0.91	1.39	63.9	9.24
629	947		90		517	270	0.85	9.08	0.91	1.40	64.1	9.27
659	1006		90		540	281	0.85	9.44	0.91	1.39	63.1	9.57
689	1064		90		540	300	0.85	9.78	0.91	1.40	65.2	9.83
719**	1140		35	4.5	228	125	0.85	10.24	0.82	1.32	55.2	9.57

* Plus Protein in skim milk

** Last Period 13 days

[illegible]

TABLE IX Animal G-9

Feed Consumed by 30 day Periods from 90 days of age to First Calving. Average Daily Requirements and Consumption of Digestible Protein and Energy according to the Armsby Standard.

Age for period	Av. body wt.	Feed Consumed					Nutrients Required		Nutrients Consumed			
		Skim milk	C.S.M.	Corn	Silage	Timothy	Digestible Protein	Energy	Protein C.S.M.	Total Prot.	Excess Prot.	Energy
Days	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Therms	Lbs.	Lbs.	Per Ct.	Therms
94	217	360	15	33	68	66	0.62	3.84	0.62*	0.79	27.5	4.42
124	254	360	16	33	107	71	0.67	4.00	0.63*	0.82	22.9	4.76
154	292	240	32	33.7	116	112	0.72	4.21	0.70*	0.94	30.0	5.37
184	335		61.8	36	139	129	0.76	4.50	0.78	1.05	37.8	5.57
214	380		66	36	143.5	159	0.79	4.92	0.81	1.12	41.3	6.13
244	412		66	36	157	180	0.80	5.20	0.85	1.13	41.8	6.49
274	449		68	13.5	190	180	0.82	5.53	0.85	1.14	39.2	6.12
304	480		71	9	230	201	0.83	5.80	0.88	1.19	42.8	6.58
334	525		69.8	8.1	217	208	0.84	6.18	0.86	1.17	39.4	6.57
364	548		72.0	9	286	252	0.85	6.38	0.89	1.27	49.2	7.62
394	590		72	9	358	270	0.85	6.72	0.89	1.31	54.4	8.26
424	673		73	9	374	270	0.85	7.10	0.89	1.32	55.2	8.36
454	683		72	9	390	270	0.85	7.46	0.89	1.32	55.8	8.44
484	715		72	9	420	270	0.85	7.69	0.89	1.34	57.1	8.60
514	746		67.2	8.4	360	270	0.85	7.88	0.83	1.01	18.7	8.11
544	785		72	9	444	271	0.85	8.10	0.89	1.34	57.8	8.68
574	835		72	9	453	277	0.85	8.41	0.89	1.35	59.2	8.86
604	886		72	9	556	287	0.85	8.72	0.89	1.40	65.1	9.57
634	933		72	9	600	300	0.85	9.00	0.89	1.43	68.4	9.98
664	962		72	9	600	316	0.85	9.17	0.89	1.45	70.1	10.20
694	989		72	9	600	300	0.85	9.33	0.89	1.43	68.4	9.98
724	1019		72	9	600	300	0.85	9.51	0.89	1.43	68.4	9.98
754**	1055		24.6	3.9	200	100	0.85	9.73	0.93	1.48	73.5	10.16

* Plus protein in skim milk

** Last period 11 days

TABLE X Animal G-10

Feed Consumed by 30 day Periods from 90 days of age to First Calving. Average Daily Requirements and Consumption of Digestible Protein and Energy according to the Armsby Standard.

Age for period	Av. body wt.	Skim milk	Feed Consumed L.O.M.	Feed Consumed Corn	Silage	Timothy	Nutrients Required Digestible Protein	Nutrients Required Energy	Nutrients Consumed Protein L.O.M.	Nutrients Consumed Total Prot.	Nutrients Consumed Excess Prot.	Energy
Days	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Therms	Lbs.	Lbs.	Per Ct.	Therms
92	216	360	18	30	60.5	56.5	0.62	5.84	0.61*	0.77	23.7	6.00
122	259	360	18	30	68	82	0.68	4.03	0.61*	0.79	16.8	6.40
152	297		75	30	94	99	0.72	4.24	0.75	0.96	33.5	4.99
182	348		75.2	30	134	130	0.77	4.62	0.75	1.01	39.0	5.64
212	392		81	3	166	170	0.79	5.03	0.82	1.15	45.2	5.57
242	426		86	17	156	171	0.81	5.33	0.88	1.15	41.7	6.34
272	461		90		200	180	0.82	5.63	0.91	1.16	41.5	6.31
302	512		90		225	216	0.84	6.07	0.91	1.21	43.5	6.96
332	570		90		286	252	0.85	6.56	0.91	1.26	48.6	7.79
362	603		90		358	270	0.85	6.82	0.91	1.31	54.2	8.47
392	656		90		374	270	0.85	7.25	0.91	1.32	55.0	8.57
422	698		90		390	270	0.85	7.58	0.91	1.32	55.5	8.65
452	740		90		420	270	0.85	7.84	0.91	1.33	56.8	8.81
482	772		90		450	270	0.85	8.05	0.91	1.34	57.8	8.92
512	812		90		450	272	0.85	8.27	0.91	1.34	58.1	8.97
542	856		90		528	300	0.85	8.54	0.91	1.40	64.7	9.77
572	906		90		556	300	0.85	8.24	0.91	1.41	65.9	9.91
602	943		90		600	300	0.85	9.06	0.91	1.43	67.8	1 0.15
632	990		90		600	354	0.85	9.34	0.91	1.48	74.1	10.92
662	1042		90		600	360	0.85	9.53	0.91	1.49	74.8	11.01
692	1078		90		600	360	0.85	9.87	0.91	1.49	74.8	11.01
722	1135		90		600	360	0.85	10.21	0.91	1.49	74.8	11.01
752	1197		90		600	360	0.85	10.58	0.91	1.49	74.8	11.01
782**	1289		54		350	194	0.85	11.13	0.91	1.38	62.7	9.52

* Plus protein in skim milk

** Last period 18 days.

[illegible]

TABLE XI Animal G-11

Feed Consumed by 30 day Periods from Birth to 17 Months of Age. Average Daily Requirements and Consumption of Digestible Protein according to the Armsby Standard.

Age for period	Av. body wt.	Feed Consumed							Nutrients Required		Nutrients Consumed			
		Whole milk	Skim milk	C.S.M.	Corn	Oats	Silage	Timothy	Digestible Protein	Energy	Protein C.S.M.	Total Prot.	Excess Prot.	Energy
Days	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Therms	Lbs.	Lbs.	Per Ct.	Therms
30	101	300							0.40	3.11		0.33	-18.00	2.90
60	128	196	126		4	4		7	0.44	3.34		0.40	-10.00	2.80
90	162		360	4.9	18	18		42	0.54	3.58	0.49*	0.64	+18.00	3.28
120	193		360	9.8	31	3.5	13	71	0.59	3.73	0.55*	0.70	+18.00	3.86
150	220		360	16.9	31		70	85	0.63	3.85	0.64*	0.82	+31.00	4.66
180	282		360	32.4	15		128	111	0.71	4.15	0.83*	1.03	45.1	5.43
210	321		12.5	60.2			150	154	0.75	4.38	0.74*	0.95	26.7	4.86
240	349			68.6			180	199	0.77	4.63	0.85	1.11	44.2	5.94
270	400			69.0			210	215	0.80	5.10	0.85	1.14	42.6	6.36
300	430			69.0			237	210	0.81	5.36	0.85	1.15	37.7	6.42
330	476			69.0			278	210	0.83	5.77	0.85	1.16	39.8	6.64
360	504			69.0			300	210	0.83	6.00	0.85	1.17	41.0	6.75
390	559			69.0			300	210	0.85	6.47	0.85	1.17	37.7	6.75
420	597			69.0	2.8		348	237	0.85	6.78	0.85	1.22	42.7	7.39
450	630			69.0	12.0		372	244	0.85	7.04	0.85	1.26	48.3	7.95
480	688			69.0	12.0		414	300	0.85	7.50	0.85	1.33	56.5	8.99
510	710			69.0	12.0		363	300	0.85	7.66	0.85	1.31	54.1	8.70

*Plus protein in skim milk.

TABLE XII Animal G-12

Feed Consumed by 30 day Periods from Birth to 17 Months of Age. Average Daily

Requirements and Consumption of Digestible Protein according to the Armsby Standard.

Age for per-iod	Av. body wt.	Whole milk	Skim milk	Feed Consumed L.O.M.	Corn	Oats	Sil-age	Tim-othy	Nutrients Required Digestible Protein	Energy	Nutrients Consumed Protein L.O.M.	Total Prot.	Excess Prot.	Energy
Days	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Therms	Lbs.	Lbs.	Per Ct.	Therms
30	106	300							0.41	3.15		0.33	-19.0	2.90
60	125	176	150					5	0.44	3.31		0.40	- 8.0	2.71
90	166		360	5.6	14.5	14.5		36	0.55	3.60	0.49*	0.61	11.0	3.15
120	197		360	13.7	31.5	4	16	16	0.59	3.75	0.58*	0.73	22.0	4.15
150	234		360	26.3	30		78	97	0.64	3.91	0.70*	0.90	39.0	5.18
180	290		360	38.7	12		150	117	0.71	4.19	0.81*	1.01	42.3	5.65
210	330			78.1			150	138	0.75	4.45	0.79	0.98	30.7	5.09
240	366			78			184	198	0.78	4.79	0.79	1.05	34.7	6.48
270	420			8 1			210	215	0.81	5.28	0.82	1.11	38.0	6.61
300	464			81			240	210	0.82	5.66	0.82	1.11	35.4	6.68
330	504			83			284	210	0.83	6.00	0.85	1.17	41.0	7.01
360	537			84			300	210	0.85	6.29	0.85	1.17	37.7	7.09
390	584			84			300	210	0.85	6.67	0.85	1.17	37.7	7.09
420	619			84			336	240	0.85	6.95	0.85	1.21	42.4	7.71
450	655			84			381	252	0.85	7.24	0.85	1.24	45.9	8.12
480	712			84			450	300	0.85	7.67	0.85	1.31	53.9	9.18
510	741			84			450	300	0.85	7.85	0.85	1.31	53.9	9.18

*Plus protein in skim milk

TABLE XIII Animal G-13

Feed Consumed by 30 Day Periods from Birth to 15 Months of Age. Average Daily

Requirements and Consumption of Digestible Protein according to the Armsby Standard.

Age for period	Av. body wt.	Whole milk	Skim milk	Feed Consumed C.S.M.	Corn	Oats	Silage	Timothy	Nutrients Required Digestible Protein	Energy	Nutrients Consumed Protein C.S.M.	Total Prot.	Excess Prot.	Energy
Days	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Therms	Lbs.	Lbs.	Per Ct.	Therms
30	91	312							0.39	3.03		0.34	-14.0	3.07
60	108	180	171		2.5	2.5		6	0.41	3.17		0.44	6.0	2.81
90	137		360		17	17		31	0.46	3.41		0.56	22.0	3.01
120	167		360	4.8	29.7	4		58	0.55	3.61	0.49*	0.64	16.4	3.67
150	204		360	17.4	30		14	83	0.60	3.78	0.65*	0.82	36.7	4.42
180	242		360	18	30		96	120	0.66	3.95	0.65*	0.88	33.4	6.36
210	289			48.8			137	137	0.71	4.19	0.60*	0.79	11.3	4.19
240	328			60			180	152	0.75	4.43	0.74	0.96	28.0	4.67
270	349			62			191	151	0.77	4.63	0.78	1.00	30.0	5.13
300	385			63			210	178	0.79	4.97	0.78	1.03	30.4	5.61
330	435			64			228	180	0.81	5.41	0.78	1.04	28.4	5.75
360	469			67	3.6		223	204	0.82	5.70	0.81	1.11	35.4	6.35
390	507			69	12.4		182	194	0.84	6.03	0.85	1.19	41 .7	6.27
420	549			69	16.8		218	230	0.85	6.39	0.85	1.20	41.2	7.10
450	587			69	12.0		360	240	0.85	6.70	0.85	1.25	47.1	7.84

*Plus protein in skim milk.

TABLE XIV Animal 14

Feed Consumed by 30 Day Periods from Birth to 12 months of Age. Average Daily Requirements and Consumption of Digestible Protein according to the Armsby Standard.

Age for period	Av. body wt.	Feed Consumed: Whole milk	Skim milk	L.O.M.	Corn	Oats	Silage	Timothy	Nutrients Required: Digestible Protein	Energy	Nutrients Consumed: Protein L.O.M.	Total Prot.	Excess Prot.	Energy
Days	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Therms	Lbs.	Lbs.	Per Ct.	Therms
30	92	300							0.37	2.86		0.33	-11.0	2.90
60	118	180	180		2.5	2.5		2	0.43	3.25		0.43	0	2.75
90	158		360		29.5	29.5		28	0.53	3.55		0.63	18.9	3.64
120	201		360	15	30	6		97	0.60	3.76	0.58*	0.77	28.4	4.54
150	235		360	21	30			120	0.65	3.92	0.64*	0.84	31.4	5.78
180	276		360	24	30		77	120	0.70	4.11	0.68*	0.90	28.6	5.55
210	303			38.5	19		110	146	0.73	4.27	0.39	0.63	-14. 7	4.35
240	339			75.5			124	163	0.76	4.54	0.76	0.97	27.7	5.55
270	376			78.4			150	180	0.79	4.90	0.79	1.02	29.2	5.69
300	408			81.0			153	180	0.80	5.17	0.82	1.05	31.3	5.79
330	456			81.0			199	209	0.82	5.59	0.82	1.10	35.0	6.46
360	489			81.0			236	221	0.83	5.87	0.82	1.12	35.0	6.84

* Plus protein in skim milk

TABLE XV Animal C-15

Feed Consumed by 30 Day Periods from Birth to 11 months of Age. Average Daily Requirements and Consumption of Digestible Protein according to the Armsby Standard.

Age for period	Av. body wt.	Whole milk	Skim milk	Feed Consumed C.S.M.	Corn	Oats	Silage	Timothy	Nutrients Required Digestible Protein	Energy	Nutrients Consumed Protein C.S.M.	Total Prot.	Excess Prot.	Energy
Days	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Therms	Lbs.	Lbs.	Per Ct.	Therms
30	71	326							0.29	2.81		0.36	24.2	3.16
60	96	186	174		5	5		10	0.40	3.10		0.45	12.5	3.02
90	132		360		30.5	30.5		20	0.45	3.37		0.62	37.9	3.54
120	162		360	12.6	30			58	0.54	3.58	0.58*	0.72	35.5	3.82
150	192		360	15	30		42	78	0.59	3.72	0.62*	0.79	34.0	4.67
180	231		360	16.5	15		83	91	0.64	3.90	0.64*	0.79	23.5	4.68
210	260			28.4			90	133	0.68	4.03	0.33	0.50	- 27.4	3.21
240	298			57.8			113	150	0.72	4.24	0.70	0.90	25.0	4.53
270	330			60.0			127	152	0.75	4.45	0.74	0.94	25.4	4.75
300	367			60.8			150	180	0.80	4.80	0.74	0.98	25.7	5.25
330	394			63.3	1.2		186	194	0.80	5.05	0.78	1.04	30.0	5.75

*Plus protein in skim milk.

[illegible]

TABLE XVI Animal G-16

Feed Consumed by 30 day Periods from Birth to 4 months of Age. Average Daily Requirements and Consumption of Digestible Protein according to the Armsby Standard.

Age for period	Av. body wt.	Feed Consumed: Whole milk	Skim milk	Corn	Oats	Silage	Timothy	Nutrients Required: Digestible Protein	Energy	Nutrients Consumed: Total Protein	Energy
Days	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Therms	Lbs.	Therms
30	93	231						0.37	2.90	0.25	2.23
60	113	176	180	3	3		10	0.42	3.21	0.44	2.88
90	154		360	24.5	24.5		32	0.51	3.53	0.62	3.57
120	189		360	45.7	45.7		43	0.58	3.70	0.74	4.65

TABLE XVII

Feed Record of Male Calves by 30 day Periods from Birth to 90 days of Age.

Average Daily Requirements and Consumption of Digestible Protein according to the Armsby Standard.

Age for period	Av. body wt.	Feed Consumed: Whole Milk	Feed Consumed: Skim milk	Feed Consumed: Corn	Feed Consumed: Oats	Feed Consumed: Timothy	Nutrients Required: Digestible Protein	Nutrients Required: Energy	Nutrients Consumed: Total Prot.	Nutrients Consumed: Excess Prot.	Nutrients Consumed: Energy
Days	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Therms	Lbs.	Per Ct.	Therms
G-4's											
30	92	299					0.37	2.85	0.33	-18.0	2.90
60	115	186	174	5	5	10	0.42	3.23	0.45	0.7	3.02
90	157		360	24.5	24.5	24	0.52	3.55	0.59	13.5	3.29
G-8's											
30	90	218					0.36	2.82	0.24	-34.2	2.12
60	115	160	200	5	5	9	0.42	3.23	0.45	7.2	2.86
90	158		360	37	37	19	0.53	3.55	0.65	22.7	3.90
G-3's											
30	96	304					0.38	2.98	0.33	-18.0	2.90
60	124	188	176	1	1	3	0.43	3.30	0.42	13.0	2.66
90	150		360			31	0.5	3.50	0.58	11.6	3.75

[illegible]

TABLE XVIII Animal G-1

Milk Production and Feed Consumed from first to second calving. Average Daily Nutrients Required and Nutrients Consumed according to the Savage Standard.

30 day periods	Av. body wt.	Production: Milk	Production: Test	Production: Fat	Production: Av. daily milk	Feed Consumed: C.S.M.	Feed Consumed: Corn	Feed Consumed: Silage	Feed Consumed: Timothy	Nutrients Required: Protein	Nutrients Required: T.D.N.	Nutrients Consumed: Protein C.S.M.	Nutrients Consumed: Total Protein	Nutrients Consumed: Excess Protein	Nutrients Consumed: T.D.N.
	Lbs.	Lbs.	Per Ct.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Per Ct.	Lbs.
1	939	1189	2.9	34.5	39.6	186	125	708	270	2.93	18.57	2.29	3.14	7.1	17.07
2	918	1319	3.2	42.2	42.9	278	135	864	300	3.09	19.65	3.44	4.4	42.4	21.1
3	959	1249	3.3	41.2	41.6	288	157	900	300	3.23	20.8	3.55	4.57	41.5	22.1
4	991	1222	3.1	37.9	40.7	283	162	880	301	2.99	14.49	3.48	4.50	50.6	22.01
5	1014	1177	3.0	35.3	39.2	279	162	750	400	2.92	19.08	3.44	4.52	54.8	22.75
6	1049	968	3.3	31.9	32.3	249	94	750	420	2.69	18.43	3.07	4.00	49.0	20.36
7	1057	850	3.0	25.5	28.3	234	66	750	420	2.35	16.48	2.89	3.60	53.1	19.19
8	1090	742	3.5	26.0	24.7	224	67	711	395	2.27	16.45	2.78	3.59	58.3	18.53
9	1153	570	3.5	20.0	19.0	202	52	660	417	1.97	15.14	2.48	3.27	65.7	17.33
10	1142	448	4.2	18.8	14.9	184	57	629	420	1.79	14.38	2.26	3.05	70.5	16.91
11	1168	112	4.2	4.7	5.7	153	15	705	361	1.06	10.58	1.89	2.57	142.5	13.97
12	1222					74		660	360	0.86	9.68	0.93	1.53	77.6	11.67
13*	1265					20		175	114	0.89	10.05	0.67	1.17	37.4	9.58

9958 lbs. total milk for lactation 2633 lbs. total consumption of C.S.M. for lactation Av. excess protein 51.2%

9846 lbs. total milk for 10 months 7.1 lbs. av. daily consumption of C.S.M. for lactation

* Last period 11 days.

TABLE XIX Animal G-2

Milk Production and Feed Consumed from first to second calving. Average Daily

Nutrients Required and Nutrients Consumed according to the Savage Standard.

30 day periods	Av. body wt.	Production				Feed Consumed				Nutrients Required		Nutrients Consumed			
		Milk	Test	Fat	Av. daily milk	L.O.M.	Corn	Silage	Timothy	Protein	T.D.N.	Protein L.O.M.	Total Protein	Excess Protein	T.D.N.
	Lbs.	Lbs.	Per Ct.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Per Ct.	Lbs.
1	1047	785	3.3	25.9	26.1	182	7.4	660	259	2.32	16.54	1.81	2.50	8.0	14.88
2	1066	804	3.6	28.9	26.8	266	41.0	880	286	2.39	16.98	2.69	3.40	42.4	17.89
3	1087	824	3.7	30.5	27.5	261	36	900	300	2.48	17.57	2.63	3.35	35.1	17.98
4	1098	776	3.6	27.9	25.9	261	36	860	307	2.36	17.04	2.63	3.34	41.6	17.84
5	1114	727	3.7	26.9	24.2	261	36	750	390	2.23	16.30	2.63	3.41	53.0	18.47
6	1118	645	3.7	23.9	21.8	249	7	750	382	2.12	15.81	2.51	3.19	50.5	17.45
7	1122	640	3.8	24.3	21.3	240		750	389	2.15	16.16	2.42	3.08	43.3	16.96
8	1143	558	3.8	21.2	18.6	221		750	360	2.01	15.49	2.23	2.87	42.8	16.01
9	1164	437	4.5	19.7	14.8	213		750	384	1.84	14.79	2.14	2.80	52.2	16.16
10	1199	144	4.5	6.5	4.8	190		660	394	1.17	11.31	1.90	2.54	11.71	14.76
11	1231	dry				106		600	396	0.86	9.76	1.06	1.67	94.6	12.67
12	1273					85		635	360	0.89	10.09	0.88	1.47	64.7	11.80
13*	1312					3	1.5	20	10	0.92	10.40	0.91	1.43	55.0	10.73

6340 lbs. total milk for lactation 2538 lbs. total consumption of L.O.M. for lactation Av. excess protein 47.6%
6340 lbs. total milk for 10 months 7.0 lbs. av. daily consumption of linseed oil meal for lactation.

* Last period 1 day

[illegible]

TABLE XX Animal G-3

Milk Production and Feed Consumed from first to second calving. Average Daily

Nutrients Required and Nutrients Consumed according to the Savage Standard.

30	Av.	Production				Feed Consumed				Nutrients Required		Nutrients Consumed			
day per-iods	body wt.	Milk	Test	Fat	Av. daily milk	C.S.M.	Corn	Sil-age	Tim-othy	Pro-tein	T.D.N.	Pro-tein C.S.M.	Total Pro-tein	Excess Pro-tein	T.D.N.
	Lbs.	Lbs.	Per Ct.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Per Ct.	Lbs.
1	902	1315	3.7	48.7	43.8	212	103	774	291	3.3	20.03	2.63	3.46	5.0	17.79
2	896	1506	3.2	48.2	50.2	340	233	888	306	3.5	20.43	4.18	5.40	54.4	26.61
3	926	1361	3.6	49.0	45.4	311	183	768	375	3.42	21.68	3.85	4.96	45.1	23.95
4	958	1284	3.0	38.5	42.8	288	162	750	440	3.12	19.83	3.55	4.67	49.7	23.71
5	979	1167	3.5	40.8	38.9	271	95	750	390	3.13	20.41	3.33	4.23	35.2	20.43
6	974	989	3.5	34.6	33.0	275	130	750	372	2.70	19.15	3.40	4.37	61.9	21.32
7	976	890	3.6	32.0	29.6	251	85	683	406	2.49	17.09	3.11	3.98	59.9	19.70
8	1010	718	3.4	24.4	23.9	253	60	660	418	2.15	15.41	2.87	3.68	71.2	18.43
9	1042	585	4.0	23.4	79.5	210	54	660	415	2.00	14.89	2.59	3.38	69.0	17.21
10	1059	416	4.8	20.0	13.9	169	26	618	420	1.73	13.84	2.07	2.79	61.3	15.59
11	1073	55	4.8	2.6	1.8	59		520	325	0.88	9.21	0.74	1.25	42.1	9.86
12	1061					51		485	303	0.74	8.41	0.63	1.11	50.0	9.09
13*	1178					5		40	24	0.82	9.34	0.89	1.47	79.3	11.24

10,286 lbs. total milk for lactation
10,231 lbs. total milk for 10 months

2665 lbs. total consumption C.S.M. for lactation.
7.4 lbs. av. daily consumption of C.S.M. for lactation.

Av. excess protein 49.4%

* Last period 2 days

[illegible]

TABLE XXI Animal G-4

Milk Production and Feed Consumed from first to second calving. Average Daily

Nutrients Required and Nutrients Consumed according to the Savage Standard.

30 day per-iods	Av. body wt.	Production				Feed Consumed				Nutrients Required		Nutrients Consumed			
		Milk	Test	Fat	Av. daily milk	L.O.M.	Corn	Sil-age	Tim-othy	Pro-tein	T.D.N.	Pro-tein L.O.M.	Total Pro-tein	Excess Pro-tein	T.D.N.
	Lbs.	Lbs.	Per Ct.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Per Ct.	Lbs.
1	909	1440	3.6	51.8	48.0	222	105	737	229	3.55	22.37	2.23	3.00	-15.0	16.92
2	929	1615	3.2	51.7	53.8	383	152	765	358	3.73	22.78	3.85	4.87	30.4	24.56
3	928	1393	3.8	52.9	46.4	374	124	547	363	3.64	23.28	3.74	4.62	26.9	22.26
4	946	1314	3.5	42.5	40.5	361	94	464	385	3.15	20.54	3.62	4.41	40.0	20.96
5	976	1240	3.5	43.4	41.3	367	117	582	383	3.20	20.79	3.68	4.57	42.8	22.49
6	943	985	3.5	34.4	32.8	313	118	580	386	2.66	17.84	3.14	4.03	51.5	21.02
7	967	930	3.9	36.3	30.3	303	85	600	387	2.62	17.97	3.05	3.87	47.7	20.06
8	950	851	4.1	34.9	28.3	283	65	600	390	2.53	17.49	2.84	3.61	42.7	18.77
9	989	754	4.2	31.7	28.5	275	68	600	390	2.59	18.04	2.78	3.56	37.5	18.98
10	1031	666	4.2	28.0	22.2	258	60	600	390	2.20	16.12	2.60	3.36	52.8	18.26
11	1063	566	4.2	23.8	18.9	246	56	600	390	2.00	15.75	2.47	3.23	61.5	17.86
12	1094	448	4.2	18.8	14.9	221	30	460	390	1.76	14.00	2.20	2.84	61.4	15.56
13	1121	dry				74		420	360	0.78	8.88	0.73	1.24	59.0	10.17
14	1157					78		450	360	0.81	9.17	0.79	1.31	61.8	10.50
15*	1220					23		120	96	0.85	9.67	0.91	1.43	59.5	10.82

12,102 lbs. total milk for lactation 3780 lbs. total consumption of L.O.M. for lactation
11,088 lbs. total milk for 10 months 8.8 lbs. av. daily consumption of L.O.M. for lactation

* Lastperiod 8 days.

TABLE XXII Animal G-5

Milk Production and Feed Consumed from first to second calving. Average Daily Nutrients Required and Nutrients Consumed according to the Savage Standard.

30 day per-iods	Av. body wt.	Production				Feed Consumed				Nutrients Required		Nutrients Consumed			
		Milk	Test	Fat	Av. daily milk	C.S.M.	Corn	Sil-age	Tim-othy	Pro-tein	T.D.N.	Pro-tein C.S.M.	Total Pro-tein	Excess Pro-tein	T.D.N.
	Lbs.	Lbs.	Per Ct.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Per Ct.	Lbs.
1	852	1149	3.7	42.5	38.3	159	91	716	249	2.90	17.74	1.96	2.70	-1.0	14.98
2	868	1333	3.5	46.7	44.4	278	168	838	295	3.29	20.92	3.44	4.69	42.6	20.57
3	880	1228	2.9	35.6	40.9	297	171	750	360	2.97	18.86	3.66	4.72	58.9	22.87
4	903	1215	3.1	37.6	40.5	277	131	750	360	2.97	18.86	3.40	4.37	47.2	21.21
5	926	1120	3.1	34.7	37.3	262	117	750	360	2.76	17.92	3.22	4.15	50.4	20.39
6	923	944	3.7	34.9	31.5	245	91	675	354	2.57	17.27	3.03	3.86	50.2	18.69
7	908	832	3.5	29.1	27.7	225	92	600	358	2.33	15.95	2.78	3.58	53.7	17.82
8	914	816	3.5	28.5	27.2	207	88	600	360	2.29	15.84	2.59	3.39	48.0	17.32
9	941	776	3.9	30.3	25.9	215	99	600	360	2.30	16.26	2.63	3.46	50.4	17.74
10	985	686	3.8	26.1	22.8	212	98	600	360	2.13	15.42	2.63	3.45	62.0	17.65
11	1008	622	3.8	23.6	20.7	200	85	600	360	2.02	14.90	2.59	3.38	67.3	17.23
12	1010	176	3.8	6.7	5.8	66	3	460	360	1.08	9.94	0.81	1.35	25.0	10.26
13	1077					60		558	360	0.75	8.54	0.74	1.31	7.5	10.68
14*	1095					33		216	174	0.77	8.68	0.74	1.26	63.7	9.95

10,897 lbs. total milk for lactation
10.099 lbs. total milk for 10 months 7.3 lbs. av. daily consumption of C.S.M. for lactation.

Last period 16 days.

TABLE XXIII Animal G-6

Milk production and Feed Consumed from first to second calving.* Average Daily

Nutrients Required and Nutrients Consumed according to the Savage Standard.

30 day per-iods	Av. body wt.	Production				Feed Consumed				Nutrients Required		Nutrients Consumed			
		Milk	Test	Fat	Av. daily milk	L.O.M.	Corn	Sil-age	Tim-othy	Pro-tein	T.D.N.	Pro-tein L.O.M.	Total Pro-tein	Excess Pro-tein	T.D.N.
	Lbs.	Lbs.	Per Ct.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Per Ct.	Lbs.
1	865	1205	3.5	42.2	40.1	180	78	540	346	3.05	19.58	1.81	2.24	-26.0	15.70
2	830	1071	3.1	33.2	35.7	272	90	540	360	2.80	18.79	2.72	3.50	25.0	19.58
3	856	969	3.3	32.0	32.3	282	79	584	345	2.57	16.99	2.84	3.58	39.2	18.53
4	883	969	3.1	30.0	32.3	297	72	600	348	2.49	16.43	2.99	3.74	50.1	18.94
5	926	896	3.8	34.1	26.5	287	59	600	360	2.33	16.19	2.90	3.63	55.8	18.55
6	910	683	3.4	23.2	22.7	264	51	600	360	2.00	14.25	2.66	3.37	68.3	17.67
7	925	590	3.8	22.4	19.6	230	19	600	360	1.89	13.88	2.33	2.95	56.1	15.87
8	953	524	3.9	20.4	17.4	213		600	360	1.78	13.47	2.14	2.72	53.0	14.89
9	964	503	3.7	18.6	16.7	208		600	360	1.72	13.12	2. 11	2.70	57.0	14.81
10	995	444	3.9	17.3	14.8	204		600	360	1.65	12.92	2.05	2.63	59.4	14.66
11	1016	407	4.9	20.0	13.8	186	17	600	360	1.71	13.53	1.87	2.50	46.2	15.70

7854 lbs. total milk for 10 months

* Lactation incomplete when data was assembled.

TABLE XXIV Animal G-7

Milk Production and Feed Consumed from first to second calving.* Average Daily.

Nutrients Required and Nutrients Consumed according to the Savage Standard.

30 day per-iod	Av. body wt.	Production				Feed Consumed				Nutrients Required		Nutrients Consumed			
		Milk	Test	Fat	Av. daily milk	C.S.M.	Corn	Sil-age	Tim-othy	Pro-tein	T.D.N.	Pro-tein C.S.M.	Total Pro-tein	Excess Pro-tein	T.D.N.
	Lbs.	Lbs.	Per Ct.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Per Ct.	Lbs.
1	816	1092	3.3	36.0	36.4	222	46	541	287	2.77	17.84	2.74	3.34	20.0	16.15
2	859	1064	3.3	35.1	35.4	256	66	600	337	2.76	17.99	3.15	3.87	40.1	17.50
3	872	1005	3.3	33.2	33.5	246	134	600	357	2.60	17.00	3.03	3.95	51.9	19.94
4	896	835	4.1	34.3	27.8	242	128	600	343	2.46	16.89	3.00	3.88	57.7	19.09
5	904	734	3.8	27.9	24.4	217	98	600	355	2.18	15.31	2.66	3.49	60.1	17.72
6	904	633	4.0	25.3	21.1	189	66	600	360	2.01	14.47	2.33	3.08	53.3	16.17
7	908	608	4.0	24.3	20.2	182	44	600	360	1.95	14.19	2.26	2.95	51.3	15.42
8	907	582	3.8	22.1	19.4	189	46	600	360	1.87	13.67	2.33	3.02	61.5	15.57
9	909	527	3.8	20.0	17.6	182	53	600	360	1.75	13.08	2.26	2.97	69.8	15.67
10	932	449	4.2	18.9	14.9	166	31	600	360	1.65	12.72	2.04	2.69	63.0	14.52
11															

7529 lbs. total milk for 10 months.

* Lactation incomplete when data was assembled.

TABLE XXV Animal G-8

Milk Production and Feed Consumed from first to second calving.* Average Daily

Nutrients Required and Nutrients Consumed according to the Savage Standard.

30 day per-iod	Av. body wt.	Production: Milk	Test	Fat	Av. daily milk	Feed Consumed: L.O.M.	Corn	Sil-age	Tim-othy	Nutrients Required: Pro-tein	T.D.N.	Nutrients Consumed: Pro-tein L.O.M.	Total Pro-tein	Excess Pro-tein	T.D.N.
	Lbs.	Lbs.	Per.Ct.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Per Ct.	Lbs.
1	889	1117	2.9	32.4	37.2	210	45	559	316	2.73	17.63	2.11	2.75	0.8	15.12
2	903	1140	3.5	39.9	38.0	279	69	654	360	2.95	19.16	2.81	3.58	21.4	18.89
3	918	1097	3.5	38.4	36.6	286	115	660	346	2.88	18.84	2.87	3.74	31.1	20.13
4	950	1047	3.3	34.6	34.9	318	95	660	333	2.74	18.14	3.20	4.02	46.7	20.28
5	960	976	3.5	34.2	32.5	306	76	660	352	2.66	17.88	3.08	3.86	45.1	19.66
6	972	846	3.7	31.3	28.2	272	60	660	360	2.45	16.95	2.75	3.49	42.5	18.52
7	975	809	3.6	29.1	27.0	282	60	660	360	2.35	16.42	2.84	3.59	52.8	18.75
8	980	756	3.7	27.9	25.2	272	54	660	360	2.26	16.03	2.75	3.49	54.4	18.35
9	995	748	4.3	32.2	24.9	254	42	660	360	2.38	16.95	2.57	3.27	37.4	17.54
10	1030	704	4.2	29.6	23.4	263	48	660	360	2.28	16.54	2.66	3.38	48.2	17.94

9240 lbs. total milk for 10 months

*Lactation **incomplete** when data was assembled.

TABLE XXVI Animal G-9

Milk Production and Feed Consumed from first to second Calving.* Average Daily

Nutrients Required and Nutrients Consumed according to the Savage Standard.

30 day period	Av. body wt.	Production				Feed Consumed				Nutrients Required		Nutrients Consumed			
		Milk	Test	Fat	Av. daily milk	C.S.M.	Corn	Silage	Timothy	Protein	T.D.N.	Protein C.S.M.	Total Protein	Excess Protein	T.D.N.
	Lbs.	Lbs.	Per Ct.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Per Ct.	Lbs.
1	871	870	4.8	41.8	29.0	128	63	468	273	2.68	18.26	1.59	2.19	19.4	12.34
2	880	1227	3.5	42.9	40.9	237	128	593	360	3.11	19.90	2.92	3.80	22.2	19.19
3	886	1356	3.4	46.1	45.2	287	153	600	360	3.34	21.03	3.66	4.83	44.7	21.47
4	880	1347	3.6	48.5	44.9	306	202	600	360	3.39	21.43	3.77	4.85	43.1	23.08
5	903	1210	3.7	44.7	40.3	300	220	600	360	3.15	20.37	3.70	4.83	17.5	23.44

*Lactation incomplete when data was assembled.

TABLE XXVII Animal G-10

Milk Production and Feed Consumed from first to second calving.* Average Daily

Nutrients Required and Nutrients Consumed according to the Savage Standard.

30 day per- iod	Av. body wt.	Production				Feed Consumed				Nutrients Required		Nutrients Consumed			
		Milk	Test	Fat	Av. daily milk	L.O.M.	Corn	Sil- age	Tim- othy	Pro- tein	T.D.N.	Pro- tein L.O.M.	Total Pro- tein	Excess Pro- tein	T.D.N.
	Lbs.	Lbs.	Per Ct.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Per Ct.	Lbs.
1	1042	1261	3.3	41.6	42.0	224	113	600	321	3.22	21.03	2.24	3.05	-6.3	17.67
2	1084	1067	2.5	26.7	35.6	337	135	600	360	2.65	17.71	3.38	4.30	62.3	21.94
3	1108	838	3.6	30.2	27.9	273	65	600	360	2.50	17.77	2.75	3.49	39.6	18.33

* Lactation incomplete when data was assembled.

TABLE XXVIII Animal G-1

Milk Production and Feed Consumed from second to third calving.* Average

Daily Nutrients Required and Nutrients Consumed according to the Savage Standard.

30 day per-iod	Av. body wt.	Production				Feed Consumed				Nutrients Required		Nutrients Consumed			
		Milk	Test	Fat	Av. daily milk	C.S.M.	Corn	Sil-age	Tim-othy	Pro-tein	T.D.N.	Pro-tein C.S.M.	Total Pro-tein	Excess Pro-tein	T.D.N.
	Lbs.	Lbs.	Per Ct.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Per Ct.	Lbs.
1	1040	1326	2.8	37.1	44.2	227	119	600	326	3.18	20.44	2.89	3.73	17.3	18.18
2	1059	1577	2.6	41.0	52.5	318	226	600	360	3.57	22.15	3.92	5.07	42;0	24.08
3	1102	1495	2.9	43.4	49.8	313	227	600	360	3.57	22.78	3.85	4.99	39.8	23.93
4	1136	1371	3.1	42.5	45.7	300	216	600	360	3.44	22.35	3.70	4.82	40.1	23.35

* Lactation incomplete when data was assembled.

[illegible]

TABLE XXIX   Animal G-2

Milk Production and Feed Consumed from second to third calving.* Average Daily

Nutrients Required and Nutrients Consumed according to the Savage Standard.

30 day period	Av. body wt.	Production				Feed Consumed				Nutrients Required		Nutrients Consumed			
		Milk	Test	Fat	Av. daily milk	L.O.M.	Corn	Silage	Timothy	Protein	T.D.N.	Protein L.O.M.	Total Protein	Excess Protein	T.D.N.
	Lbs.	Lbs.	Per Ct.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Per Ct.	Lbs.
1	1126	1029	3.6	37.0	34.3	248	69	600	314	2.91	19.97	2.48	3.18	9.3	16.99
2	1158	1094	3.6	39.4	36.5	315	139	600	360	3.07	20.93	3.17	4.10	33.6	21.48
3	1187	1042	3.6	37.5	34.9	316	164	600	360	2.99	20.65	3.17	4.16	39.1	22.17
4	1215	979	3.7	36.2	32.9	320	149	600	360	2.91	20.42	3.20	4.15	42.6	21.82

* Lactation incomplete when data was assembled.

TABLE XXX Animal G-3

Milk Production and Feed Consumed from second to third calving.* Average Daily Nutrients Required and Nutrients Consumed according to the Savage Standard.

30 day per-iod	Av. body wt.	Production				Feed Consumed				Nutrients Required		Nutrients Consumed			
		Milk	Test	Fat	Av. daily milk	C.S.M.	Corn	Sil-age	Tim-othy	Pro-tein	T.D.N.	Pro-tein C.S.M.	Total Pro-tein	Excess Pro-tein	T.D.N.
	Lbs.	Lbs.	Per Ct.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Per Ct.	Lbs.
1	951	1450	2.9	42.0	48.3	280	143	600	360	3.38	21.15	3.44	4.38	29.6	20.75
2	976	1565	3.2	50.0	52.2	353	254	600	360	3.74	23.22	4.22	5.43	45.2	25.47
3	992	1360	3.3	44.9	45.3	319	234	600	360	3.39	21.64	3.92	5.09	50.2	24.33

* Lactation incomplete when data was assembled.

TABLE XXXI

Similarity in Breeding and Inheritance of Milk Production

Animal Number	Dam's Number	305 day 2 yr. milk record of dam	Sire	Sire of Dam	Best yearly milk record of grand dam
G-1	78	7,688 a	Kalamazoo Goshen Caesar Pontiac		
G-2	180	8,040 a	Kalamazoo Cornucopia Lad		
G-3	M-274	7 ,481	Mich. Col. Mutual Johan	Kalamazoo Hengerveld Colantha	6,742 (2 yr)
G-4	M-260	9,538	" " " "	" "	12,033
G-5	M258	8,332	" " " "	" "	10,289
G-6	M-234	9,026	" " " "	" "	7,026 (2 yr)
G-7	M-240	9,444	" " " "	Kalamazoo Fayne Pontiac	9,761
G-8	M-240	9,444	" " " "	" "	9,761
G-9	M-243	8,050 b	" " " "	" "	4,333 (8mo.2yr)
G-10	M-253	7,343	" " " "	Kalamazoo Goshen Caesar Pontiac	13,560

a- Average of four yearly records
b- Ration very poor

TABLE XXXII

Summary of Reproduction Record to First Calving.

Lot I C.S.M.	Age of 1st oestrum	Number of Services	Age at 1st Calving	Placenta	Weight of calf	Per Cent Normal	Length of Gestation	Health of calf at birth
	Days		Days		Pounds	Per Cent	Days	
G-1	337	2	740	Normal	90	100	275	Normal
G-3	430	1	720	Normal	87	96.7	272	Normal
G-5	385	1	722	Normal	87	96.7	277	Normal
G-7	439	1	730	Normal	63	70.0	270	Normal
G-9	425	1	760	Normal	75	83.4	275	Normal*
Total		6						
Average	403		734		80.4	89.4	274	
Lot II L.O.M.								
G-2	221	2	744	Normal	92	102.3	277	Normal
G-4	407	3	776	Normal	79	87.8	276	Normal
G-6	414	1	732	Normal	79	87.8	277	Normal
G-8	430	1	727	Normal	80	89.0	276	Normal
G-10	493	2	794	Normal	88	97.8	281	Normal
Total		9						
Average	393		755		85.6	95.1	277	

* Died 48 hours after birth with Pneumonia.

TABLE XXXIII

Summary of Reproduction Record to Second Calving

Lot I C.S.M.	1st. oestrum period after calving	Number of services	Age at second calving	Placenta	Weight of calf	Per Cent Normal	Length of Gestation	Health of calf at birth
G-1	Days 59	1	Days 1111	Retained	Lbs. 87	Per Ct. 96.7	Days 271	Normal **
G-3	28	1	1082	Normal	82	91.2	275	Normal
G-5	17	2	1128	Normal	95	105.6	278	Normal
G-7	Had not calved when data was assembled							
G-9	Had not calved when data was assembled							
Lot II								
L.O.M.								
G-2	47 *	1	1106	Normal	88	97.8	276	Normal **
G-4	32	2	1204	Normal	81	90.0	287	Normal
G-6	Had not calved when data was assembled							
G-8	Had not calved when data was assembled							
G-10	Had not calved when data was assembled							

* Date of first oestrum period not noted. Calculated back 28 days from second period.

** Died at 48 hours after birth from Bacillus Coli Infection.

TABLE XXXIV

Growth in Weight and Height at Withers

Lot I Cottonseed Meal

Age months	Eckles Normal Weight Lbs.	Eckles Normal Ht at Withers CM	G-1 Weight Lbs.	G-1 Ht. at Withers CM	G-3 Weight Lbs.	G-3 Ht. at Withers CM	G-5 Weight Lbs.	G-5 Ht. at Withers CM	G-7 Weight Lbs	G-7 Ht. at Withers CM	G-9 Weight Lbs.	G-9 Ht. at Withers CM
Birth	90	71.8			78	69	69	70.5	65	65.6	81	71
6	349	100.9	318	101.4	304	96.5	266	96.0	288	92.0	306	101
12	558	114.0	572	117.9	565	114.0	488	111.4	476	109.6	531	116
18	686	121.8	811	128.4	808	124.7	731	121.9	701	116.7	754	126.5
24*	841	126.5	950	135.2	950	130.7	875	128.7	853	122.0	930	131.7
30	1021	130.7	1051	135.0	967	129.5	916	129.4	905	122.5	910	134.7
36**		132.8	1108	137.0	1017	130.5	964	129.0	***	***	***	***

Lot II Linseed oil meal

Age months	Eckles Normal Weight Lbs.	Eckles Normal Ht at Withers CM	G-2 Weight Lbs.	G-2 Ht. at Withers CM	G-4 Weight Lbs.	G-4 Ht. at Withers CM	G-6 Weight Lbs.	G-6 Ht. at Withers CM	G-8 Weight Lbs	G-8 Ht. at Withers CM	G-10 Weight Lbs.	G-10 Ht. at Withers CM
Birth	90	71.8			76	70	90	73.5	71	68	89	72.5
6	549.	100.9	387	104.0	331	97.4	311	98.6	295	95.2	322	99.6
12	558	114.0	670	119.2	593	114.1	564	113.6	542	112.2	574	115.5
18	686	121.8	923	127.6	831	123.0	782	124.5	768	120.4	832	121.3
24*	841	126.5	1110	133.0	970	129.0	925	128.0	989	127.0	1095	131.0
30	1021	130.7	1225	133.5	960	130.5	907	130.0	973	128.3	***	***
36**		132.8	1224	134.7	1057	131.0	***	***	***	***	***	***

* Weight just after first calving

** Weight just after second calving

*** Had not reached disignated age when data was assembled.

TABLE XXXV

Showing the Effect on the Consistency of the Feces of Cottonseed Meal

and Linseed Oil Meal when Fed with Timothy Hay and Corn Silage

Lot I

Animal Number	Days	No. of degrees which ball sank in Feces										Ration				
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	Cotton-seed meal	Linseed oil meal	Corn	Silage	Timothy
												Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
G-1		22	21	20	21	28	20	27	25	29	24	7.8		2	25	14
G-3		35	30	25	30	30	36	35	25	34	32	9.0		3	25	15
G-5		40	25	28	26	28	29	30	30	36	30	9.0		3.9	25	12
Daily Total		97	76	73	77	86	85	92	78	99	86					
Daily Average		32.3	25.3	24.3	25.7	28.3	28.3	30.7	26.	33.	28.7					
Lot II																
G-2		29	25	25	30	23	25	25	30	26	25		8.2		25	13
G-4		27	22	25	25	25	32	25	25	35	32		12.6	3	14	13
G-6		23	20	20	21	28	32	25	26	20	32		6.0	3	18	12
Daily Total		79	67	70	76	76	89	75	81	91	89					
Daily Average		26.3	22.3	23.3	25.3	25.3	29.7	25.	27.	30.3	29.7					

Grand Total of Degrees, Lot, I, Cottonseed Meal 849

Grand Total of Degrees, Lot II, Linseed Oil Meal 793

Difference Cottonseed Meal feces 56 degrees softer than Linseed Oil Meal Feces.

TABLE XXXVI

Showing the Effect on the Consistency of Feces of only 2.4 Pounds of Cottonseed Meal and 3 Pounds of Linseed Oil Meal When Fed with Timothy Hay and Corn Silage

Number of Degress Which Ball sank in Feces

Animal Number Days	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	C.S.M. Lbs.	Ration L.O.M. Lbs.	Corn Lbs.	Sil-age Lbs.	Tim-othy Lbs.
G-7	20	20	33	30	22	30	35	37	35	20	2.4		0.3	15	8
G-9	25	26	25	33	24	30	15	20	30	15	2.4		0.3	18	9
Daily Total	45	46	58	63	46	60	50	57	65	35					
Daily Average	22.5	23.0	29.0	31.5	23.0	30.0	25.0	28.5	32.5	17.5					
Lot II															
G-8	30	29	30	25	30	30	30	30	25	30		3.0		18	10
G-10	21	26	25	20	25	22	25	20	25	20		3.0		18	10
Daily Total	51	55	55	45	55	52	55	50	50	50					
Daily Average	25.5	27.5	27.5	22.5	27.5	26.0	27.5	25.0	25.0	25.0					

Grand Total of Degrees Lot I Cottonseed Meal 525
Grand Total of Degrees Lot II Linseed Oil Meal 518
Difference: Cottonseed Meal Feces 7 Degrees softer than Linseed Oil Meal Feces

TABLE XXXVII

Showing the Effect on the Consistency of Feces of Cottonseed Meal and Linseed Oil Meal when Fed with Timothy Hay without Corn Silage

Animal Number	Lot I														
	First Period								Second Period						
Ration	9 lbs. C.S.M.			9 lbs. corn & oats				Change	9 lbs. L.O.M.			9 lbs. corn & oats			Timothy
No. of degrees which ball sank in feces															
Days	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	Lbs.
155	39	40	38	36	37	30	36	39	38	32	34	41	31	40	22
150	37	35	28	37	40	31	30	31	32	36	34	30	23	31	18
179	44	34	34	38	35	33	31	28	33	36	35	38	30	38	22
Daily Total	120	109	100	111	112	94	97	98	103	104	103	109	84	109	
Daily Average	40	36.3	33.3	37.	37.3	31.3	32.3	32.7	34.3	34.7	34.3	36.3	28	36.3	
	Lot II														
Ration	9 lbs. L.O.M.			9 lbs. corn and oats					9 lbs. C.S.M.			9 lbs. corn and oats			
217	31	33	36	34	26	25	31	33	28	25	24	30	31	35	18
225	39	32	32	27	33	30	28	31	30	32	35	27	27	34	16
226	34	32	25	28	31	30	27	31	28	28	26	26	28	30	13
Daily Total	104	97	93	89	90	83	86	95	86	85	85	83	86	99	
Daily Average	34.7	32.3	31.0	29.7	30.	27.7	28.7	31.7	28.7	28.3	28.3	27.7	28.7	33.	

Sum Total of Degrees Lot I, 1st Period, Cottonseed Meal 646

Sum Total of Degrees Lot II, 2nd Period, Cottonseed Meal 524

Grand Total of Degrees for Cottonseed Meal 1170

Sum Total of Degrees Lot I, 2nd Period Linseed Oil Meal 612

Sum Total of Degrees, Lot II, 1st Period Linseed Oil Meal 556

Grand Total of Degrees for Linseed Oil Meal 1168

Difference: Cottonseed meal Feces 2 degrees softer than linseed oil meal Feces.

TABLE XXXVIII

Showing the Effect on the Consistency of Feces of only Two Pounds of Cottonseed Meal and Linseed Oil Meal when Fed with Timothy Hay as a Roughage

Lot I

	Number of Degrees which Ball Sank in Feces																	
	1st Period										2nd Period							
Animal number	Ration 2 lbs. C.S.M. 4 lbs. corn & oats							Change			2 lbs. L.O.M. 4 lbs. corn & Oats							Timothy
Days	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th	16th	17th	lbs.
1 B	35	25	38	36	33	20	20	25	35	25	25	21	21	30	21	28	25	14
202	20	15	20	17	16	15	15	20	15	15	20	20	20	20	25	20	25	20
194	28	25	26	33	30	35	22	25	27	20	21	25	28	25	24	30	30	20
Daily Total	83	65	84	86	79	70	57	70	77	60	66	66	69	65	70	78	80	
Daily Average	27.7	21.7	28	28.7	26.3	23.3	19.0	23.3	25.7	20.0	22	22	23	21.7	23.3	26	26.7	

Lot II

	Ration 2 lbs. L.O.M. 4 lbs. corn & Oats							Change		2 lbs. C.S.M. 4 lbs. corn & oats								
23B	36	26	27	31	30	25	26	25	27	32	25	25	25	25	27	28	25	14
153	35	38	35	35	35	33	38	35	38	43	35	38	30	30	37	35	38	22
173	31	30	36	43	30	30	28	30	30	23	21	28	30	25	33	30	35	20
Daily Total	102	94	98	109	95	88	92	90	95	98	81	91	85	80	97	93	98	
Daily Average	34	31.3	32.7	36.3	31.7	29.3	30.7	30.7	31.7	32.7	27	30.3	28.3	26.7	32.3	31.	32.7	

Sum Total of Degrees Lot I, 1st Period, C.S.M. 594 — Sum Total of Degrees Lot I, 2nd Period, L.O.M. 554
Sum Total of Degrees, Lot II, 2nd Period, C.S.M. 723 — Sum Total of Degrees Lot II, 1st Period, L.O.M. 768
Grand Total of Degrees for C.S.M. 1317 — Grand Total of Degrees for L.O.M. 1322
Difference: Linseed Oil Meal Feces 5 degrees softer than Cottonseed Meal Feces

[illegible]

TABLEXXXIX

Rate of Food Passage

Lot I 2.4 lbs. C.S.M. daily						Lot II 3 lbs. L.O.M. daily					
G-5			G-7			G-4			G-6		
Time after feeding iron		Fe_2O_3	Time after feeding iron		Fe_2O_3	Time after feeding iron		Fe_2O_3	Time after feeding iron		Fe_2O_3
Hrs.	Min	Per ct.	Hrs.	Min	Per Ct.	Hrs.	Min	Per Ct.	Hrs.	Min.	Per Ct.
2	30	0.06	2	30		2	30		2	30	0.062
7	45	0.06	6	45	0.081	5		0.065	6	15	0.062
10		0.08	9	45	0.082	6	45	0.065	9	10	0.064
11	45	0.154	11	30	0.193	9	45	0.065	12		0.911
12	30	*	13		0.232	12	30	0.113	13	45	*
14	30		14	55		13	40		15	30	
15			16	30		14	50		18		
16	35		18	30		16	50		22	25	
18	20		19	30		21	30		24	50	1.56
18	45		21	35	2.02	22	30	1.42	27	30	2.26
19	35		23	20	2.02	25	20	1.83	31		2.34
21	35	1.56	24	45	2.13	26	35	2.10	33	25	2.16
24	20	2.00	26	30	2.05	28	25	2.10	37	35	1.82
25	30	2.40	27	40	2.01	31	10	2.92	40	30	1.63
26	35	2.14	28	25	1.88	33		2.72	43	50	
27	35	2.28	33		1.77	36	35	1.98	45		
29	10	2.28	36	40	1.55	40	30	1.99	49	30	
30	20	2.20	38	20		42			51	15	
33	25	1.99	40	30		44		1.56	53.45		
36	35		42			48	15	0.78	56	45	0.838
37	45		44			50	30		62	35	0.684
40			47			52	30		64	45	
40	30		48			57		0.62	66	45	0.504
41			49	15		61			70	45	0.4
42			55			64	45				
44			56	30		68	25	0.340			
47			62	30	0.7						
48			64	45							
50	45		67		0.5						
53			71	30	0.356						
56	30										
59	30	0.544									
64	45										
68		0.426									
71	30	0.401									

* Only those samples were analyzed which would determine the starting point, high point of iron excretion.

TABLE XL

Bacteria per cc of Freshly Drawn Milk

	Lot I Cottonseed meal					Lot II Linseed oil meal				
Date	G-1	G-3	G-5	G-7	G-9	G-2	G-4	G-6	G-8	G-10
10-17-28	Dry	400	80	50	15	Dry	295	25	25	Not calved
10-18-28	"	1660	65	40	100	"	885	65	60	" "
1019-28	"	3320	260	30	60	"	980	65	70	" "
11-14-28	"	Dry	65	50	25	Dry	265	75	40	" "
11-15-28	"	"	430	15	10	"	200	30	15	" "
11-16-28	"	"	155	5	120	"	190	10	45	" "
12-18-28	15	Dry	130	10	140	315	305	15	75	65
12-19-28	10	"	160	40	225	1610	130	65	235	140
12-20-28	15	"	125	10	185	525	50	20	35	65
1-18-29	20	970	Dry	170	285	205	20	20	40	60
1-19-29	40	120	"	20	190	270	55	130	70	110
2-25-29	50	960	Dry	15	25	5	Dry	5	15	15
2-26-29	30	4920	"	10	60	0	"	15	5	10
2-27-29	20	2890	"	5	20	5	"	15	10	10
3-19-29	60	2870	25	45	70	290	"	85	30	25
3-20-29	40	2250	25	40	35	125	"	20	0	10
3-21-29	20	400	15	165	20	60	"	15	5	5

TABLE XLI

Reduction of Methylene Blue in Hours by 10 cc of Freshly Drawn Milk

	Lot I Cottonseed meal					Lot II Linseed Oil meal				
	G-1	G-3	G-5	G-7	G-9	G-2	G-4	G-6	G-8	G-10
11-14-28	Dry	Dry	39	38	24	Dry	21	72	41	Not calved
11-15-28	"	"	26	24	22	"	23	23	26	" "
11-16-28	"	"	24	26	22	"	22	28	28	" "
12-18-28	20	"	30	14	32	30	18	30	12	14
12-19-28	30	"	23	14	19	14	19	19	14	14
12-20-28	30	"	30	14	20	30	18	20	17	14

TABLE XLII

Condition of Coat

	Lot I C.S.M.					Lot II L.O.M.				
Date	G-1	G-3	G-5	G-7	G-9	G-2	G-4	G-6	G-8	G-10
3-17-26	S					FS				
4-19-26	S	FR				FS	FS	VS		
5-13-26	S	FS	S			FS	FS	S		
6-19-26	VS	S	VS			FR	S	S		
7-19-26	FS	S	S	S		FS	S	S	S	
8-31-26	FS	FS	S	S		FS	FS	S	S	
9-27-26	FR	FR	FS	FS		FR	FR	R	FS	
10-29-26	FR	FR	S	FR		FR	FR	FS	FR	
12-6-26	FS	FS	FS	FS	FS	FS	FS	FS	FS	
1-8-27	R	R	FR	R	FR	R	R	FR	R	FS
2-7-27	FR	FR	FS	FS	FS	FR	FR	FS	FS	FS
3-8-27	R	R	S	FR	FR	R	R	FR	FR	FS
4-6-27	FR	R	FS	FS	FS	FR	FR	FR	FS	FS
5-7-27	FS	FS	S	FS	FS	FS	FS	FS	FS	FS
6-7-27	FS	FS	FS	FS	FS	FS	FS	FS	FS	FS
7-15-27	FS	FS	FS	FR	FR	FS	FS	FS	FS	FR
8-22-27	S	S	S	S	FS	S	S	S	S	FS
10-11-27	FS	FS	FS	FR	R	FS	FS	FS	FR	FR
12-1-27	FS	S	FS	FR	R	FR	FS	FS	FR	R
1-17-28	FS	FS	FS	FS	R	FS	FS	FR	R	R
2-15-28	FS	FS	VS	S	FR	S	FS	FS	FS	FS
2-20-28	FS	FS	FS	FR	FR	FS	FS	FR	FR	FR
4-20-28	VS	S	S	S	S	S	S	S	S	S
5-10-28	VS	S	VS	VS	FR	S	S	S	S	FS
8-10-28	S	FS	S	FS	FS	FS	FS	FS	FS	FS
9-21-28	FS	FS	VS	FS	FR	FS	VS	FS	FS	S
10-16-28	FS	S	VS	FS	FR	FR	FS	VS	FS	FS
11-14-28	FS	FS	S	FS	FR	FR	FR	S	FS	FR
12-12-28	FS	FS	S	FS	FR	FR	FR	S	FS	FR
1-23-29	FS	FS	FS	FR	FS	FR	FR	FR	S	FR
2-20-29	FR	FR	FS	FR	FS	FR	FR	S	S	FS
3-20-29	FR	FR	FR	FS	FR	FR	FR	FS	FS	FR

V - Very F- Fairly R - Rough S - Sleek

TABLE XLIII

Length of Hair in Milimeters

	Lot I					Lot II				
Date	G-1	G-3	G-5	G-7	G-9	G-2	G-4	G-6	G-8	G-10
3-17-26	21					20				
4-19-26	22	30				35	32	35		
5-13-26	32	25	24			40	28	32		
6-19-26	24	30	18			25	30	30		
7-19-26	23	19	21	22		23	25	25	23	
8-31-26	19	19	19	19		25	25	19	18	
9-27-26	18	33	25	25		28	19	29	25	
10-29-26	22	30	30	40		40	40	45	40	
12-6-26	45	40	30	40	30	40	35	50	38	
1-8-27	48	33	40	33	27	47	24	34	45	30
2-7-27	50	38	35	55	40	32	35	40	60	25
3-8-27	35	40	28	45	50	35	30	40	45	25
4-6-27	28	30	25	35	35	30	24	30	30	22
5-7-27	26	22	25	28	25	32	23	30	18	30
6-7-27	26	21	24	20	25	25	28	20	24	28
7-15-27	28	18	15	23	28	28	18	22	22	24
8-22-27	17	13	22	22	18	20	20	25	23	25
10-11-27	31	19	29	25	23	27	18	23	35	25
12-1-27	35	32	31	33	25	40	28	35	45	30
1-17-28	35	32	25	30	35	30	18	30	35	30
2-15-28	20	15	25	25	28	18	20	25	28	25
8-10-28	19	14	14	14	24	19	18	12	16	21
9-21-28	15	14	16	10	24	22	9	12	19	22
10-16-28	26	20	23	26	25	33	25	19	27	20
11-14-28	29	20	20	32	29	31	29	29	29	28
12-12-28	26	22	22	26	28	33	25	25	37	24
1-23-29	24	25	23	25	25	27	25	29	29	27
2-20-29	20	22	20	25	27	22	28	23	20	26
3-20-29	18	22	24	22	27	24	24	21	23	23

TABLE XLIV

Double Thickness of Hide in Milimeters

	Lot I C.S.M.					Lot II L.O.M.				
Date	G-1	G-3	G-5	G-7	G-9	G-2	G-4	G-6	G-8	G-10
3-17-26	4.3					7.4				
4-19-26	5	4				7	5	4		
5-13-26	6	4	5.5			7	5	4		
6-19-26	6	6	5			8	6	5		
7-19-26	8	7	5	4		9	8	5	4	
8-31-26	8	7	6	4		9	9	5	4	
9-27-26	9	7	7	4		9	7	6	4	
10-29-26	9	7	7	5		11	8	5	6	
12-6-26	10	8	8	6	4	10	10	7	6	
1-8-27	9	8	9	6	5	11	9	7	8	4
2-7-27	11	9	8	6	6	11	10	8	7	5
3-8-27	11	9	9	7	6	11	10	9	9	5
4-6-27	12	9	9	7	6	12	10	10	8	6
5-7-27	11	10	11	8	8	13	11	11	10	6
6-7-27	11	7	10	8	7	11	9	10	11	6
7-15-27	12	11	10	10	11	12	10	12	13	8
8-22-27	11	10	11	10	10	13	11	9	15	8
10-11-27	12	12	13	11	9	13	12	13	13	10
12-1-27	12	11	10	11	11	12	11	9	14	11
1-7-28	12	10	10	10	11	12	10	10	11	9
2-15-28	11	10	10	11	10	11	9	11	12	11
8-10-28	9.8	9.5	9	9.5	11.5	10.5	11	11	13.5	10.5
9-21-28	12	10.5	10.7	8.5	12	11.5	11.2	10.2	12	11
10-16-28	10.5	10.5	9.5	10.5	11	10	11.5	10.5	13.5	10
11-14-28	11.5	10	10	11	11	10.5	11.5	11.5	13.5	10
12-12-28	12	9	10.5	10	10.5	10	11.5	11.5	13.5	8.5
1-23-29	11	10	9	10	9.5	10	10	11.5	11	11
2-20-29	11	9	8	10	10	10.5	10	11	13	11
3-20-29	10.5	10	9	9.5	11	9.5	10.5	10	11	10.5

TABLE XLV

Looseness and Pliability of Hide

	Lot I C.S.M.					Lot II L.O.M.				
Date	G-1	G-3	G-5	G-7	G-9	G-2	G-4	G-6	G-8	G-10
3-12-26	FL & P					FT				
4-19-26	L & P	P				L & P	P	L & P		
5-13-26	L & P	L & P	T & P			FT & P	L & P	L & P		
6-19-26	L & P	L & P	FL & P			FL & P	L & P	L & P		
7-19-26	L & P	VL & P	L & P	L & P		L & S	L & P	L & P	L & P	
8-31-26	FL & P	L & P	L & P	L & P		FL & S	FT & P	VL & P	L & P	
9-27-26	FL & S	L & P	FL & P	L & P		FL & S	L & P	FL & P	L & P	
10-29-26	FL & S	L & P	L & P	VL & P		FL & S	FL & P	VL & P	VL & P	
12-6-26	L & P	FT & P	FT & [illegible]	L & P	FL & P	FT & S	FL & P	L & P	FL & P	
18- 27	FL & P	L & P	FL & P	L & P	FL & P	FL & P	FL & P	L & P	L & P	L & P
2-17-27	L & F S	L & P	FL & S	L & P	FL & P	FL & S	FL & S	L & P	FL & P	L & P
3-8-27	FT & S	FL & F P	FL & S	L & P	FT & P	FT & S	FL & FS	FL & FS	L & P	L & P
4-6-27	FL & VS	FL & FP	FL & S	L & P	FL & FP	FL & S	FL & FP	FL & FP	FL & FP	L & P
5-7-27	L & P	L & P	FL & FS	L & P	L & P	FL & S	L & P	FL & P	L & P	VL & P
6-7-27	L & P	L & P	FL & FS	VL & P	FL & FP	FL & S	L & FP	L & FS	FL & FS	FL & P
7-15-27	FL & FS	L & P	FL & P	FL & P	FT & FP	FL & S	FL & FP	FL & S	FL & S	VL & P
8-22-27	FL & S	FL & FP	FT & FS	L & P	FT & FS	FL & FS	FT & FS	FL & FP	T & VS	L & P
10-11-27	FL & S	FL & S	FL & S	L & P	FT & FP	FL & S	FL & S	FL & S	T & VS	FL & P
12-1-27	FL & VS	FL & S	L & FS	L & FP	FT & FS	FL & S	L & FS	FL & FP	FL & VS	L & FS
1-17-28	FT & VS	L & P	T & FS	FL & P	FT & FS	FL & S	FL & S	FT & FS	FT & VS	L & P
2-15-28	FT & S	L & FS	L & FP	L & FS	FL & S	FL & S	FL & P	FT & FP	FL & VS	FL & S
8-10-28	FL & P	L & FP	VL & P	VL & P	FT	L & P	FP	FL	FT	T
9-21-28	FL & P	FL & P	VL & P	VL & P	T	FL & P	VL & P	FL & P	FL & P	FL & P
10-10-28	L & P	L & P	L & P	FL & P	T	VL & PL	FL & P	FL & P	FL & P	VL & P
11-14-28	L & P	L & P	FL & P	L & P	FL & P	L & P	FL & P	FL & P	FT	L & P
12-12-28	FL & P	L & P	L & P	VL & P	FL & P	L & P	L & P	FL & P	FL & P	L & P
1-23-29	VL & P	VL & P	FL & P	VL & P	FL & P	FL & P	FL & P	FL & P	FT	FL & P
2-20-29	FL & P	VL & P	L & P	VL & P	FT	FL & P	FL & P	FL & P	L & P	L & P
3-20-29	L & P	L & P	L & P	VL & P	FT	FL & P	L & P	L & P	T	VL & P

F - fairly V - very L - loose P - pliable T - tight S - stiff

TABLE XLVI

Condition of Flesh

	Lot I C.S.M.					Lot II L.O.M.				
Date	G-1	G-3	G-5	G-7	G-9	G-2	G-4	G-6	G-8	G-10
3-17-26	F									
4-19-26	G	F				G	G	G		
5-13-26	G	G	G			G	G	G		
6-19-26	G	G	G			G	G	G		
7-19-26	G	G	G	G		G	G	G	G	
8-13-26	G	G	G	G		G	G	G	G	
9-27-26	F	F	G	G		F	F	G	G	
10-29-26	G	G	G	G		G	G	G	G	
12-6-26	G	G	G	G	G	G	G	G	G	
1-8-27	F	F	F	G	G	F	F	G	G	G
2-7-27	G	G	G	G	G	G	G	G	G	G
38-27	FG	FG	G	G	G	FG	FG	FG	G	G
4-6-27	G	G	G	G	G	G	G	G	G	G
5-7-27	G	G	G	G	G	G	G	G	G	FG
6-7-27	G	G	G	G	G	G	G	G	G	G
7-15-27	G	G	G	G	G	G	G	G	F	G
8-22-27	G	G	G	G	F	G	G	G	G	G
10-11-27	G	G	G	G	F	G	G	G	G	G
12-1-27	G	G	G	FG	FG	FG	G	G	FG	FG
1-17-28	FP	F	G	G	F	G	G	G	G	FG
2-15-28	G	G	G	G	G	G	G	G	G	G
4-20-28	G	G	G	G	FG	G	G	G	G	FG
5-10-28	VG	G	G	G	G	VG	G	G	G	G
8-10-28	G	G	G	G	G	VG	FG	G	G	G
9-21-28	G	F	G	F	G	G	F	G	G	G
10-11-28	F	G	G	G	F	G	F	G	G	G
11-14-28	G	G	G	G	F	G	F	G	G	G
12-12-28	F	G	G	G	F	G	F	G	G	G
1-23-29	F	F	G	G	F	G	G	G	G	G
2-20-29	F	F	G	G	F	G	G	G	G	G
3-20-29	F	F	F	VG	F	F	G	G	G	F

P - Poor F- Fairly G- Good V - Very

TABLE XLVII

Shedding of Hair

Date	Lot I C.S.M. G-1	G-3	G-5	G-7	G-9	Lot II L.O.M. G-2	G-4	G-6	G-8	G-10
3-17-26	No					No				
4-19-26	No	No				No	No	No		
5-13-26	No	No	No			No	No	Yes		
6-19-26	No	No	No			Very little	No	No		
7-19-26	No	No	No	No		Some	No	No	No	
8-31-26	No	No	No	No		No	No	No	No	
9-27-26	No	No	No	No		No	No	No	No	
10-29-26	No	No	No	No		No	No	No	No	
12-6-26	No	No	No	No	No	No	No	No	No	
1-8-27	Very little	Very little	No	No	No	No	Very little	No	No	
2-7-27	Yes	Some	Some	Some	No	Yes	Yes	Some	Some	Some
38 - 27	Some	Slight	Yes	Some	Very little	Some	Soight	Some	Some	No
4-6-27	Almost through	Almost through	Through	No	Some	Yes	Through	Some	Some	No
5-7-27	Through	Through	Through	Through	Almost through	Through	Through	Through	Through	Through
6-7-27	No	Almost through	Very little	No	Starting	Some	Very little	Very little	Very little	No
7-15-27	Some	Some	Some	Some	Some	Some	Some	Some	Some	Some
8-22-27	Some	No	No	No	Some	Some	No	Very little	No	No
10-11-27	No	No	No	No	No	No	No	No	No	No
12-1-27	No	No	Little	No	No	No	No	No	Yes	No
1-17-28	Very little	Some	Yes	No	No	Yes	Some	Some	No	Some
2-15-28	Yes	Yes	Yes	Very little	Starting	Yes	Yes	Some	Little	Some
8-10-28	No	No	No	No	No	No	No	No	No	No
9-21-28	No	No	No	Some	Some	No	No	Some	No	No
10-16-28	Some	No	No	No	Some	Some	No	No	No	Some
11-14-28	No	Some	No	No	Some	No	No	No	No	No
12-12-28	No	No	No	No	Some	No	No	No	No	No
1-23-29	Some	Some	Some	Some	Some	Some	Some	Some	Some	Some

Shedding of Hair (continued)

	Lot I C.S.M.					Lot II L.O.M.				
Date	G-1	G-3	G-5	G-7	G-9	G-2	G-4	G-6	G-8	G-10
2-20-29	Quite a bit	Some	Some	Some	Some	Quite a bit	Some	Some	Some	Some
3-20-29	Quite a bit	Quite a bit	Quite a bit	Some	Quite a bit	Quite a bit	Some	Quite a bit	Quite a bit	Quite a bit

TABLE XLVIII

Erythrocytes and Leucocytes per cubic m.m. of Blood from First to Second Calving.

Lot I C.S.M.	First Calving Time		120 Days After		270 Days After		Second Calving Time	
	Erythrocytes	Leucocytes	Erythrocytes	Leucocytes	Erythrocytes	Leucocytes	Erythrocytes	Leucocytes
G-1	5,248,000	24,000	5,496,000	12,000	6,768,000	20,000	8,936,000	4,000
G-3			6,495,000	6,000	9,168,000	36,000	7,840,000	12,000
G-5	5,656,000	24,000	8,568,000	14,000	8,472,000	40,000	8,032,000	16,000
G-7	7,616,000	12,000	8,000,000	30,000	7,008,000	18,000		
G-9	8,840,000	20,000	6,824,000	8,000				
Lot II L.O.M.								
G-2	7,488,000	24,000	9,004,000	18,000	5,784,000	12,000	6,496,000	12,000
G-4	4,288,000	14,000	6,840,000	16,000	6,888,000	12,000	7,392,000	28,000
G-6	10,256,000	32,000	8,784,000	32,000	9,528,000	16,000		
G-8	9,432,000	28,000	7,392,000	20,000	8,208,000	22,000		
G-10	10,392,000	28,000	6,840,000	12,000				

TABLE XLIX

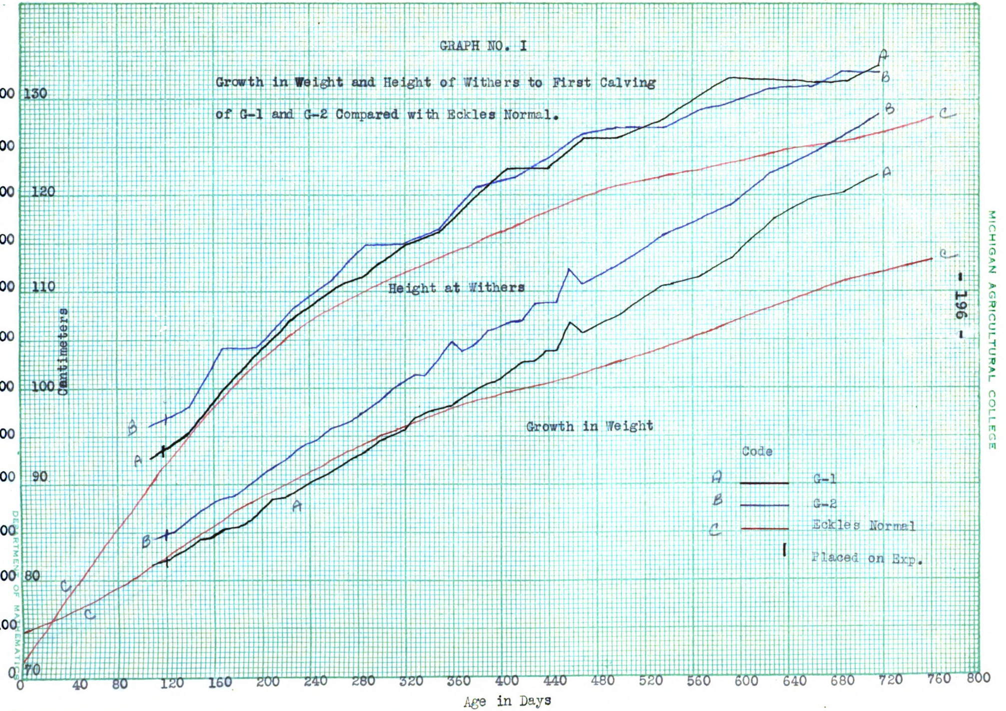
Erythrocytes and Leucocytes per cubic m.m. of Blood of Calves at Birth

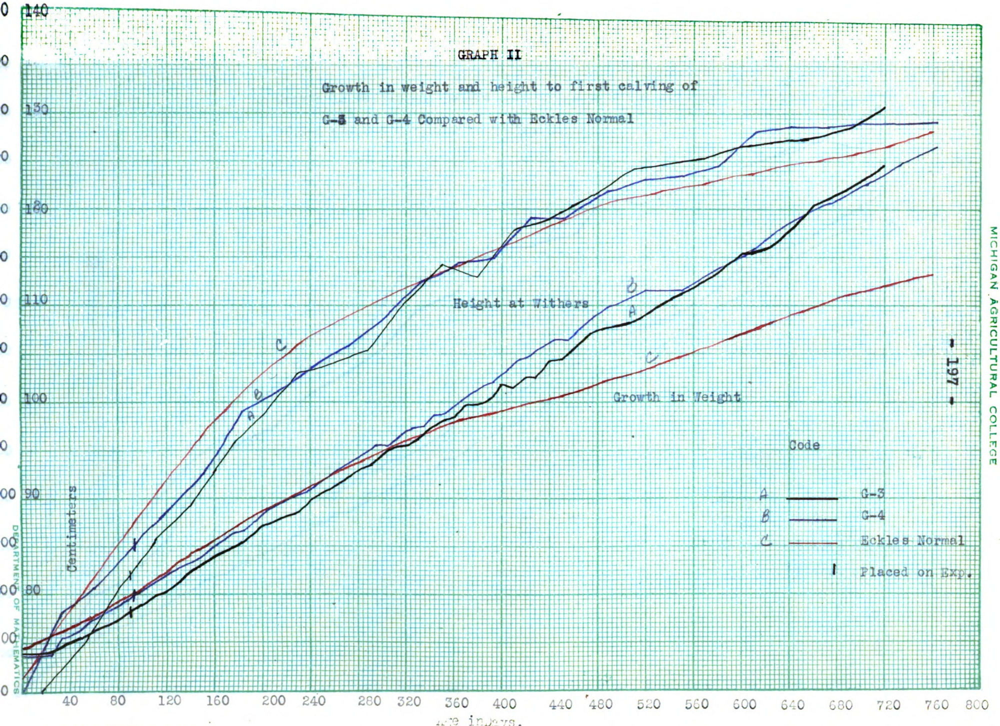
Calves from Lot I	Erythrocytes	Leucocytes
G-1's calf	5,064,000	16,000
G-5's calf	5,656,000	24,000
G-7's calf	7,928,000	4,000
G-9's calf	9,680,000	28,000
Calves from Lot II		
G-2's Calf	6,952,000	40,000
G-4's calf	4,288,000	14,000
G-6's calf	10,256,000	32,000
G-8's calf	5,068,000	8,000
G-10's calf	11,664,000	4,000

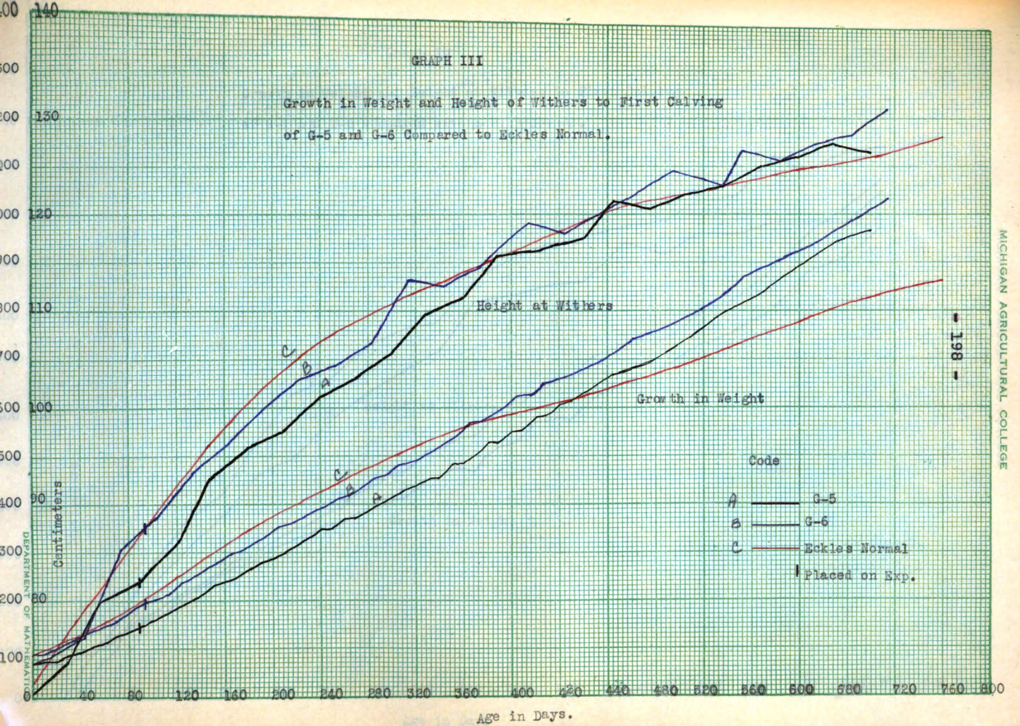
TABLE L

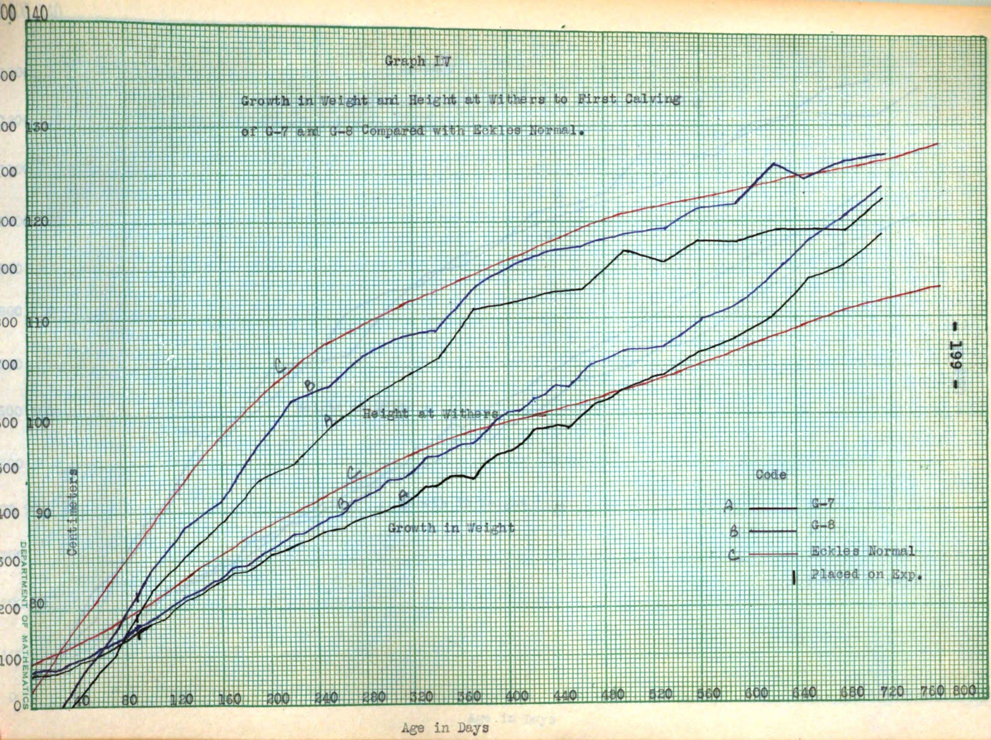
Hemoglobin as Determined by the Tallquist Hemoglobin Scale

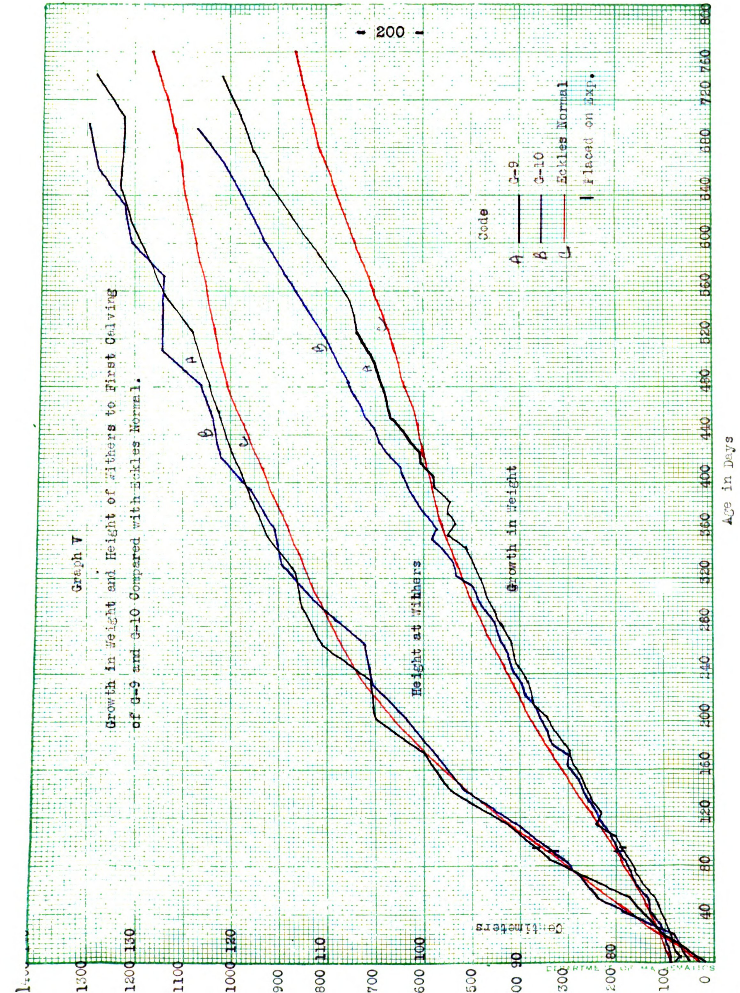
	Lot I C.S.M.					Lot II L.O.M.				
Date	G-1	G-3	G-5	G-7	G-9	G-2	G-4	G-6	G-8	G-10
3-16-28	60	70	55			60	45			
4-17-28	65	55	55			70	60			
5-16-28	70	75	55			65	60	65		
6-14-28	70	70	65	60		60	55	60	70	
7-16-28	60	65	60	60		65	50	60	50	
8-14-28	70	70	65	60		60	55	65	50	
9-24-28	70	80	75	65		70	70	65	60	
10-10-28	80	70	70	60	70	80	70	60	55	70
11-14-28	70	65	75	65	75	70	65	65	70	60
12-14-28	70	70	70	65	75	65	70	70	65	70
1-16-29	80	80	80	75	65	60	80	75	75	70
2-15-29	75	70	70	80	60	60	70	75	65	80
3-15-29	75	70	65	65	65	70	70	65	65	70
4-16-29	70	65	60	70	70	70	75	75	70	65

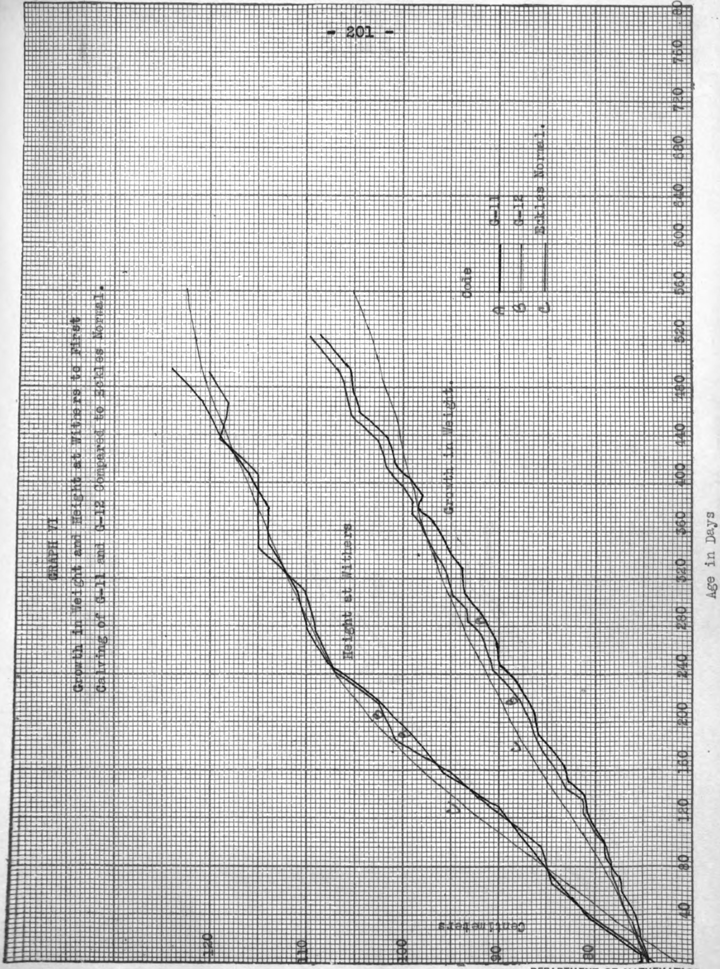

MICHIGAN AGRICULTURAL COLLEGE
GRAPH NO. I
Growth in Weight and Height of Withers to First Calving
of G-1 and G-2 Compared with Eckles Normal.
Height at Withers
Growth in Weight
Centimeters
Age in Days
Code
A G-1
B G-2
C Eckles Normal
Placed on Exp.
A
B
C
130
120
110
100
90
80
70
0
40
80
120
160
200
240
280
320
360
400
440
480
520
560
600
640
680
720
760
800
DEPARTMENT OF MATHEMATICS

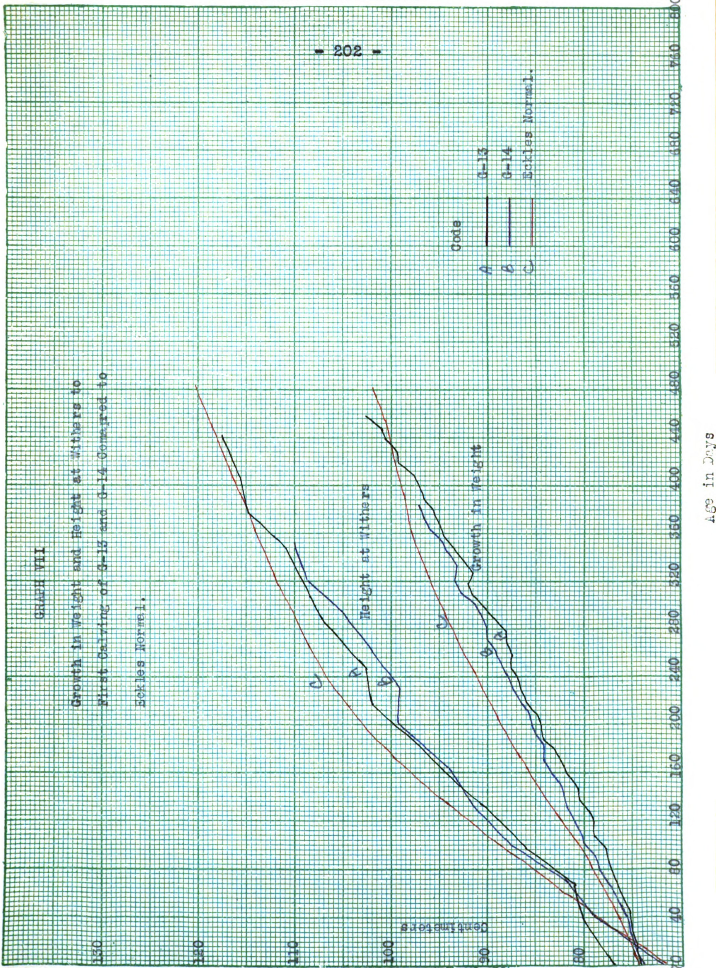

GRAPH II
Growth in weight and height to first calving of
G-3 and G-4 Compared with Eckles Normal
Height at Withers
Growth in Weight
Centimeters
Code
A G-3
B G-4
C Eckles Normal
Placed on Exp.
Age in Days
MICHIGAN AGRICULTURAL COLLEGE
DEPARTMENT OF MATHEMATICS

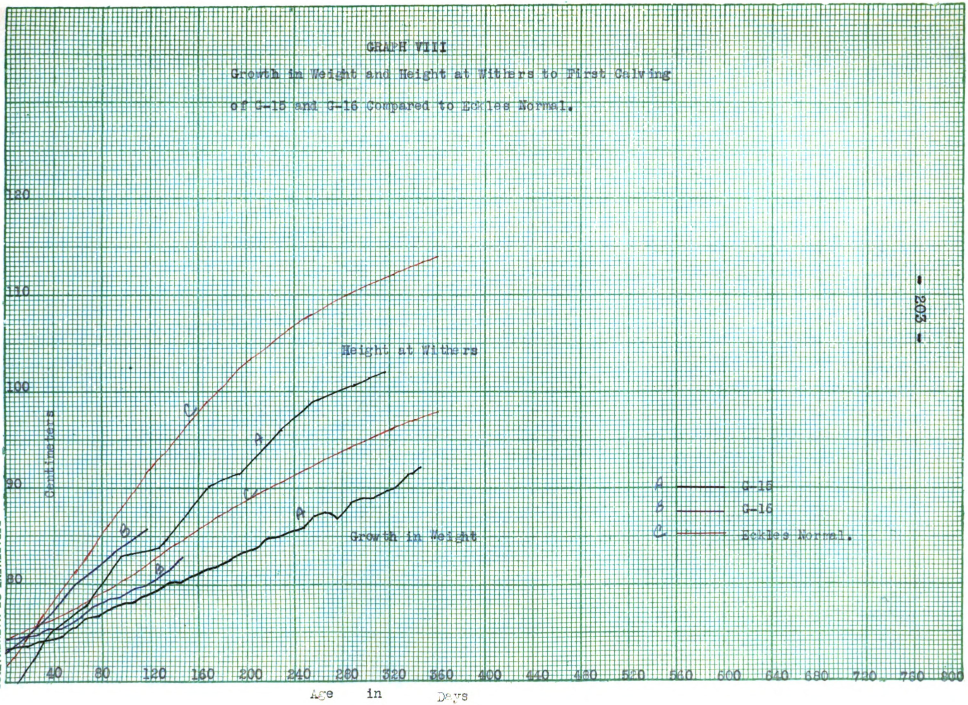

GRAPH III
Growth in Weight and Height of Withers to First Calving
of G-5 and G-6 Compared to Eckles Normal.
Height at Withers
Growth in Weight
Code
A G-5
B G-6
C Eckles Normal
Placed on Exp.
Centimeters
Age in Days.
0
40
80
120
160
200
240
280
320
360
400
440
480
520
560
600
680
720
760
800
80
90
100
110
120
130
140
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
MICHIGAN AGRICULTURAL COLLEGE
DEPARTMENT OF MATHEMATICS


Graph IV
Growth in Weight and Height at Withers to First Calving
of G-7 and G-8 Compared with Eckles Normal.
Height at Withers
Growth in Weight
Centimeters
Code
A G-7
B G-8
C Eckles Normal
Placed on Exp.
Age in Days
MICHIGAN AGRICULTURAL COLLEGE
DEPARTMENT OF MATHEMATICS


Graph V
Growth in Weight and Height of Withers to First Calving
of G-9 and G-10 Compared with Eckles Normal.
Height at Withers
Growth in Weight
Code
A G-9
B G-10
C Eckles Normal
Placed on Exp.
Centimeters
Age in Days
0 40 80 120 160 200 240 280 320 360 400 440 480 520 560 600 640 680 720 760 800
0 100 200 300 400 500 600 700 800 900 1000 1100 1200 1300
80 90 100 110 120 130

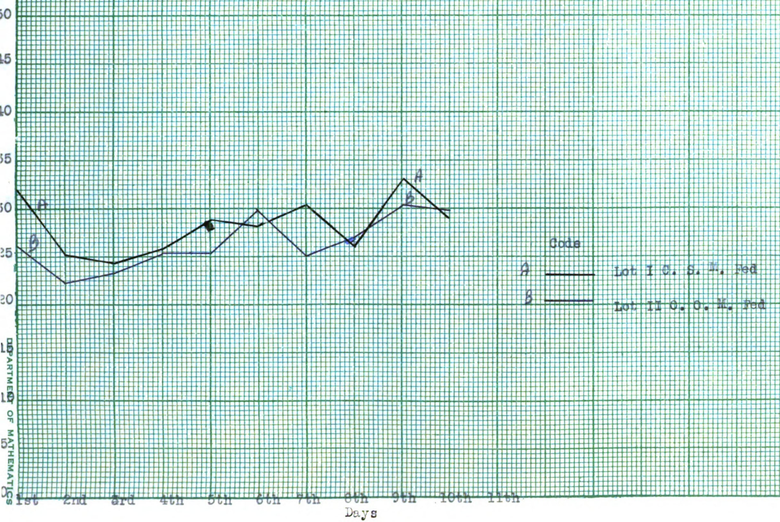

GRAPH VI
Growth in Weight and Height at Withers to First
Calving of G-11 and G-12 Compared to Eckles Normal.
Height at Withers
Growth in Weight
Code
A — G-11
B — G-12
C — Eckles Normal.
Centimeters
Age in Days
40
80
120
160
200
240
280
320
360
400
440
480
520
560
600
640
680
720
760
800
80
90
100
110
120


GRAPH VII
Growth in Weight and Height at Withers to First Calving of G-13 and G-14 Compared to Eckles Normal.
Code
A G-13
B G-14
C Eckles Normal.
Height at Withers
Growth in Weight
Centimeters
130
120
110
100
90
80
70
0
40
80
120
160
200
240
280
320
360
400
440
480
520
560
600
640
680
720
760
800
Age in Days
A
B
C


GRAPH VIII
Growth in Weight and Height at Withers to First Calving
of G-15 and G-16 Compared to Eckles Normal.
Height at Withers
Growth in Weight
A G-15
B G-16
C Eckles Normal.
Centimeters
120
110
100
90
80
40
80
120
160
200
240
280
320
360
400
440
480
520
560
600
640
680
720
760
800
Age in Days
A
B
C

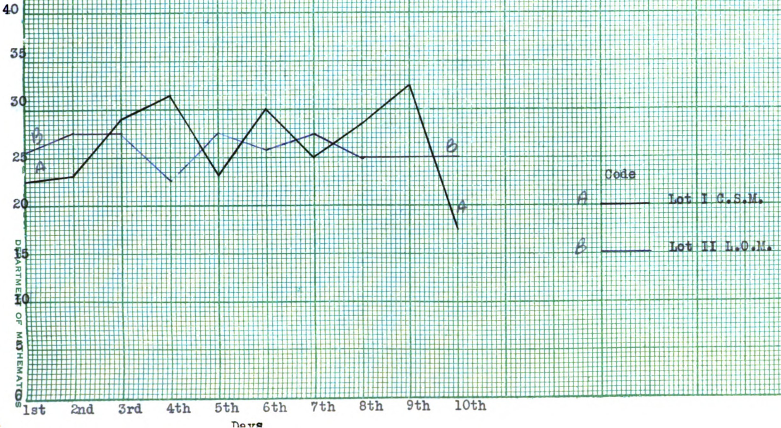
GRAPH IX

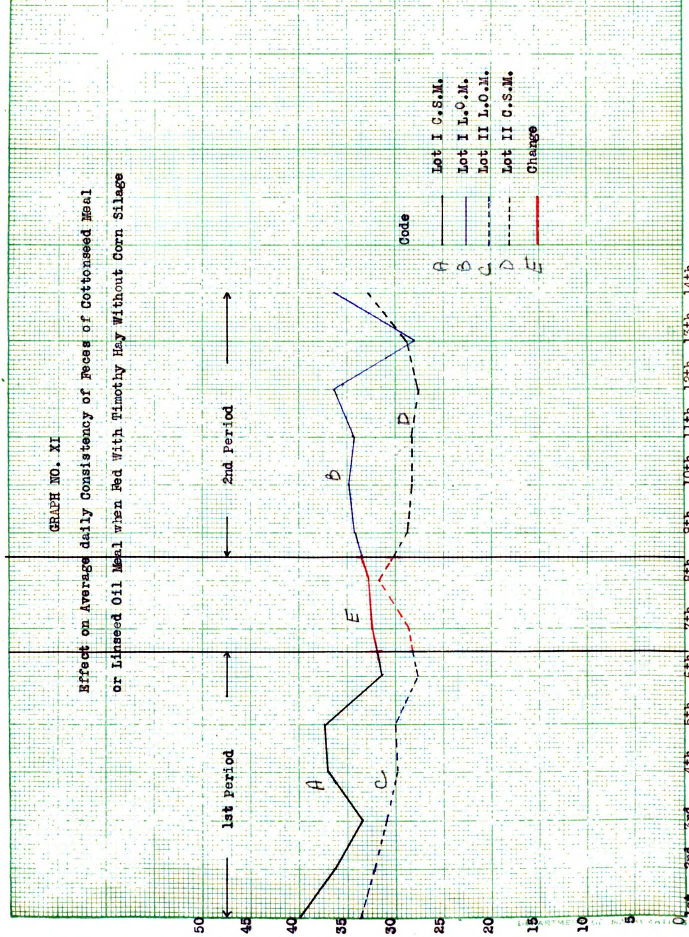
Effect on Average Daily Consistency of Feces of Cottonseed Meal or Linseed Oil Meal When fed With Timothy Hay and Corn Silage.



GRAPH NO. X

Showing the Effect on the Consistency of Feces of only 2.4 pounds of Cottonseed Meal and 3 Pounds of Linseed Oil Meal when Fed with Timothy Hay and Corn Silage




GRAPH NO. XI
Effect on Average daily Consistency of Feces of Cottonseed Meal
or Linseed Oil Meal when Fed With Timothy Hay Without Corn Silage
1st Period
2nd Period
A
B
C
D
E
Code
A Lot I C.S.M.
B Lot I L.O.M.
C Lot II L.O.M.
D Lot II C.S.M.
E Change
1st
2nd
3rd
4th
5th
6th
7th
8th
9th
10th
11th
12th
13th
14th
Days
50
45
40
35
30
25
20
15
10
5
0

GRAPH NO. XII

Effect on Average Daily Consistency of Feces of Only Two Pounds of Cottonseed Meal or Linseed Oil Meal when Fed with Timothy Hay as a Roughage.

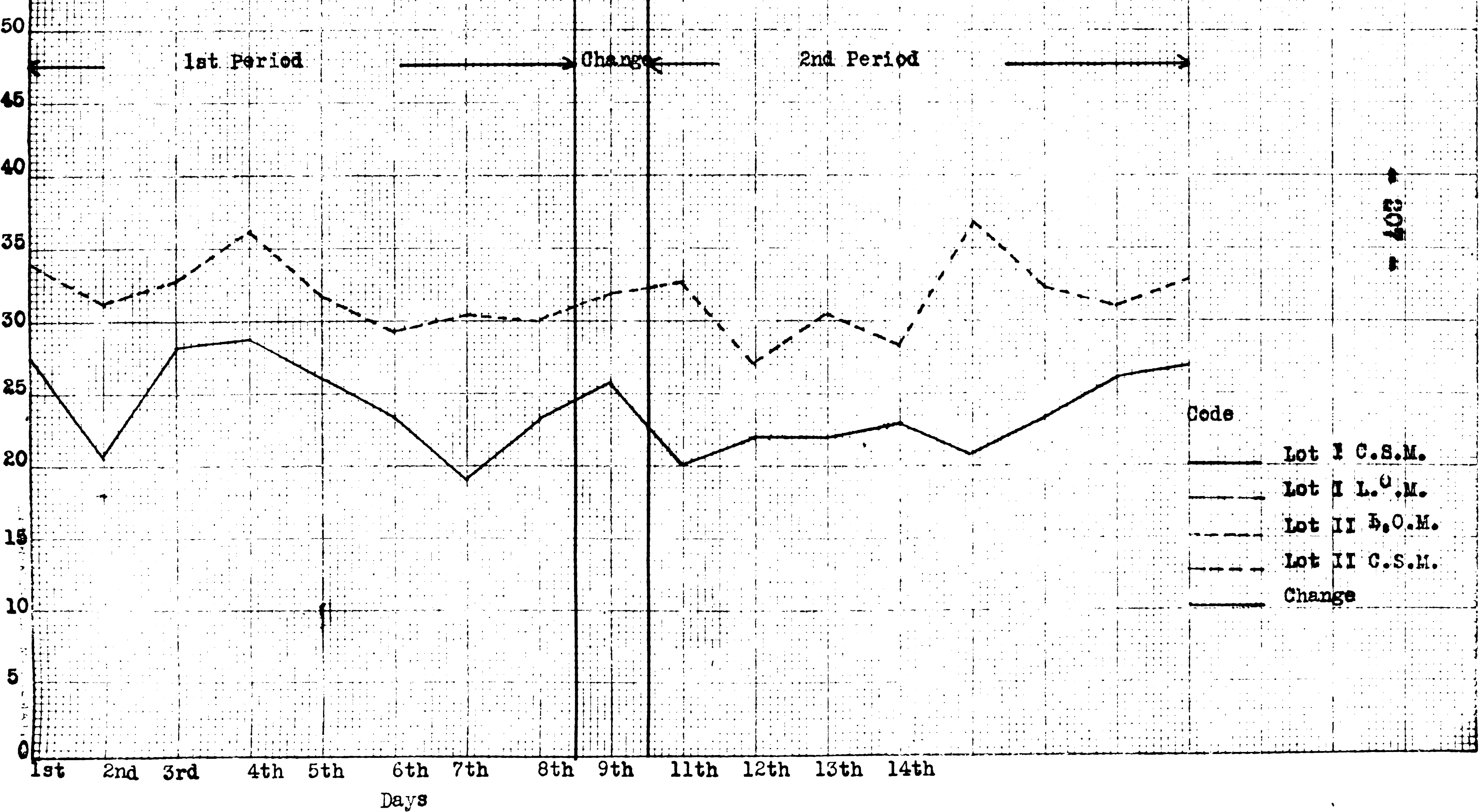
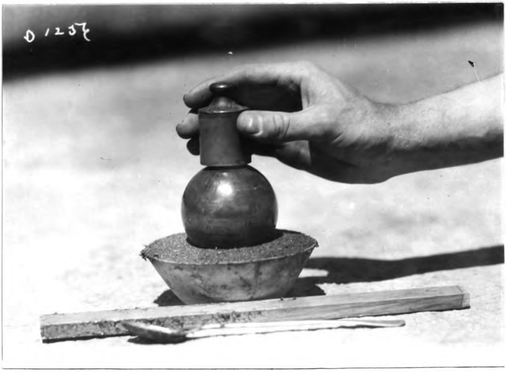


PLATE I

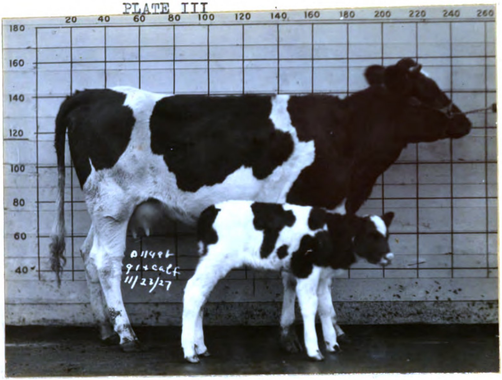
Showing Apparatus used to determine
Consistency of Feces

Plate II



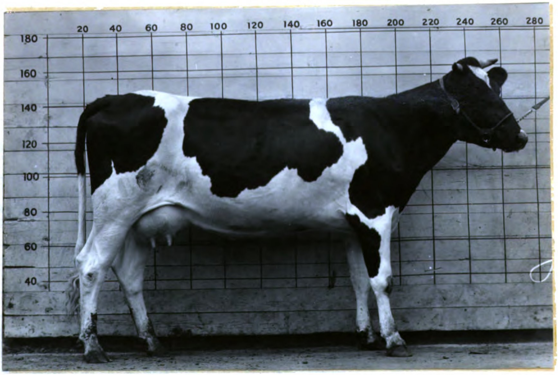
Showing operation of Determining
Consistency of Feces.

PLATE III



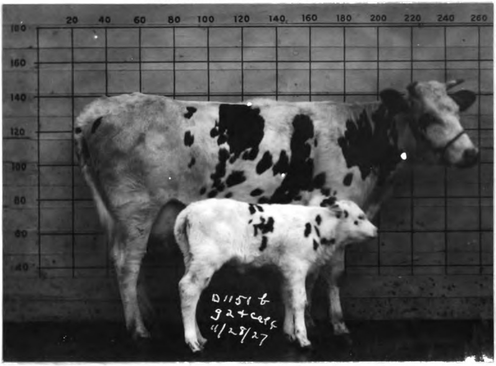
G-1 and calf at first calving.
Principal source of Protein - Cottonseed Meal

PLATE IV



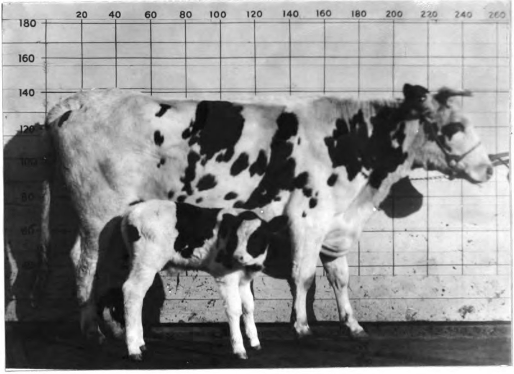
G-1 at 43 months of age. This animal consumed an average of 7.1 pounds daily of cottonseed meal during first lactation.

PLATE V



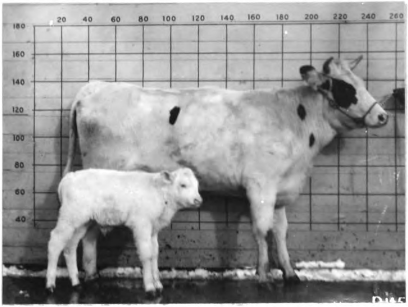
G-2 and calf at first calving. Principal source of Protein, Linseed oil meal.

PLATE VI



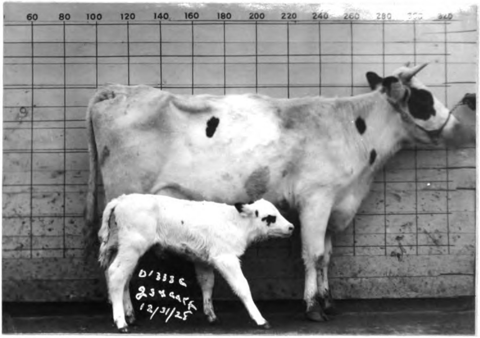
G-2 and calf at second calving.

PLATE VII



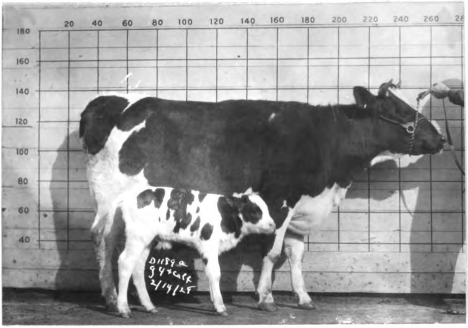
G-3 and calf at first calving. Principal source of Protein, Cottonseed Meal

PLATE VIII



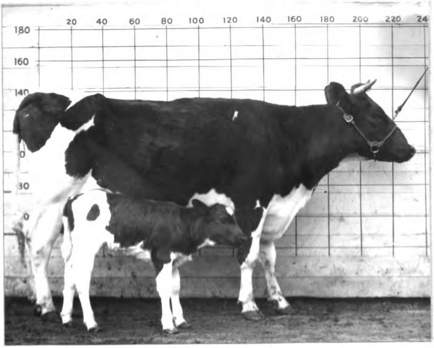
G-3 and calf at second calving time. Consumed an average of 7.4 pounds of Cottonseed Meal during the first lactation.

PLATE IX



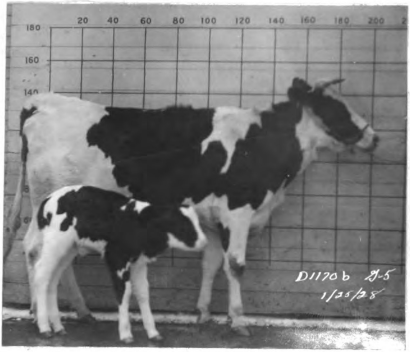
G-4 and calf at first calving. Principal source of Protein, Linseed Oil Meal

PLATE X



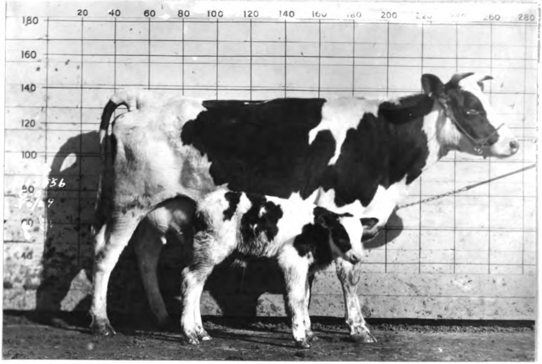
G-4 and calf at second calving.

PLATE XI



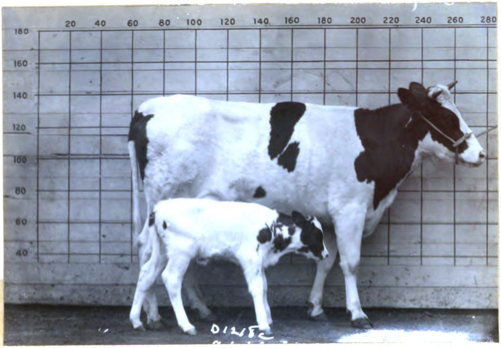
G-5 and calf at first calving. Principal source of Protein, Cottonseed Meal

PLATE XII



G-5 at second calving. Consumed an average of 7.3 pounds of Cottonseed Meal during first lactation.

PLATE XIII

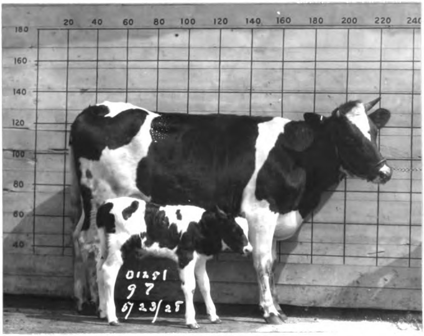


G-6 and calf at first calving. Principal source of Protein, Linseed Oil Meal.

PLATE XIV

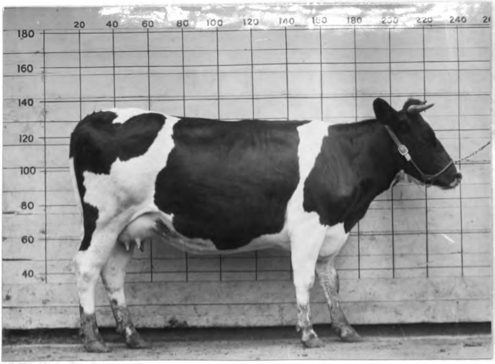
G-6 at 38 months of age. Has not calved second time.

PLATE XV



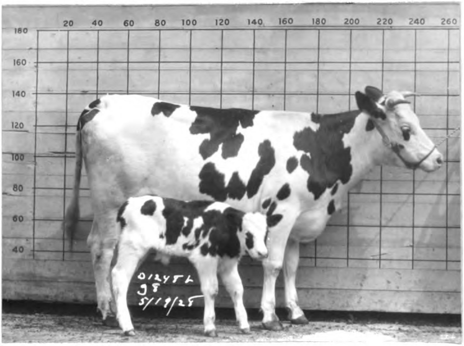
G-7 and calf at first calving. Principal source of Protein, Cottonseed Meal.

PLATE XVI



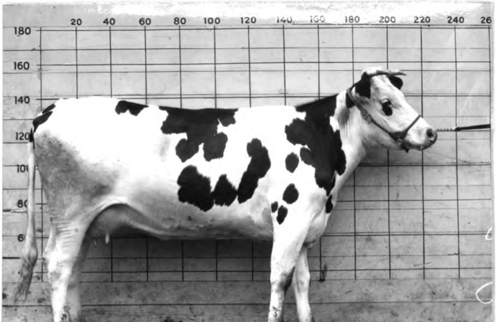
G-7 at 37 months of age. Has not calved second time.

PLATE XVII



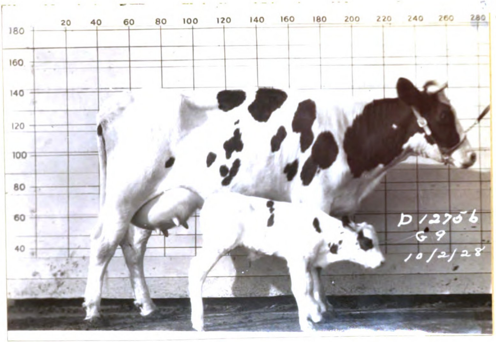
G-8 and calf at first calving. Principal source of Protein, Linseed Oil Meal

PLATE XVIII



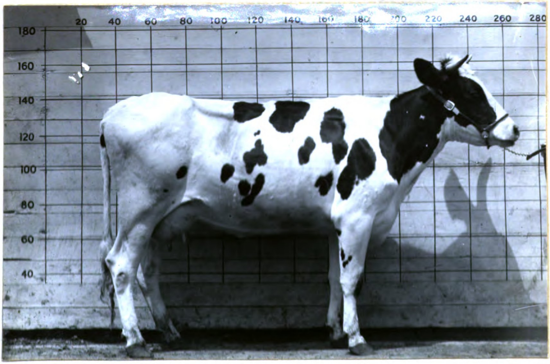
G-8 at 37 months of age. Has not calved second time.

PLATE XIX



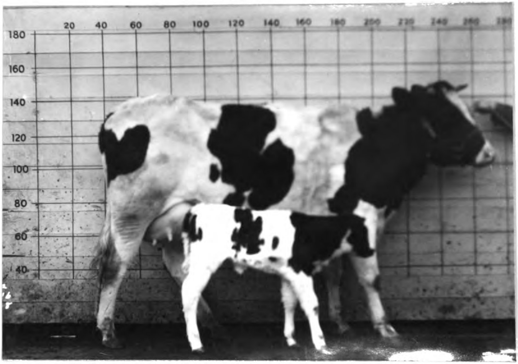
G-9 and calf at first calving. Principal source of Protein, Cottonseed Meal.

PLATE XX



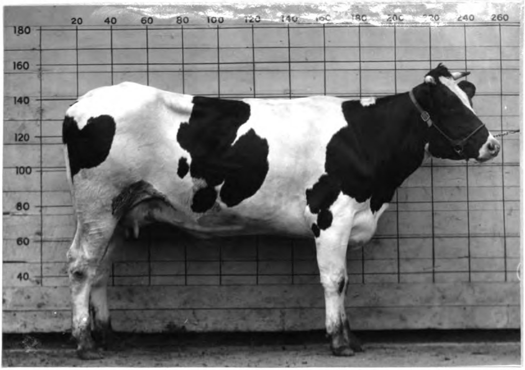
G-9 at 33 months of age. Has not calved second time.

PLATE XXI



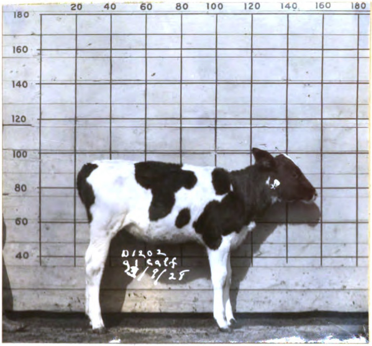
G-10 and calf at first calving. Principal source of Protein, Linseed Oil Meal.

PLATE XXII



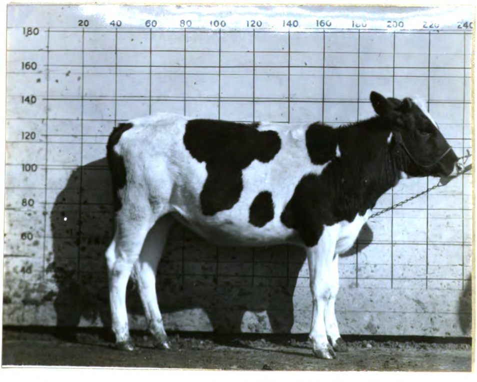
G-10 at 32 months of age. Has not calved second time.

PLATE XXIII



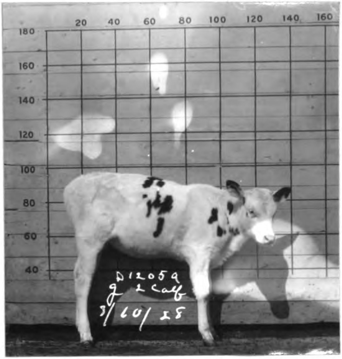
G-11 or G-1 's first calf (female) at
3 months of age.

PLATE XXIV



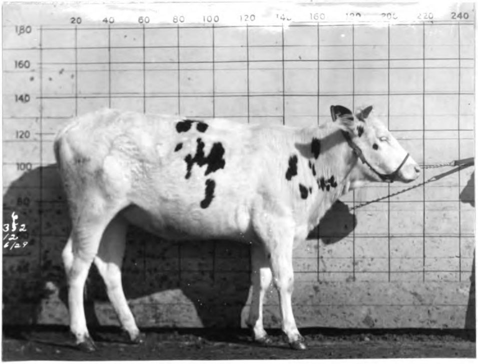
G-11 at 15 months of age. -Principal source
of protein, Cottonseed Meal.

PLATE XXV



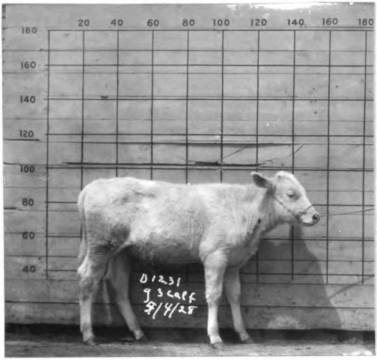
G-12 or G-2's first calf (female) at 3 months of age.

PLATE XXVI



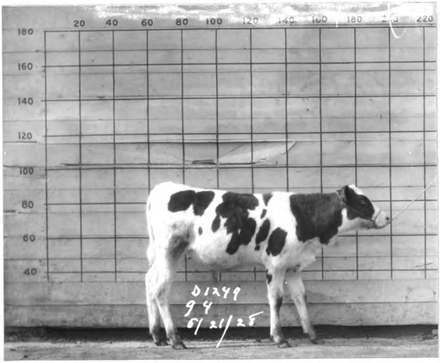
G-12 at 15 months of age. Principal source of Protein, Linseed oil Meal.

PLATE XXVII



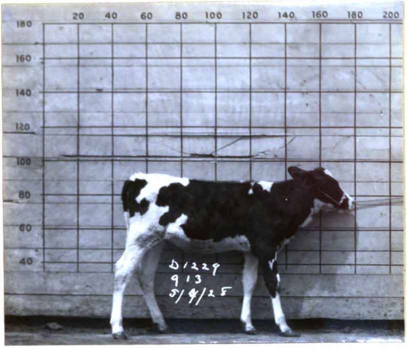
G-3's first calf (male) at 3 months of age.

PLATE XXVIII



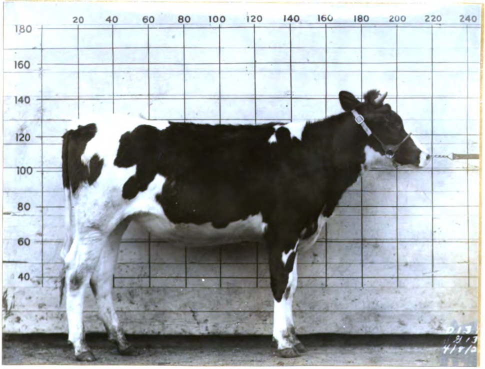
G-4's first calf (male) at 3 months of age.

PLATE XXIX



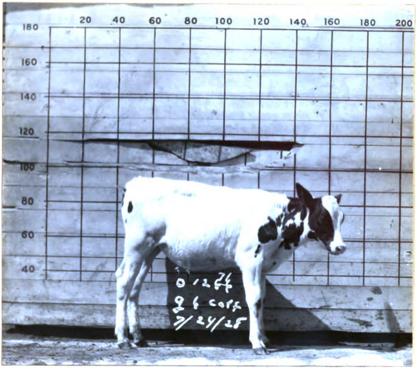
G-13 or G-5's first calf (female) at 3 months of age.

PLATE XXX



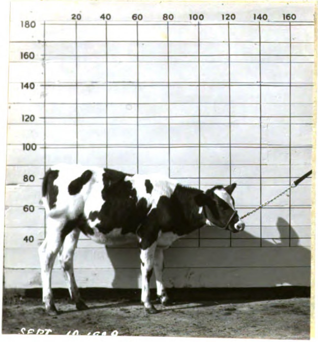
G-13 at 15 months of age. Principal source of Protein, Cottonseed Meal

PLATE XXXI



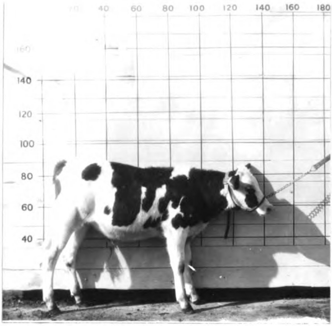
G-14 or G-6's first calf (female) at 3 months of age.

PLATE XXXII



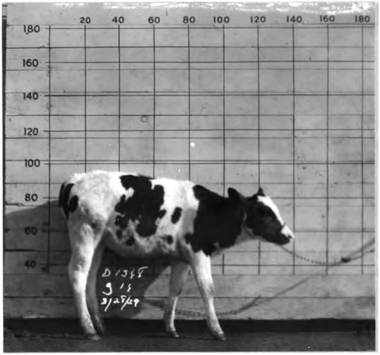
G-15 or G-7's first calf (female) at 3 months of age.

PLATE XXXIII



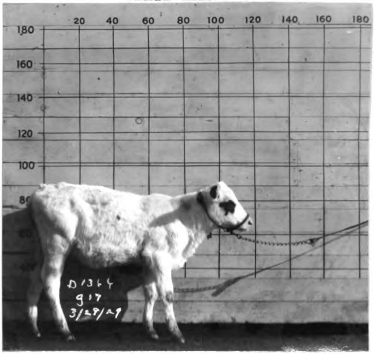
G-8's first calf (male) at 3 months of age.

PLATE XXXIV



G-16 or G-10's first calf at 3 months of age.

PLATE XXXV



G-17 or G-3's second calf at 3 months of age.

6/03 BG