THE UNIVERSITY OF MINNESOTA

GRADUATE SCHOOL

Report

of

Committee on Thesis

The undersigned, acting as a Committee of the Graduate School, have read the accompanying thesis submitted by Vernon Maurice Williams for the degree of Master of Science.
They approve it as a thesis meeting the requirements of the Graduate School of the University of Minnesota, and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science.

C. H. Eckles
Chairman

L. S. Palmer

J. J. Willaman

Aug. 30 1922

THE UNIVERSITY OF MINNESOTA

GRADUATE SCHOOL

Report

of

Committee on Examination

This is to certify that we the undersigned, as a committee of the Graduate School, have given Vernon Maurice Williams final oral examination for the degree of

Master of Science.

We recommend that the degree of

Master of Science

be conferred upon the candidate.

C. H. Eckles
Chairman

L. S. Palmer

J. J. Willaman

Date Aug. 30 1922

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YEAST AS A FACTOR IN THE NUTRITION OF DAIRY CATTLE

by

Vernon Maurice Williams, B.S.

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I N T R O D U C T I O N

Yeast has been used in the human dietary as a therapeutic for centuries. The mechanism of its action, however, in causing the many favorable results, which have been attributed to its use, has never been satisfactorily explained. For several hundred years yeast was thought to possess some mysterious curative property which combated all diseases. A later explanation was that it aided the body to resist bacterial invasion. Then a third idea was advanced that yeast inhibited the growth of putrefactive intestinal flora and so diminished auto-intoxication. Investigators in the last decade, however, have demonstrated the presence in yeast of a high concentration of the "water-soluble B" or "growth-promoting" vitamin. The substance, or class of substances, included in the term vitamin B, when administered to animals suffering from a deficiency of this factor, has shown remarkable growth-promoting, appetite-provoking and curative properties.

Little or nothing has been determined concerning the chemical composition of the vitamins, but it is known that different species vary in their requirements for these dietary factors. The requirements of the bovine have not been worked out but it has generally been assumed that they approximate those of the albino rat. If this assumption be correct the danger of a deficiency occurring, where cattle are fed rations of mixed natural foods, is remote. The present tendency, however, is toward the feeding of certain milling by-products which are not necessarily rich in any of the vitamins. Possibly then, the winter rations fed to some dairy cattle are deficient in vitamin B.

Remarkable effects from feeding this vitamin in the form of yeast have been obtained not only upon small experimental animals, but pediatricians have reported increased growth and improved health following the administration of yeast to infants. With these reports in view, it would not seem unreasonable to suppose that yeast might stimulate growth and health in calves. Moreover, a number of workers have suggested a relation between vitamin B and glandular functions. This idea would suggest, in turn, that yeast, added to rations deficient in this factor, might stimulate the activity of the mammary glands.

"The dairy industry must be preserved" is the cry heard on every side from those interested in public health. To maintain this industry at its present level, requires the raising of about five million calves each year. If some substance could be fed to calves which would bring them to maturity quicker and reduce the mortality rate with a saving of a few cents per calf, the saving to the nation could be counted in hundreds of thousands of dollars. Furthermore, if milk secretion could be stimulated so that a fraction of a cent could be saved on each of the ninety-eight billion pounds of milk produced annually, the saving to the nation would be tremendous. Yeast is available in large quantities as waste from breweries, distilleries and yeast factories, so could be obtained at a low rate if its use were shown to be advantageous.

The review of literature presented includes a discussion of the importance of vitamin B to the bovine, and the uses of yeast in animal rations.

The experimental work reported was carried on to determine the importance of yeast in the nutrition of dairy cattle. It was planned to determine the effects of yeast-feeding on: (1) the growth of calves, (2) the health of calves, (3) the milk production of cows, and (4) the vitamin B content of the milk.

REVIEW OF LITERATURE

I. GENERAL PHASES OF NUTRITIONAL DEVELOPMENT WITH REFERENCE TO VITAMIN B.

The value of yeast feeding may best be considered when the work leading to its use has been reviewed. In this consideration it would seem pertinent to mention briefly some of the landmarks in nutrition history with special reference to our present knowledge of the vitamins. We have made tremendous advances but our knowledge of these substances is still in its infancy. The barriers have seemed almost insurmountable, but, scattered contributions, some representing the work of a lifetime, have served to carve out steps in the steeper cliffs and to bridge the deeper chasms, until we have gained a vast store of learning in what to feed and how to feed.

Some of the more recent problems have been summed up by Sherman and Smith (1922): "Until recent years the discussion of foods and nutrition from the chemical point of view was hampered by the embarrassing fact that all attempts at prolonged feeding upon artificial mixtures containing the substances known to be necessary had ended in failure. Nor were such feeding experiments any more successful when great care was devoted to the chemical purity of the substances fed. Whether nutritive failure resulted from the need of other substances than those known as essential, or from faulty selection or quantitative combination of the nutrients entering into the artificial food mixture remained obscure until the work of Hopkins in England and of Osborne and Mendel and McCollum and Davis in this country made it clear that a natural food supply furnishes, and normal nutrition requires, other substances in addition to proteins, fats, carbohydrates, water and salts. With this fact now convincingly established it is easier to see that it was foreshadowed by many earlier observations than it is to say definitely when or by whom the existence of the substances now known as vitamins was discovered. Our present 'vitamin theory', or point of view in regard to this branch of food chemistry, is rather the product of development than of any isolated discovery, and much of this development antedates the introduction of the word vitamin."

1. Evidences from deficiency diseases.

The study of and the attempt to find the etiology and a cure for the deficiency diseases that occurred at sea and in certain oriental regions gave countless evidences that pointed to these unknown factors, whose absence in experimental rations had caused failure. We find Kramer writing in 1720 in his Medicina Castrensis that neither medicine nor surgery could give relief in scurvy. "But if you can get green vegetables; if you can prepare a sufficient quantity of fresh antiscorbutic juices, if you have oranges, lemons, citrons, or their pulp and juice preserved with whey in cask, so that you can make a lemonade, or rather give to the quantity of 3 or 4 ounces of their juice in whey, you will, without other assistance, cure this dreadful evil." Lind as surgeon of the ship Salisbury carried on some very carefully controlled work with some scurvy patients and confirmed the suggestions of Kramer. Writing in 1757, Lind noted that there was no hope of preventing scurvy by means of dried spinach since this had lost during its preparation "something contained in the natural juices of the plant" which "no moisture whatever could replace".

This idea that scurvy curing properties of certain foods were due to some unknown but definite thing was again stated by Budd who ascribed the action of certain of these foods to "an essential element, which it is hardly too sanguine to state, will be discovered by organic chemistry or the experiments of physiologists in a not far distant future."

Just as scurvy had caused so much trouble in European shipping crews, so had Beriberi wrought havoc at times in the Japanese navy up until Admiral Takaki (1885) became convinced that the diet had something to do with the disease and in making several modifications in the ration he had a part of the polished rice replaced with barley as a result of which the occurrence of beriberi dwindled to almost nothing.

For a number of years the procession moved gradually on until Eijkman (1897) summarized the results of a large amount of work he had done during the previous six years upon "an illness of fowls similar to beriberi" which he was able to produce experimentally by feeding fowls on polished rice and then either cure or prevent by feeding extracts of the polishings. He did not attribute this to any unknown substance but rather to a toxin in the polished rice, nevertheless, his work did much to help others in locating the true etiology of this illness a few years later.

Grijns (1901) added his share by showing that the polyneuritis produced in fowls by feeding polished rice as had been done by Eijkman could be cured and prevented by adding the native bean, katjang idjo (Phaseolus radiatus), to the polished rice diet.

Then Chamberlain and Vedder (1911) working for the United States Army medical commission for the study of tropical diseases in the Philippines made some long and rapid strides in the study of the chemical nature of this substance that cured beriberi in man and prevented and cured polyneuritis in fowls.

The work so begun was taken up by Funk (1911) who, publishing in December 1911, claimed for the first time to have isolated the substance in the pure state. He named it beriberi"vitamine" because this indicated an amine necessary or vital to life.

About the same time that Funk came forward with his suggestion, Holst and Frölich (1912) published the results of their work of several years in a very systematic study of the etiology and prevention of experimental scurvy. They went so far as to announce that their work indicated very clearly that scurvy is due to the deficiency in the diet of a substance soluble in water and easily destroyed by heating, but more stable in acid than in neutral or alkaline medium.

A little later, Osborne and Mendel (1913) found that their experimental animals developed a characteristic eye disease when their rations were free from fat, while the addition of butterfat served to both cure and prevent the disease. Further observation showed that cod liver oil and some other fats had the same effect with different potencies as indicated by the amounts necessary for cure. As this last disturbance includes an infection, it is not purely a deficiency disease but is prevented by the fat soluble A vitamin so has its place in the development of the theory.

Observations on disease then, led to the idea of the existence of three or more substances of the vitamin type, one soluble in fat and necessary to a normal healthy condition and the other two soluble in water and necessary for the prevention of beriberi and scurvy. Normal nutrition work also did its share because it furnished us with a wealth of knowledge concerning the known dietary essentials without which the other work would have been impossible.

2. Evidences from normal nutrition.

It is to Hopkins, (1906) that the credit should go for having first clearly and definitely announced that natural foods contain, and that normal nutrition of the animal body requires some other substances besides proteins, carbohydrates, fats and minerals. He reported as early as 1906 that, "no animal can live upon a mixture of pure protein, fat and carbohydrate and even when the necessary inorganic material is carefully supplied, the animal still cannot flourish. The animal body is adjusted to live either upon plant tissues or upon other animals and these contain countless substances other than protein, carbohydrates and fats."

In 1916 McCollum and Kennedy (1916) introduced the terms Water-soluble B and Fat soluble A to designate the two chemical substances, or possibly, so far as could be determined at that time, two groups of substances both of which were indispensable in the diet.

The work continued to advance so rapidly and the reports were so numerous that, already as early as 1917, we find Vedder presenting a review and general discussion of "the present status of our knowledge of the vitamines".

In the same year Osborne and Mendel (1917) continued the discussion of the role of the vitamins in the diet. They found that about two per cent of yeast solids were necessary in a purified mixture to furnish the water-soluble B vitamin. They were of the opinion that the water-soluble vitamin exerts a favorable influence upon metabolism, improving the general condition of the animal and thus increasing the appetite, rather than merely rendering the food mixture more palatable and thus inducing the animal to eat more. Subsequently they demonstrated experimentally that an animal's appetite for vitamin-free food can be improved by feeding the vitamin separately in the form of a small amount of dried yeast or spinach.

About this time the "vitamin theory" had gained such headway and was indeed, beginning to be so popular that some workers, notable amongst which was Mockeridge (1917), offered the suggestion that plant microorganisms were affected by certain unidentified substances or "auximones". The following year Pacini and Russel (1918) demonstrated the presence of a growth-promoting substance in cultures of typhoid bacilli.

3. Vitamin requirements of different species.

Hart, Halpin and McCollum (1917) opened a new field, which perhaps was destined to explain many of the inconsistencies in the reports relative to the source of the vitamins, when they suggested: "It is apparent that the mineral requirements, at least, and possibly the requirements for the other normal nutritive factors are not the same for chickens as they are for mammals. Further, the chicken's ability to tolerate without disaster, and without modification of the ration, the toxic material of wheat speaks for a metabolism distinct from that of swine or rats." A few months later Abderhalden and Schaumann (1918) working on the "specific action of organic feeding stuffs" supported this idea somewhat by maintaining that substances which can act as vitamins differ in different classes of animals.

By this time the advances in the work with proteins had reached a point where McCollum and Simmonds (1918) could state: "Since the solution of the main problems involved in the successful feeding of simplified diets, which consisted of purified substances, progress in the advancement of our knowledge of nutrition has been rapid. It has become evident that among the thousand or more chemical substances which occur in animal and plant tissues it is essential that the diet of the mammal shall contain only the following:

Sixteen or seventeen amino acids which result from the digestion of the complete proteins, the carbohydrate glucose or one of its polysaccharides (starch, dextrin etc.,) or other sugar which in the body is convertible into glucose; probably nine inorganic elements in the form of suitable compounds (Ca, Mg, Na, K, Cl, P, I, Fe, and S) and two, as yet unidentified, dietary essentials, fat-soluble A and water-soluble B. Such a mixture may be capable of supporting normal nutrition throughout the life of an animal beyond the weaning period."

4. Sources of vitamin B.

Our present information concerning the sources of the different vitamins represents the work of several years of very painstaking work by a number of different investigators. Their results were frequently somewhat contradictory but the potency of the more common substances as vitamin sources has been generally accepted, providing that the manner of preparation of the source previous to feeding is specified. Eddy (1921) has tabulated the more common foods, using a quadruple plus system to designate the potency based on the work of the greater part of the British and American workers. In quoting from him we will mention only those foods in the double, triple and quadruple plus grouping. The quadruple plus will be considered as the best sources, the triple as very good and the double as fair. Most of the common foods not mentioned have been tested and found to be poor or lacking in potency.

Best sources:

Clover and brewer's yeast.

Very good sources:

Cereals: barley, bread (whole meal), maize, oats, rice, rye, corn embryo, kaffir, wheat embryo, wheat kernel.

Dairy products: milk powder (skim and whole), whole milk and whey.

Fruits: grapefruit, lemons, oranges and tomatoes.

Meats: brains, pancreas.

Nuts: almonds, brazil nuts, chestnut, cocoanut, English walnuts, filberts.

Other seeds (not cereals): beans (kidney, navy and soy), cotton seed, flaxseed, hemp seed and millet seed.

Vegetables: cabbage (fresh and dried), carrots, cauliflower, celery onions, parsnips, potatoes, rutabaga, spinach.

Miscellaneous: alfalfa, timothy and yeast cakes.

Fair sources of B:

Cereals: corn pollen.

Dairy products: eggs.

Fruits: apples, limes and pears.

Meats: fishroe, herring and kidney.

Other seeds (not cereals): peanuts, peas (dry).

Vegetables: chard, dasheens, lettuce, mangels, peas (fresh) potatoes (sweet).

Miscellaneous: honey and yeast cake.

There may be another problem, not as yet worked out, that may throw light on some of the contradictory reports of the sources of the vitamins. Just as some mineral troubles seem to be related to the organism's ability to absorb and retain minerals there may be a relation in some cases between dietary deficiencies and the ability of the organism to retain the vitamin offered in the diet. Muckenfuss (1919) found the antineuritic vitamin present in the bile of the ox and in human urine which might indicate that there is an excretion of this substance and it is possible that this excretion might vary enough to be significant in the health of the animal. This is a new phase of the work and like many other features will have to be worked out by careful experimental study.

5. Effects of a deficiency of vitamin B.

A great amount of work has been done in determining the etiology of the two common deficiency diseases scurvy and beriberi. Almost every worker in the field has produced these diseases experimentally in guinea pigs and pigeons respectively, observed the gross changes, and then cured them by the addition to the diet of some food rich in the needed vitamin. The field of the pathologist and the physiologist in vitamin work however, has as yet barely been entered.

Abderhalden (1921) studied the gas metabolism changes in pigeons while coming down with polyneuritis and noted there was a gradual falling off until the onset of the disease, which was checked and then increased with the addition of yeast.

Karr (1920) working on dogs found that in this species some relation existed between the desire to partake of food and the amount of the so-called water-soluble vitamin B ingested. He found brewer's yeast, baker's yeast, tomatoes and milk to be sources of this appetite provoking substance. The brewer's yeast that he tested was more potent than the baker's, but this would not necessarily be significant because there are so many different varieties of yeast obtainable. He observed that drying at 100°C did not affect the efficacy of the preparation of water-soluble B but that autoclaving at 120°C. led to some destruction. He was able to induce mammalian polyneuritis in several animals in which the symptoms were alleviated in few hours by the ingestion of brewer's yeast or tomatoes, both rich in water-soluble B vitamin.

The changes in the central nervous system in polyneuritis have been so marked, as evidenced by the action of the animal and a recovery so rapid upon administration of small amounts of the curative substances, that other effects on the organism have perhaps been unnoticed. McCarrison (1919) after conducting a series of studies at the Pasteur Institute of Southern India was the first to call attention to the pathogenesis of deficiency disease. Working first with pigeons he was able to demonstrate a certain parallelism between the effects of simple starvation and lack of vitamins. In cases uncomplicated by bacterial invasion, both simple starvation and a diet of polished rice and autoclaved rice brought about a loss in weight, a progressive fall in body temperature, and a slowing of respiration. The weights of the different organs of the body immediately after death showed atrophy of the thymus, testicle, spleen, ovary, pancreas, heart, liver, kidneys, stomach and thyroid in decreasing order, and marked hypertrophy of the adrenals. The pituitary gland and the brain showed no change in the starved pigeons, but on the vitamin deficient diet a slight tendency to enlargement of the pituitary was noted in the male birds and slight atrophy of the brain in both male and female. The central nervous system as a whole underwent little atrophy, the paralytic symptoms being mainly due to impaired functional activity of the nerve cells rather than to their degeneration.

McCarrison places great significance on the hypertrophy of the adrenals from a want of vitamin substances since this occurs both as a result of starvation and a polished rice dietary. "Endocrinology provides another striking illustration of such hypertrophy, namely, that of the thyroid for want of iodine. The thyroid hypertrophies either because of the lack of iodine in the food or because of its imperfect assimilation due to the microbic action of the gastro-intestinal tract and most commonly when both factors operate together. My researches with regard to beriberi are leading me to a like conclusion concerning the adrenals: these enlarge for want of antineuritic vitamins in the food and probably also in consequence of the inadequate assimilation of these substances - owing to microbic or parasitic action in the gastro-intestinal tract, or for both reasons."

McCarrison's study of the relation between infection and deficiency disease was conducted on pigeons both naturally and artificially infected with Bacillus suipestifer. The infected birds when fed on polished rice developed symptoms of polyneuritis more rapidly than non-infected birds. Asthenic and fulminatory forms of polyneuritis were much more frequent in the infected birds, which rarely survived long enough to develop cerebellar symptoms. Such symptoms, however, developed in birds in which infection had been prevented by isolation and immunization. Control birds fed on a liberal diet of mixed grains were in general immune, although exposed to infection. These results are thought to illustrate the influence which infectious agencies probably exert in man under like conditions of dietetic deficiency, beriberi being more frequent among peoples subjected to the attack of innumerable bacterial and other parasitic agencies, to which they are rendered highly susceptible in consequence of a dietetic deficiency.

The general conclusion of McCarrison at this time was that the pathological condition resulting from vitamin free diet is due to: (a) chronic under nutrition, (b) derangement of function of the organs of digestion and assimilation, (c) disordered endocrine function, especially of the adrenal glands, and (d) malnutrition of the nervous system. "The whole morbid process is believed to be the result of nuclear starvation of all tissue cells. Even the adrenals, which alone of all organs of the body undergo hypertrophy, show on section changes in some of the cells indicative of nuclear starvation."

In a more detailed histological study McCarrison (1919a) reported many changes in the intestinal condition of pigeons on vitamin deficient diets.

Autoclaved rice alone was used as the diet deficient in all three vitamins, rice and butter alone as the one deficient in B and C, and rice and onion as the one deficient in A and B. The chief microscopical changes observed on autopsy in pigeons on these diets were atrophy and congestion, the latter being more largely confined to the upper part of the alimentary tract, and tending to open the way to systemic infection from the diseased intestine. Interpreted in terms of bowel function the derangements to which these pathological changes may ultimately lead are classified as impairment of the neuromuscular control of the bowel; impaired transport of the intestinal content along the alimentary canal; impairment of assimilative power; impairment of secretory function; impaired protective resources leading to infection of the mucous membrane of the bowel by pathogenic saprophytes or ingested bacteria and to systemic infection therefrom. That these gastro-infestinal lesions are much more deep seated than those of the nervous system is indicated from the observation that the nervous symptoms present in avian polyneuritis may be rapidly ameliorated and recovered from, and yet the birds die in consequence of gastro-intestinal lesions. In the nervous system the symptoms are considered to be mainly the result of functional disorder, while in the intestine a greater destruction of tissue takes place.

From the order of severity in which histological changes occur in different organs, McCarrison concludes that "the organs which suffer most are those which are the least essential to the life of the individual. Next in order are the organs of digestion and assimilation and lastly the organs of internal secretion. That the central nervous system suffers least from the point of view of organic lesions is shown by the rapidity with which the nervous symptoms due to the deficient diet can be controlled or abated by the administration of vitaminic substances. It seems probable that the cellular elements of the organs least essential to the life of the individual are utilized to provide accessory food factors and other nutritive materials for the cells of higher function."

He reports again (1922) that deficiencies of certain vitamins, especially when combined with certain other excesses, may have a very profound disturbing effect on the balance of the endocrine functions.

6. Physiological properties of water-soluble B vitamin.

There has been much controversy, ever since Funk's (1911) claim that he had isolated the antipolyneuritic substance, concerning the identity of the antiberiberi factor and the growth promoting substance in water-soluble B vitamin. Emmett and Luros (1920) by a set of very carefully controlled experiments on pigeons, rats and guinea pigs claim to have demonstrated three different substances: yeast growth-promoting substance, antineuritic substance and water-soluble B vitamin. They admit, however, that the requirements of the different species of experimental animals may have been different so they suggest that the substances may be different rather than positively assert that the observed differences indicate different substances.

We will, however, in the absence of convincing proof, include all these substances -- if there is more than one -- under the one name water-soluble B vitamin as is done by Sherman and Smith (1922c) in reviewing the physiological properties of vitamin B : "The term vitamin B at present includes: (1) the antineuritic vitamin found by Eijkman in rice, Grijns in beans, Funk and others in yeast, and lately found in a wide variety of animal and vegetable substances, the absence of which causes polyneuritis in fowls, beriberi in man and a similar pathological condition in other mammals; (2) a water-soluble growth-promoting substance found by Hopkins, Osborne and Mendel, and McCollum in milk, and later found in wheat embryo, yeast and the various materials furnishing the antineuritic vitamin. Absence of this vitamin causes loss of appetite, cessation of growth and finally pathological symptoms resembling those of beriberi. Similarity in occurrence and many properties speak for the identity of the antineuritic and growth-promoting water-soluble vitamins. In the absence of positive proof it seems probable that the water-soluble growth-promoting substance is among the substance having antineuritic action.

"Vitamin B may also include the "bios" which stimulates the growth of yeast, the "auximones" or growth-promoting substances apparently synthesized by soil bacteria and necessary for the growth of green plants, and a substance found in blood and other materials and which is necessary for the growth of microorganisms particularly of the hemophilic type.

"Pending the chemical identification of vitamin B and quantitative experiments in which the same substance is tested for all the above mentioned properties, it is impossible to do more than classify these substances under the general heading of vitamin B.

"Birds fed on polished rice or the corresponding products of other grains develop polyneuritis as the result of the lack of vitamin B. Usually they show considerable loss of weight at the same time but the nervous symptoms predominate in the pathological picture presented by birds on such a diet.

"In mammals a deficiency of vitamin B in the diet causes loss of appetite commonly followed by a more complex and less clear-cut set of symptoms than in the case of birds. These symptoms are grouped by Mc Carrison in the order of undernutrition, derangement of function of the organs of digestion and assimilation, disordered endocrine function, and malnutrition of the nervous system. A partial but not complete deficiency in this vitamin leads to impaired growth and a general undermining of health and vigor. This lowered vitality may have a far reaching effect in its influence on reproduction and successful rearing of the young.

"While often referred to as growth-promoting, it should be emphasized that vitamin B is essential to normal nutrition at all ages.

"The mechanism of the action of vitamin B has been variously thought to be that of a physiological stimulant to glandular secretion; of an indirect metabolic stimulant particularly for carbohydrate metabolism; and of a specific cell nutrient, the nucleoplast of McCarrison and Findlay. This latter view is of especial interest in correlating the growth-promoting vitamin essential to normal nuclear metabolism in the body, with that thought by Mockeridge to be essential to the nuclear metabolism of the plant.

"While the relation of vitamin B to cellular metabolism seems still a matter of speculation, it is clear that it often exerts a very direct influence upon appetite, as frequently demonstrated by Osborne and Mendel. It is also plain that the vitamin can cure nutritional polyneuritis in both birds and mammals (Funk, Williams, McCollum, Cowgill and Mendel) and both by administration through the mouth and by injection. Thus it has pronounced effect upon the appetite but need not act through the digestive tract.

V. Summary

Thus by leaps and bounds our knowledge concerning the vitamins has advanced even to the point where the popular viewpoint has, indeed, gone too far for the public has become so enthusiastic over the "vitamin theory" that it has permitted a number of exploitations to take place. Vitamins, almost a magic word for the public ear, are now sold in fancy preparations to cure a great host of evils, restore failing health, renew vigor and preserve youthful vitality. The great mass of experimental evidence has apparently shown that there are possibilities of having a diet for both humans and domestic animals which would be deficient in one or more of the vitamins but that this danger is not imminent to the extent that the popular mind has been led to believe. The other nutritional factors, namely, the proper balance of protein, fat and carbohydrates, the adequate mineral supply and sufficient energy all have their place as has been well noted by Hopkins (1921): "What we have actually to recognize is that each of several factors may become that which limits efficiency, and that no one of these is in any strict sense more important than the other. Normal nutrition calls for a certain minimum of each and every one. If a diet is harmoniously balanced in a chemical sense, then indeed energy becomes the sole limiting factor. Nutrition then fails, of course, only when too little of the diet is eaten to yield the essential minimum of energy. But the supply of fat may become the limiting factor, and no less that of the carbohydrate. Or, again, when the supply of energy consumed is ample, with fat and carbohydrate duly adjusted, the circumstance that a single essential amino acid in one case, or a vitamin in another, is present in amount below the necessary minimum converts each of these in turn into the factor which limits utilization. Small as the necessary minimum in either case may be, unless it is reached, the proper use of the rest of the diet is reduced to a degree which is proportional to the deficiency. If the deficiency be complete normal utilization is altogether impossible."

II. YEAST FEEDING IN COMMON PRACTICE

1. Utilization of waste

Utilization of by-products has been an industry in itself during the last half century. Many industries are today deriving as much income from their by-products as they formerly did from the main product of the plant. Especially is this true in the case of the milling industry in manufacturing all sorts of products from the bran and germ that were practically wasted at one time. In an attempt to do likewise the brewers have tried to find an outlet for the large amounts of spent yeast and brewing residues that have accumulated on their hands, and which in the past, have been worse than valueless because they have had to be transported away from the breweries. We would expect the Germans to be the ones that would find a method for utilizing these wastes as they have put such great emphasis on the brewing industry and the study of its various phases. Numerous feeding tests were run on livestock but the real popularity of the practice did not come until about 1905 when a number of workers commenced to run trials so that the breweries might have some ground for selling their wastes as food.

2. Preparation of yeast feeds.

The Pure Products magazine (1905) summarized a large amount of the earlier work with a report of the methods for the preparation of the feeding stuffs from yeast but did not have much data on the value of them. About the same time the Wissenschaftliche Station für Brauerie at Munchen patented a process of preparing a stable feeding stock from yeast discharged from the brew. Their method consisted in heating the yeast to 75°C after first exposing it to the action of about 1 per cent common salt for about five minutes. This product was mixed with other feeding stuffs as hops, malt sprouts, malt husks, beet scraps, and the like with a binding material, without, however, occasional ferment. The viscous mass is mixed with cut straw and quickly dried in the form of cakes.

A year later Schmidt (1906) patented an English process of "preparing cattle or like food from yeast by raising the temperature of the yeast rapidly to at least 58°C." The same year Makin (1906) another Englishman patented a process of "preparing foods from yeast consisting in sterilizing it by admixture with boiling saccharine matter or with boiling vegetable oils or with both and either with or without further admixture." In 1907, Pure Products again reported yeast work in a method for the "preparation of a preservable dry fodder from yeast". Compressed waste yeast, it was stated, may be converted into a feeding stuff of good keeping qualities by heating such a material, to which common salt has been added, to about 70°C. for some five minutes. This converts it to a gelatinous mass, which combines readily with other materials and may be mixed with such feeds as spent hops, malt sprouts, grain, beet chips, etc. The treated yeast possesses little enzymatic power. If chopped straw constitutes a part of the mixture, the mechanical condition is improved and the material dries more readily. A year later Pott (1908) writing in Berlin furnished a long discussion of data regarding the composition and feeding value of yeast and yeast feeds the general discussion of which was that there were a number of ways of preparing very good stock feeds from spent yeast.

To get the spent yeast dried and still retain its nutritive properties and good keeping qualities was the problem that had caused a large amount of experimentation. But there was a well founded objection to the feeds so prepared, that is, they all had a bitter taste and were frequently refused altogether by cattle. In 1909, however, Jaroschka and Richter (1909) patented a process in Germany for doing away with some objections by adding charcoal and turf dust to the yeast. By the addition of these two constituents, the slimy character of the yeast was destroyed and a product was obtained which dried readily and had a pleasant odor. Two years later another British patent described a process where the yeast was digested with water at 45-60 degrees C., the hydrolysis being hastened by either digesting in thin layers, or aerating, or adding an oxidizing agent. The extract is filtered and then derived of bitter resins etc., by adding and then coagulating with an albumin or by forming a precipitate of calcium carbonate or tricalcium phosphate. The product is reported to be suitable for both animal and human consumption. About the same time Hayduck (1911), one of the more prominent workers at the brewery experiment stations, reviewed the preparation of yeast foods and their value declaring them to be very good sources of concentrated food in the cases where they were prepared properly.

As a further improvement Fallada (1911) worked out a method for preparing a feed from dried yeast and molasses where he used 10 parts of molasses to 8 parts of dried yeast. After 10 weeks he states that there was no appreciable loss of nutriment. His analysis of this mixture was:

Water	13.71	per cent
Protein	20.81	" "
Amino acids	8.19	" "
Fat	1.8	" "
Sugar	28.8	" "
Ash	8.6	" "
Other N free extracts.	18.09	" "
Fiber and invert sugar	Traces	

A little later a French patent ("Visca" Nahrungsmittle 1912) described the manufacture of a food extract for human use where the washed yeast was brought to fermentation in the solution of a fermentable sugar, killed only after reaching a high stage of fermentation, and then worked up into an extract. As they used an excess of sugar in this case perhaps the alcoholic nature of the resulting extract made it more marketable.

The use of dried yeast had now become so common that Hayduck (1912) described the manufacture of yeast feeds on a very large scale by machinery provided especially for that purpose. He encouraged the use of dried yeast in cookery and maintained that, in view of the successful feeding trials that had been carried on, the price of dried yeast was considerably below its feeding value.

Krause (1912) patented in England a process very similar to the French patent on the preparation of an extract after washing, fermenting and killing.

Rapid growth of the yeast feed industry led to a host of attempted improvements in the simplicity of preparation, removing the bitter taste, increasing the digestibility and the economy of preparation. It would not seem inappropriate to mention a few of these to show the variety of means that were used to obtain these ends and to show the popularity of yeast feeding in some regions.

One of the first methods was patented by Hamburg in 1913, "to improve the digestibility of brewer's grains by mixing 10 parts of washed and pressed yeast, which had been heated to 50°- 60° C. and stirred until a liquid mass was obtained, with 90 parts of wet grains or with other substances and a suitable quantity of water so that the mixture is thorough and then drying with heat.

Gothard (1913) patented another process the same year in which "cattle feed is prepared by drying and grinding a mixture of yeast 50 parts, peat moss 25 and hop meal 25."

Another extract for use as a human food was patented by Nilson (1916) a process whereby the yeast was heated with dilute HCl to rupture the yeast cells and then the soluble contents were extracted. The solution was withdrawn from the residual matter, heated and treated with a sufficient amount of Na_2CO_3 to neutralize the HCl. The solution was then evaporated to a much higher concentration, seasoned and preserved with NaCl. Another novel method was that patented by Floare (1917) in this country where the spent yeast from brewery or distillery operations is mixed with water and placed in a closed vessel, partly filled with compressed air, agitated for some time, and then allowed to settle before the water is drawn off. These operations are repeated until the product is sufficiently purified; it is then removed from the vessel, drained or filtered while exposed to the air, pressed and mixed with corn meal in equal parts, and with cocoa hulls or shells, and sweetened when served as a food.

Petit (1917) also suggested a method for making food from a yeast extract, also a malt extract and a product called flaked yeast which was made by low temperature drying of the yeast.

Herzfield (1921) in an attempt to provide an outlet for the wastes from the breweries and distilleries in this country, reported a method for preparing a food which could be used either for human or livestock consumption. The yeast was freed from invertase and rendered slightly alkaline by the addition of 0.05 - 0.10 per cent NaOH before heating to 100°C. If the water was over 60 per cent it was reduced to this percentage at lower temperatures before the final heating. The yeast preparation was then mixed with twice its amount of sucrose and the mixture was evaporated to a syrup-like constituency (which is accomplished without inversion of the sucrose). The concentrated mixture is then mixed with 5-10 per cent of fresh yeast, rich in invertase, which is allowed to act for 30 minutes to 24 hours to effect a regulated production of invert sugar and the mass is finally heated to near the boiling point (but in no case over 108°C.) to evaporate the water and produce a brown food rich in albuminous substance.

Plauson and Vielle (1921) patented a process in England for improving the taste of the yeast and rendering it more digestible. They treated the yeast with hydrogen under heat and pressure. It could be first treated with a solution of $(NH_4)_2CO_3$ or Na_2CO_3 or borax, washed to remove the bitter taste and disintegrated in any known way. It was then treated with hydrogen at a pressure of 100-200 atmospheres and a temperature of 100-130°C.

A number of other preparations for making yeast to be used in baking have also been reported, Penniman's (1921) three patents being among the more recent. His first was mixing the yeast with starch or flour and with a smaller amount of glucose or dextrin, and to this mixture there may be added small amounts of soluble inorganic salts such as ammonium phosphate, potassium nitrate or magnesium phosphate and the mixture is then dried at a low temperature, in vacuo. His second patent was a similar method in which the glucose or dextrin was omitted. The third patent covered the preparation of a dry yeast product by first propagating yeast in a barley malt wort containing wheat flour, then thickening the liquid culture with cornmeal to form a soft dough, granulating the latter and drying, in vacuo, until the moisture content is reduced to about 10 per cent.

One of the last food preparations was patented by Miller (1921) which consisted of drying brewer's yeast to obtain a flour suitable for admixture with wheat flour or for use alone as a food. The wet yeast may be dried by delivery into a rapidly rotating cylinder from which it is discharged by centrifugal force at the delivery end of the cylinder in the form of a very fine annular spray and subjected to a current of heated air which is blown annularly across the centrifugally discharged material so that the moisture is very rapidly taken up and the material can then be collected in a dry pulverized or flour-like condition. A temperature of 57°C or higher for the drying air may be employed. A second one of his patents relates to a similar method except that the drying is conducted with air heated to about 43-49°C to avoid disintegration of the yeast and retain it, as nearly as possible, in its original condition with the same food value as the undried yeast.

3. Yeast feeds as sources of digestible nutrients.

The variety of methods described above would, of course, give feeds with large differences in composition. They are all, in the cases where the yeast makes up the greater part of the feed, very high in protein and very low in crude fiber. Two of the representative analyses will serve to show the general nature of the analyses of yeast feeds. That analyzed by Czadek (1911) was as follows:

Water	10.9 per cent	
Organic substance	80.87	(Protein N 4.50 and P_2O_5 7.73)
Protein	55.6	
Fat	0.53	
N free extract	18.9	
Fiber	5.85	
Ash	8.19	
Sand	0.12	

After conducting some lengthy feeding trials with hogs he found the following digestible coefficients:

Crude protein	90.8 per cent
Fat	62.5 " "
Carbohydrates	76.4 " "
Ash	88.4 " "
P_2O_5	83.8 " "
Organic substances	84.4 " "

When 3 kgm of yeast were fed per 100 kgm. of weight per day, which is about 10 times as much as is usually fed, no injury was noted.

Kling's (1918) analysis of a yeast mixture of 25 parts and grain 75 parts will give an idea of the composition in general of those types of feeds:

Water	7.18 per cent
Protein	30.80 " "
Fat	5.63 " "
N free extract	37.58 " "
Fiber	13.63 " "
Ash	5.18 " "

A number of very careful studies have also been made in the brewery experiment stations concerning the chemical composition of the yeast cells. Dreyer (1913) made a very thorough analysis of the protein of the cell and concludes that the yeast membrane contains a hemmicellulose and a manno-dextran, and that freshly pressed yeast, when treated with NH_3, $(NH_4)_2CO_3$ or NaOH yields 12 per cent coagulable protein, consisting of 60 per cent albumin and 40 per cent globulin.

Schulze (1913) added a very valuable contribution to the study of the composition of yeasts especially as there is quite a complete bibliography appended. He states that yeast like other forms of life is composed largely of carbohydrates, fats, proteins, lecithin and inorganic constituents. All other substances occur only in very small quantities and are almost unknown chemically. Of the carbohydrates, yeast dextran and yeast cellulose have been isolated from the membrane; furthermore yeast contains yeast gums and glycogen. Mannose and dextrose are the basis of these high molecular weight carbohydrates. Pentosans could not be detected, but the yeast nucleic acid contains a pentose. The chemical composition of the fatty substances has not been determined. Regarding the proteins likewise, little has been established, but the composition of the nuclein protein has been successfully investigated. He suggests that in the future investigations pertaining to the chemical composition of the yeast, especially as regards to the protein and the fat, the race and physiological condition be specified in order that these investigations may be comparable among themselves.

That the yeasts contain vitamin B or at least a growth-promoting substance has been common knowledge amongst nutrition workers ever since Cooper and Funk claimed to have isolated the anti-beriberi substance from yeast in 1911. There have been a large number of successful feeding experiments carried on with albino rats with yeast as a source of vitamin B, so these need hardly be mentioned, but there has been considerable controversy especially in the last three years as to the vitamin requirements of the yeast itself. That is, a number of workers have asserted that the yeast could not grow on synthetic media and that unless the media had a high content of B vitamin the yeast would be poor in this factor. Harden and Zilva (1921), however, announced in a preliminary note on the synthesis of vitamin B by yeasts that yeast grown on synthetic media contained vitamin B.

Nelson, Fulmer and Cessna (1921) affirmed the findings of Harden and Zilva, reporting from their work, "It can be concluded that after such an experience any water-soluble B present in the yeast must be synthesized by the organism." Sufficient yeast was grown by them to feed rats which made rapid gains when two per cent of the yeast grown on the synthetic medium was added to a ration free of water-soluble B and on which rats had begun to decline rapidly.

Since the digestibility of the yeast protein had been found so high the only thing remaining to make the yeast a very desirable form of food was knowledge that the protein was complete and this was demonstrated by Osborne and Mendel (1919). They reported that they kept rats successfully for more than a year covering the period of growth, upon a diet in which brewer's yeast furnished the sole source of nitrogen as well as water-soluble vitamin. The yeast used was compressed, forming 30-40 per cent of the ration, probably representing an actual protein concentration of less than 18 per cent. The nitrogen intake, as estimated by a comparison of the feces with the intake, was from 74 to 83 per cent. When bred with vigorous females, which had grown up on a normal mixed diet, two of the animals proved to be fertile but produced inferior young while two others failed to breed. The testes of the latter showed an absence of germ cells. The authors are, however, of the opinion that this infertility is not caused by the yeast per se, and that there is no toxic factor present in the yeast.

One phosphoprotein in yeast resembles the casein of milk in certain respects and, indeed, there is a possibility that this might account for some of the very favorable results from feeding of the yeast to growing animals. Thomas (1921) made some rather exhaustive studies of these proteins reporting: Two proteins are obtained on aqueous extraction of the yeast, the yield being greatest when the extraction is carried out at 35°C in a slightly alkaline medium. One is a phosphoprotein, the other an albumin, 3 parts of the latter to 1 of the former being present. The phosphoprotein, zymocasein, is insoluble in water, soluble in alkali, and contains 16.15 per cent N and 1.8 per cent P. It is coagulated by rennet. The albumin, cerevisin, is soluble in water and coagulates in stages between 41 and 70 degrees C. It contains 16.35 per cent N and 0.9 per cent sulphur. On hydrolysis the zymocasein of yeast is found to resemble milk casein in N partition and content of histidine, arginine and lysine. The N partition is as follows:

Ammonia N	6.86 per cent
Humic N	4.02 " "
Diamino or basic	26.67 " "
Mono-amino N	60.39 " "

From the basic N fraction the following amino acids were recovered:

Histidine	2.63 per cent
Arginine	3.58 " "
Lysine	4.09 " "

The tryptophane content was 1.51 per cent. The albumin resembles that of peas, differing however, in its lower content in arginine and marked richness in lysine, 8.1 per cent, the highest recorded. Other results of analysis are as follows:

Ammonia N	5.89 per cent
Humic N	1.69 " "
Diamino or basic N ..	23.69 " "
Mono-amino N	67.03 " "
Histidine	2.02 " "
Arginine	4.42 " "

The tryptophane content was likewise the highest recorded, 2.28 per cent. Because of its high tryptophane and lysine content, cerevisin is a valuable nutrient. A dog was kept in N equilibrium for 6 days with cerevisin as the sole source of N.

A number of workers reported that the yeast from breweries and artificial cultures was a good source of nutrients for stock. Schill (1917) stated that about one half of the chemical energy in yeast can be utilized by the animal organism. Voltz (1915) showed that the digestibility and composition of yeast grown on sugar solutions containing mineral matter was about the same as that obtained from breweries. Donhoff (1914) demonstrated that brewery yeast was not only a very digestible food rich in protein but that it was a very practical feed for stock when it could be obtained as cheap as the prevailing market price. Volk (1915) affirmed the work of Donhoff and added that these yeasts when properly prepared could be used occasionally as a substitute for meat.

Windisch (1913) encouraged the use of yeast as a feedstuff. He announced that dry yeast stimulates the appetite, furthers the assimilation of other foodstuffs and displays a marked curative effect upon certain diseases. It may be fed to horses, cattle, pigs, sheep and fowls, and in cows favorably influences the production of milk.

Voltz and Baudrexel (1913) tested the meat producing qualities of yeast compared to meat flour when combined with potato flakes and fed to geese. They found the yeast to be equal at least to the meat flour. Three years later Voltz (1916) asserted that yeast is one of the most digestible of feeding stuffs, produces specific effects in many directions and possesses excellent dietetic properties.

Again in 1916 Voltz (1919) discussing the utilization of yeast by the animal organism told of living yeast cells remaining alive 6.5 hours in the digestive tract of the dog and when excreted with the feces, had lost little of their motive power. After 9.5 hours the greater part of the cells were dead and about half digested. The yeast in feces contained 5 per cent living, 20 per cent "sick" and 75 per cent dead cells. The digestive value of the yeast was correspondingly low, being 53.3 per cent for the organic substance of the yeast and 46.6 per cent of the protein. He concluded that yeast to be of value as food, must not be fed in the living condition; but that this did not exclude, however, the use of living yeast as a therapeutic.

Because of the tremendous industrial development with the resultant growth of the urban population and the constant increase in complexity of food supply and distribution, several workers attempted to show that brewer's yeast was a food satisfactory for human use as well as for livestock. There was considerable controversy over the suitability of these products in the human dietary but perhaps the principal reason for their failure in gaining popularity was their lack of palatability.

Gamger (1908) concluded from his digest of the available data that the use of yeast extracts as substitutes for meat extracts was not only unjustifiable but should be discouraged. His work was challenged, however, by Chapman (1908) who maintained that yeast products were satisfactory substitutes.

Funk, Lyle and McCaskey (1916) affirmed the statements of Gamger somewhat in 1916 when they declared that yeast cannot be recommended as a source of N. It was poorly assimilated and even with 7-8 grams of N in the urine a marked loss occurred. The uric acid content of the blood was markedly increased. The addition of the vitamin to the bread rice diet which contained from 5-8 grams N per day diminished the loss of N a little, but failed to secure N equilibrium.

Voltz and Baudrexel (1911), Serger (1913), Loewy and von der Heide (1915), Schottelius (1915) and Fendler (1909) all stated that yeast was a satisfactory food for man when properly prepared and in some forms reached a very high order of digestibility.

Practically ever since grains have been fed to livestock, oats have been considered as almost essential for horses so it was considerable relief to some of the German horseman when Voltz (1911), Voltz, Paechtner and Baudrexel (1913) and Czadek (1914) showed that yeast could be substituted for about half the oats in the horse ration with very satisfactory results. This meant a very great saving owing to the high price of oats and low price of yeast when calculated on a digestible protein basis.

Rapid fattening in swine was also obtained by feeding dried yeast with a carbohydrate such as potato flakes as was shown by an unsigned article in the Wochenschrift für Brauerie in Berlin (1910). Voltz (1911a, 1912, 1913) and Klein (1915) showed that swine made more rapid gains when yeast was included as the protein feed than with any other feed combination used in common practice.

They concluded that, as a feed for swine, dried yeast was not only highly digestible but a very economic source of digestible nutrients. Honcamp (1920) one of the later workers to test out dried yeast on swine, reported that the crude protein of dried beer yeast was almost completely used by sheep and hogs. The hogs showed a superiority in the case of the N free extractives. With yeast sediment, however, the digestibility in all cases was greater with sheep than with the hogs. The dried yeast can be fed with good results to all animals used for meat and is especially suited for the raising and fattening of swine.

Ruminants too were fed very satisfactorily with dried yeast according to the reports of English and German workers although the striking results obtained by some would seem to indicate that the animals used had been improperly nourished before the experiment or else the control animals were fed improperly. Paechtner (1912) wrote that cows which were fed 15-20 liters of boiled yeast per day gave larger amounts of milk with a 20 per cent increase in fat, the fat having increased from 3.2 to 4.1 per cent. These feeding experiments show that cows can be fed large quantities of fresh boiled yeast as permanent diet and as a consequence a larger quantity and more desirable milk is obtained.

Voltz, Dietrich and Deutchland (1914) fed sheep dried yeast combined with peat meal, charcoal and with straw; they found that peat meal was to be avoided for feeding purposes and that straw was not only an excellent carrier for the yeast but that the combination made a very good feeding stuff.

Publishing again in 1920, Voltz, discussing the relative merits of brewery and "inorganic" yeasts, said that in the experiments run on dogs and sheep the nutrient yeast from breweries was somewhat more digestible and assimilable than the so-called "inorganic yeast."

Crowther, (1915) after carrying on extensive experiments in England with yeast feeding stuffs, described dried yeast as a material of powdery flakey consistency, varying in color from light to medium brown. It has an agreeable amell but a rather bitter taste, arising presumably from the presence of hop residue with which the yeast is contaminated; it is disliked by cows but it is not objected to by pigs and calves. The average composition was:

Moisture	4.3	per cent
Protein	48.5	" "
Fiber	0.5	" "
Fat	0.5	" "
Ash	10.7	" "
Soluble carbohydrates	35.5	" "

He continued: from feeding trials at Garforth, it appears that dried yeast is a desirable feed for cows if they can be induced to eat it; but it is thought that, until some means of depriving it of its bitter taste has been devised, dried yeast will never come into general use as feed for cows. In trials with 12 weeks old pigs fed 15 weeks, dried yeast proved to be good feed, giving better results than those obtained with an equal weight of middlings. It proved to be a safe feed for calves, although no tests were made of its comparative feeding value. It is said that dried yeast keeps well on being mixed with other meals and water and may be kept for some time without objectionable fermentation. It is not thought that it possesses any special medicinal or dietetic virtues other than those to be expected in any highly digestible feed rich in protein.

Crowther publishing again with Woodman (1917) described a yeast feed with the following combination:

Water	11.70	per cent	
Crude protein	32.45	" "	(true protein 27.54 per cent)
Ether extract	0.41	" "	
N free extractives	45.43	" "	
Crude fiber	1.94	" "	
Ash	8.07	" "	

Feeding this to sheep led them to conclude that, as a food for ruminants, it possessed a very high order of digestibility.

4. Summary

The tremendous quantities of material turned out as waste from breweries and distilleries presented an opportunity for a great saving to the plants able to find a means of disposal which would compensate for the transport at least of the waste. This of course led to a considerable amount of experimental work being done in an attempt to find an outlet. After a number of trials, the feeding of livestock seemed to offer the best solution, therefore, much was done not only to make the yeast satisfactory for feed but to demonstrate its nutritional and economical advantages to the livestock growers. It would appear that, when this had been done to some extent, some companies wanted to go even farther. They endeavored to make certain classes of livestock owners believe that yeast feeds were far more satisfactory than many of the natural feeds because of some special dietetic and medicinal qualities.

The literature would seem to indicate that with all the work which has been done, surely some one would have observed bad features in yeast feeding if there were any. The experiments have shown in general that dried yeast is a suitable feed for cattle and when used as a highly digestible protein supplement can be used with advantage as a feed for the several classes of domestic animals.

III. YEAST IN RELATION TO GROWTH

The age of attempts by natural scientists to determine the cause and nature of growth would have to be measured in centuries. Growth with all the changes it includes has been a most fascinating study for all workers interested in both plant and animal welfare. But still, we know practically nothing of a definite, proven character about the fundamental causes underlying the growth mysteries. Mendel (1914) stated, "It is surprising that in comparison with other topics of physiological study so little has been published in the past about growth, and much of what has been written invades the domain of hypothesis and speculation. Together with inheritance, growth provides for the permanence of the various external manifestations of life. The problems of Agriculture -- the production of the plant products from the soil and animal husbandry -- are based upon considerations of growth. I need scarcely add that it would be of immense direct importance to man and to medicine to know more about the 'regulatory power which presides over growth', so that we might derive more practical applications of the discoveries in this field. In ultimate analysis all of our material prosperity, indeed, the very possibility of the maintenance of the race depends upon the manifestation of growth. He continues (1914e) "It is almost impossible to review the salient features of the physiology of growth without directing attention to the obvious gaps in our knowledge thereof. Problems await us at every turn -- some of them clearly defined and open to experimental investigation, others obscured in the haze of conflicting data or complicated by the manifold factors which enter into the questions of development."

1. Definitions of growth.

The term growth is rather a vague one as no one has yet formulated a definition which would include all the features which are indicated by the manifestations of growth. Mendel (1914) gives expression to the peculiar looseness which has characterized the use of the word: "What is growth? One cannot penetrate far into the literature of the subject without meeting with a bewildering confusion in the significance of the terms. The most general definition of growth is 'increase in volume' or 'increase in size' (Huxley). It has been pointed out, however, that increase in volume does not always serve as an index to organic growth; for the increase may be merely due to swelling. Sachs defined growth as an increase in volume accompanied by a change in form. No universally acceptable definition has been framed; nor is it likely that one can consider all of the manifold features of growth in a single category. What is needed today is less of theory and more of facts upon which to build a more substantial conception of growth and formulate its fixed characteristics in words." He then went on (1914d) "With this prefatory statement growth may be defined as the resultant of an inherent growth impulse -- an internal factor, and a suitable environment the latter including the food supply -- an external factor. In these are concerned certain typical biological forces, the metabolism of matter and energy, as well as certain physico-chemical reactions. The conditions determining growth are mainly resident in the cells."

Armsby (1917) stated that in general growth consisted of "an increase of the structural elements of the body, chiefly by cell multiplication, resulting in a gain in size and weight."

To this Mumford adds, "From the fertilization of the egg until the full development of the mature individual, the animal increases in volume and changes in form, and this increase and change of form is called growth."

2. Theories of growth.

As stated above by Mendel (1914) much concerning the theory of growth invades the domain of hypothesis and speculation. Various speculations and theories of the nature and impulse of growth have been, like the definitions, almost as numerous as the writers. It seems to be universally accepted that the animal organism is born with an impulse to grow which gradually decreases as differentiation takes place or as age increases. Just exactly what this impulse consists of, and how it may be affected is still a matter of opinion. Some believe it lies in the nucleus of the cell; some maintain that it is a chemical matter resting entirely in the secretions of the endocrine glands; while still others suggest that it is all a result of the presence of growth-promoting substances in the diet.

Mendel (1915) put it in general form, "Growth receives its impulse from two sources, namely, (1) the internal factor, of which the inherent growth factor is an example, and (2) the external factor, which involves environment and food supply."

Minot (1907), after writing of the growth impulse as an inherent one, stated, "The growth and differentiation of the protoplasm are the cause of the loss of the power of growth." Then, after exhaustive studies of the growth rate, he (1908) estimated that over 98 per cent of the original power to grow in the rabbit and the chick has been lost at the time of birth or hatching and that a similar fact is equally true of man."

Kellicott (1910) stated his beliefs, "In many cases certain parts or tissues such as the mammary glands grow independently of the rest of the organism and their growth is regulated or caused by specific secretions or hormones. It seems quite likely, therefore, that in the organism, in general, the normal growth of each tissue or even each organ is controlled separately by a specific internal secretion. These substances may regulate growth either through inhibition or acceleration and the effect produced may be due either to the presence or the withdrawal of the specific substance."

Robertson (1916) thought that, "growth of man and animals consists of a number of phases or growth cycles which succeed one another, and to some extent merge into one another at the transitional period. These transitional periods are critical periods in the growth of the animal, and if for any reason accurate linkage with the succeeding cycle fails, the life of the animal or individual is imperiled. Each cycle of growth is characterized by an initial period of slow growth succeeded by a period of rapid growth, and that in turn by a period of slow growth." He suggested that these periods were controlled by the glands of internal secretion including the pituitary body, the thyroid and the thymus, and he supposedly isolated the growth controlling substance from the anterior lobe of the pituitary which he called "tethelin."

The "tethelin theory", however, has been attacked by Drummond and Cannan (1922) who deny that tethelin is a definite compound and class it as an impure mixture of substances of the lipoid class. They failed to find any influence upon the growth of mice by the oral administration of anterior lobe of the pituitary gland.

The various methods of attempting to correlate the growth of the different parts of the body in the endeavor to work out the nature of growth, are as numerous as investigators and would be inappropriate here except a mention of one prognostication on the future of such work by Thompson (1917), "-- simple dynamical considerations provide adequate interpretation of the growth and conformation of animals and plants .... It is not the biologist with an inkling for mathematics, but the skilled and learned mathematician who must ultimately deal with such problems."

3. Nutrition and growth.

The growing period has generally been considered to be a very critical period in the life of the animal because of the needs being so great compared with the maintenance requirements for the same weight of mature animal. To allow heredity to have full play in determining the upper limits of size the animal must be properly and fully nourished. To be fully nourished means not in energy alone, nor in protein alone, but fully in all the several required classes of nutrients for the growing animal. The importance of nutrition is intimated by Mendel (1914f), "Important economic considerations are involved in the ability to modify growth or accomplish it at lessened expense -- a possibility for which nutritive factors offer the only probable opportunity at present. Hence arises the practical importance of some of the problems in this field. Broadly put, one problem reads: How can inefficient native foods be made efficient, and what is the relative economy of different dietaries and adjuvants?"

Flint (1911) seemed to think that the only safe method of giving the growing animal sufficient food was to feed it heavily because, he concluded from his experiments, no single feeding standard would meet the requirements of all growing animals.

McCollum and Simmonds (1918a) laid down a few simple rules regarding nutrition and growth failures:

1. The young animal cannot grow when limited to a single seed or mixture of seeds as its sole source of nutriment with no accidental supply of mineral salts in the drinking water.
2. Young animals cannot grow when fed a single seed or mixture of seeds even though the latter is supplemented with purified protein and a fat

containing fat soluble A vitamin. The inorganic content is the first limiting factor and sodium chloride and calcium must be added before growth becomes possible.

3. The proteins of seeds and their content of fat soluble A, as well as all other dietary factors, are of such a value as will permit young animals to grow for a considerable time and remain in apparent good health when the diet consists of one or more seeds, supplemented with the necessary inorganic salts. On such a diet faulty nutrition is first observed only after the lapse of considerable time.

There is little danger of the animal being under nourished if it is supplied with sufficient amounts of necessary nutrients according to Lusk: "It is noteworthy that the appetite determines the regular ingestion of sufficient energy for the life processes, plus a small but fixed extra percentage necessary for growth. Strictly formulated, this law of growth is that in the development of the normal young of the same age and species a definite percentage of the energy content of the feed is retained for growth irrespective of the size of the individual.

Just as McCollum and Simmonds (1918a) showed that minerals were necessary; and numerous others that vitamins A and B were necessary, likewise Osborne and Mendel (1914) showed that certain amino acids, lacking in some foods, were necessary for growth. These were tryptophane, tyrosine, lysine and cystine.

Important as nutrition may be, the impulse to grow seems even stronger at times for the skeleton persists in growing to some extent even when an animal is provided with an inadequate food supply. Aron (1910) concluded from his experiments with a low plane of nutrition that the force which he calls "growth tendency" is more noticeable in the skeleton than in other parts of the body. If an animal fasts, the skeleton grows at the expense of the rest of the body, the fatty tissues being the first and the other organs later, since the more important organs are always the more resistant. In his opinion the force which induces growth is resident in the skeletal framework, the muscular tissue possessing apparently no specific "growth tendency", but, perhaps owing to mechanical forces, following the skeleton in its growth providing the nutrition is sufficient to permit it. His view in regard to the growth impulse being stronger in the skeleton than in the rest of the body was supported by Eckles (1918), McCrudden (1912) and Mendel and Judson (1916).

That the ration has a greater effect on the growth of the body other than the skeleton was observed by Eckles (1918) "a difference in rations fed that resulted in a variation of 46 per cent in gain in weight between two groups resulted in a difference of only 7 per cent in the growth of the skeleton." He continues, "The amount of digestible nutrients consumed during the growth period has some effect upon the rate of growth of the skeleton, but the relation to weight is much more pronounced. A ration supplying a large amount of readily digestible nutrients increases the rate of growth especially in weight; hastens the time of maturity; and allows the animal to develop to the full limit of inheritance. The animal which receives less nutrients in its ration during the growing period is thinner in flesh; and if the plane of nutrition is decidedly lower, the rate of skeletal growth is also slower, the growth period is somewhat prolonged; and the tendency is for the animal at maturity to be smaller than the ones raised on a liberal ration. There is a strong tendency for animals to recover from retarded growth if conditions are favorable later. This may be accomplished by a more rapid rate of growth or by prolonging the period of growth. If the retardation, especially in skeletal growth has gone too far the animals will not, however, reach normal size." In determining the effect of the ration on dairy qualities of the cows he (1915) also noted that it is possible to influence the rate of growth, size when mature and type to some extent, by the liberality of the ration during the growing period.

4. Stimulation of growth rate.

Since the summer pasture season on the farms is so short it is of paramount importance that the raiser of livestock for market should be able to grow his young stock to a marketable age as soon as possible with the minimum amount of winter feeding. It is obvious that, if some method were known whereby animals could be made to make their growth in less time, the saving in labor and in energy that is lost in the form of heat from the exterior of the body would be tremendous. Naturally then, investigators have tried a multitude of feeding schemes to stimulate the rate of animal growth. The evidence as to their findings is slightly contradictory in some respects but in general their results have been discouraging to the breeder who had hoped to induce more rapid growth in his stock than he had been able to obtain before with liberal feeding.

Liberal feeding as stated above by Eckles (1915), would be expected to induce more rapid growth than poor feeding, especially when the animals' needs for growth were not being met in the ration. But, beyond that, the evidence does not seem to indicate that any great increase in the growth rate has as yet been reported.

Mendel (1914b) concluded from his observations that not only was the upper limit of size determined by inheritance but that the rate of growth was a very definite one: "When the statistics derived from periodic measurements of the continuous changes going on in young animals are expressed in graphic form, the so-called curves of growth are obtained. The fixity of the growth curve for the different species and, in so far as this point has been studied, of the sexes in each species is perhaps the most remarkable phenomenon of growth. We are aware of no conditions compatible with life in which the general character of the growth curve with its acceleration during adolescence can be altered. Minor variations, however, may arise. Variations in the growth of different individuals are for the most part inborn -- inherited fundamental characteristics of the individual. We know of no method or means of altering the peculiarities of growth.

Nutrition, which is often looked upon as a controling factor, can do no more than give free scope to the inherent tendency to grow". Mendel(1914c) continues: "Experience shows that there is a fairly definite upper limit in size which the individuals of any species rarely exceed. There are forms for which the variations may be very wide; and it is reported that some of the lower forms, e.g., actinians can be caused by suitable feeding to reach a colossal size far beyond that which they ordinarily attain in nature. To the mammalian species with which we are primarily concerned here, however, this does not apply except in the limited degree determined by heredity. Why the body size is thus fixed is not known. The fact of its invariable character makes it possible to apply quantitative methods to the study of growth with some confidence in the consequences which are to be expected from any normal procedure, and with some appreciation of the standard to which proper growth should conform and by which all deviations are to be measured."

Reed (1920) noted that from his studies of a large number of growth measurements, that growth proceeds by a regular mathematical formula.

There is ample evidence in support of the statement made by Osborne and Mendel (1914a) that rats, after being stunted from the ingestion of insufficient amounts of energy or of proper proteins or other factors either accidentally or by intention in the laboratory would resume growth when fed a normal ration.

Eckles (1918) observed a like tendency in dairy heifers.

In the same paper Osborne and Mendel (1914a) stated that: "It appears that the capacity to grow is only lost by exercise of this fundamental property of animal organisms." This was not substantiated by Eckles in the above quoted writing where he observed that if the stunting, especially of the skeleton, had gone too far that normal size would never be reached.

They (Osborne and Mendel 1915) observed further that the size or age at which the stunting took place does not alter the capacity to resume growth. Such stunting does not necessarily cause the loss of the procreative functions.

Again, working with the assistance of Ferry and Wakeman (1916) on a large number of albino rats they concluded, "after periods of suppression of growth even without loss of body weight, growth may proceed at an exaggerated rate for a considerable period. This may be regarded as something apart from the rapid gains of weight in the repair or recuperation of tissue actually lost. Despite failure to grow for some time, the average normal size may thus be regained before the usual period of growth is ended.

That there is some possibility of the rate of growth being stimulated by internal secretions was intimated by Loeb (1915): "In the body, cells may be at rest or growing, and we do not know whether the conditions which determine rest are identical with those determining rest in the egg. We know, however, that specific substances circulating in the blood can induce certain resting cells in the body to grow and that these substances differ apparently for different types of cells. It may be that, in the body, substances antagonistic to these may enforce the inactivity of the cells. And finally, we come to the conclusion that the circulation in animals or the flow of substances in plants is an important factor in the phenomena of cell rest and cell growth, inasmuch as circulation or flow determines or influences the distribution of formed cells or non-formed elements which induce or influence growth."

Maxwell (1916) thought administration of extracts of the ductless glands might affect the growth rate. This idea was also supported by Robertson (1916a) who observed that pituitary feeding acted as a retarding agency during the earlier cycles of growth but later acted as a stimulant and that the pituitary fed mice, though smaller in size than normals of the same age, were heavier.

As stated before, however, Drummond and Cannan (1922) reported experiments which failed to point to any influence upon the growth of mice by oral administration of anterior lobe of the pituitary gland.

5. Vitamin B and growth.

Vitamin B is often, and perhaps rightly called the "growth-promoting vitamin or accessory". Ever since Funk (1916) showed that the addition of yeast to the diet would stimulate growth in rats, numerous investigators affirmed the use of sources of water-soluble B vitamin as a growth promoter, in fact, the basal rations in all growth experiments, except where the tests are for the determination of B, contain preparations known to be rich in B vitamin. Without an ample supply in the diet almost all animals have shown sub-normal growth curves.

Uhlman (1918) suggested from the results from his experiments with "orypan", a commercial vitamin preparation from rice, that vitamins acted as growth-stimulators by stimulating the digestive glands.

Hawk, Fishback and Bergeim (1919) obtained a pronounced increase in growth in rats when 5 per cent of compressed yeast was added to the ration.

MacDougal (1921) in an attempt to find a relation between vitamins and biocolloidal phenomena, noted that mature fruits, pith and joints of Opuntia show excessive swelling in vitamin solution. Lessened hydration ensued in young tuber potatoes and roots of corn but increased hydration took place in root tips of orange seedlings and of strawberry plants. From this, one might think it barely possible that the vitamins worked as stimulators to cell metabolism by affecting the surface phenomena in such a way that the cell absorbed more liquids and thus more nutriment.

Sherman and Smith (1922c), after reviewing the whole field of work done on vitamin B, state that absence of B from the diet causes cessation of growth; that a partial but not complete deficiency in this vitamin leads to imparied growth and a general undermining of health and vigor; and this lowered vitality may have a far-reaching effect in its influence on reproduction and successful rearing of the young.

6. Summary.

It would appear that in spite of what has been said and written about growth, no satisfactory definition has yet been made which would include the several phases of growth and still be definite enough so that the term could be used universally. It is generally understood, in the common sense, however, to mean increase in size and weight.

Much as we know of the nature of the external manifestations of growth, we still know little if anything of the causative agencies of growth. We do know that it appears to be fixed in its upper limit by inheritance and proceeds when the environment including food is suitable, to reach that limit by a definite rate. The activity of certain glands of internal secretion seem to be related to the different growth cycles but just how and by what means is as yet unknown.

Nutrition is the one means of controlling growth, because the organism must have its needs supplied or else growth will be retarded or stopped altogether. The effect of faulty nutrition is noticed in the retardation of increase in body weight more than in skeletal growth. Satisfactory nutrition is necessary, however, for the organism to reach the limits inheritance has placed upon its size. The fundamental requirements of growth are known and consist of a sufficient supply of energy and proper proteins; proper proportion of carbohydrate, fat and protein; a sufficient supply of certain inorganic elements; and, three, at least of the so-called vitamins.

It seems that as yet no means are known that will stimulate growth beyond the rate with which it proceeds when the organism is supplied with the known nutritional needs.

Vitamin B is essential in growth and when deficient will cause troubles ranging in proportion to the deficiency, all the way from impairedgrowth and vigor up to complete loss of growth and ultimate death. It appears that when the diet contains what is known as an adequate supply of vitamin B, which is generally contained in the ordinary ration of mixed fresh foods, an addition of an extra amount of substances rich in B will not have any effect on growth. If, however, the ration does not contain an adequate supply of this factor, then there will be pronounced favorable effects on growth with its addition. Yeast has appeared to be a good source of this vitamin and its addition to many diets, deficient in B, has been followed with remarkable increases in the rate of growth.

IV. YEAST IN RELATION TO HEALTH

Health is defined as "Soundness of body; that condition of a living organism and of its various parts and functions which conduces to efficient and prolonged life; a normal bodily condition. Health implies also, physiologically, the ability to produce offspring fitted to live long and to perform efficiently the ordinary functions of their species." (Century Dictionary, 1897). It is in this broad conception of health that nutrition and clinical workers consider various means of preserving and recovering health.

1. Nutrition and health.

We are interested then in work which will intimate that there is some relation between yeast and (1) preservation of health, and (2) the regaining of lost health. Even though our natural foods when properly combined are rich in all the essentials of a diet to preserve good health, there is grave danger at times that the diet of both man and animal be deficient in some one or more dietary factors to the extent that general health be impaired. McCollum (1922) after considering a number of characteristic diets used by man in Newfoundland and Laborador points out this danger: "The specimen diets which are given above have another meaning aside from that just discussed. They show that on any of these diets a man would not suffer from a single deficiency, but from several, and that where scurvy was observed it seems evident that there must have been likewise a serious shortage of the antineuritic substance, and consequently a tendency for symptoms of neuritis to develop. Furthermore, the diets listed are all decidedly deficient in one or more of the inorganic elements, notably calcium. In these diets poor in meat there was likewise a serious shortage of phosphorus as measured by the requirements of the rat.

"It seems extremely probable, therefore, that in many instances where one of the diseases, beriberi or scurvy, is diagnosed, the other exists as a complicating condition. This would account for the points of similarity in the manifestations of the two diseases as they have been described by several investigators. It also raises the question as to whether specific effects of lack of the antiscorbutic substance or of the antineuritic substance, the remaining components of the diet being of optimal quality, can be said to be fully known, at least in the human subject.

"It should be emphasized, finally, that the addition to such a diet as is ordinarily observed in the Orient to produce beriberi, of some article of food which will prevent the development of beriberi, will in many cases not go far toward correcting the inorganic faults. From the standpoint of public health, therefore, it is by no means sufficient to prevent beriberi in these countries where it occurs. This may be effectually accomplished, and yet the population may still be inefficient physically, and suffer from a very high infant mortality because of the poor quality of the mother's milk, and the adult members of the population may still early develop signs of senility. These statements are made on the basis of the assumption that the same physiological limitations with respect to nutrition, which apply to animals apply with equal force to man, and that these run parallel when the comparison of an animal with man on the same diet is made on experiments covering equivalent fractions of the average span of life of which each is capable.

"The data presented in this chapter, relative to the character of diets of several groups of people in relation to the types of nutrition disaster

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which overtook them, serve well the purpose of illustrating the soundness of the proposition which is emphasized throughout this study of the relation of man's diet to physical well-being, viz.: the danger of health in the adherence to a diet in which milled cereal products, sugar, syrup, tubers and meats of the muscle type predominate. Such a diet is unsafe to a degree which makes it a matter of national importance.

"It is especially important that the public be educated to realization of the danger of poor physical development, poor teeth, low health standards, physical inefficiency and early aging which such a type of diet is sure to bring about. The alarming increase in the incidence of malnutrition among children, and the need for dental repair, together with the train of ills from which the present generation of adults is suffering, and which may be safely traced to a faulty development and bad teeth, are in a great measure the result of the poor quality of the diet of the expectant and nursing mothers and of children. It will be apparent from what has been said, that it has become the general custom in many parts of America and Europe, to adhere to a diet which is but little better than those which in restricted areas are actually producing clinically recognized diseased conditions. General observations should convince anyone that we are now, as a nation, falling far short of the physical perfection which would result from an improved dietary.

"The observations of McCarrison afford very suggestive evidence that nutritive disturbances referable to faulty digestion with their far-reaching consequences for the health of the individual, are to be referred to borderline malnutrition brought about by food which does not meet the nutritive needs of the body. Our present living habits are characterized by too great consumption of bolted flour, degerminated cornmeal, breakfast cereals, and other seed products, tubers and muscle meats. We are taking too little of the protective foods, milk and leafy vegetables, and a movement toward stimulating the consumption of these classes of foods, would go far toward effecting the improvement in our national health standards, for which the many agencies concerned with the public health are seeking.

That yeast may have some favorable effect on the general health is indicated by the work of Hawk, Smith and Holder (1919) who worked on the problem of yeast as a protein source in the human diet. They reported that Baker's yeast can replace 9-29 per cent of the protein in the diet of a man without detriment to the best nutritive interests of the individual and that utilization of food, retention of the protein, maintenance of body weight and general condition of health point favorably to the use of yeast as a human food.

Renshaw (1921) believed that yeast in some way increased the utilization of food, stating that mice, when brought to approximate weight equilibrium on a diet of casein, starch, lard, butter, salts and 1 per cent of yeast, gain appreciably in weight when kept for approximately the same time on the same ration with 3-5 per cent of yeast, the starch and casein being changed to maintain the same calorific value. Some would interpret this to mean that the animal was suffering from a deficiency of growth-promoting factors. This might of course be true but the fact that the work was carried on with a great degree of accuracy would indicate the food was used more efficiently when the per cent of yeast was increased.

The importance of the amount of yeast in bakery products should not be overlooked according to Hawk, Smith and Bergeim (1921). They found that "standard" bread containing about 10 per cent of the total protein in the form of milk proteins was inadequate for the support of normal growth in white rats but that the addition of 5 per cent of yeast powder gave a much more efficient ration.

Publishing again the same year (1921a) they reported that rats receiving a diet of milk and yeast made more growth than did rats receiving milk alone. As milk had been shown to be low in water-soluble B vitamin while yeast has a very high concentration, they suggest that yeast may be a very important addition to the diet of infants.

Mooser (1915) believing yeast to be a very valuable adjuvant to the diet for improving general vigor and health attributed the medical value to its content of nucleins and lecithin.

Winckel (1915) and Piccoli (1912) noted that yeast had a faverable effect on certain digestive enzymes, the former asserting that it accelerated diastase and pancreatin while the latter demonstrated that beer yeast increased peptic digestion.

2. Yeast therapy.

Ever since the discovery by Cooper and Funk (1911) that yeast contained the substance which would cure and prevent experimental beriberi there have been repeated affirmations of this fact until practically every student of vitamin or deficiency disease nutrition has produced the striking symptoms of avian polyneuritis and then cured them by addition of small amounts of yeast extracts. Such work as that of Edie, Moore, Simpson and Webster (1913) and of Simonnet (1921) are only examples of a great number of experiments which have shown quite definitely that experimental beriberi can be both prevented and cured by addition of yeast to a diet complete in every respect except the presence of B vitamin.

It is the use of yeast in therapeutics in the clinical sense, however, that we are now interested. By this we mean, especially, evidence which will show that yeast may be used to build up certain immunities or resistance against bacterial invasion or actually cure cases where bacterial infection has taken place.

Yeast has been used for centuries with the supposition that it contained some sort of curative properties in many diseases. Hedrich (1904), Krause (1904) and Lardier (1901) discussed the use of yeast in therapeutics at length citing many isolated reports which were not based on definite experimental data but rather on the individual observations by practitioners. Most of the cases reported claim to have obtained some benefit in cases of certain skin afflictions but a few have claimed to have derived benefits in almost every kind of disorder that has yet invaded the health of mankind.

Walzon and Sacharow (1909) investigated the use of yeast in staphylococcus and streptococcus infections and concluded that the use of beer yeast raises the opsonic index in the above mentioned conditions, and that the repeated use of yeast preparations confers a greater resistance against infection by pus-producing organisms.

Hawk, Knowles, Rehfuss and Clarke with others (1917) made the most thorough single study on the action of yeast in therapeutics and reported as follows: "That yeast possesses curative properties was appreciated in the olden times. Hippocrates recommended its use in leukorrhea, and the monks used it for the treatment of the plague. Not until the middle of the nineteenth century, however, did the medical profession look favorably to its use. About that time, it was used successfully in furunculosis, anthrax and diabetes. Later it was shown to be effective in diseases of the skin, suppurative processes, diseases of the respiratory passages, gastro-intestinal diseases, vaginitis, general infectious diseases, etc. In fact, for an interval of many years, yeast was used as curative agent in a long list of widely differing disorders. Then came a reaction and yeast was used comparatively little by the medical profession during the latter part of the nineteenth century.

"In 1899 the researches of Bracq emphasized anew the therapeutic importance of yeast, and from 1900 to 1907 many important contributions were made to the subject of yeast therapy. For the last ten years, however, comparatively little attention has been paid to the use of yeast in medicine.

"Owing to the fact that the great majority of the yeast researches have been carried out with brewer's yeast or various dried yeast preparations and since several investigators have asserted that baker's yeast was not a satisfactory therapeutic agent, we have thought it of importance to make a comprehensive study of the curative value of ordinary baker's yeast, since that is the most available kind. In all of our tests we used Fleischmann's Compressed Yeast, as that is the best known and most widely used of baker's yeasts. The fresh yeast was used in all cases, a new supply being secured two or three times a week and kept in refrigerator until used, with the following results:

Condition	Number of cases	Number improved or cured
Furunculosis	17	16
Acne	17	17
Acne rosacea	8	8
Constipation	10	9
Gastro-intestinal catarrh	3	3
Intestinal intoxication	1	1
Eczema	5	0
Arthritis deformans	1	1
Psoriasis	4	1
Erythema and urticaria	1	1
Bronchitis	2	2
Urethritis	2	2
Pruritis	1	1
Folliculitis	1	1
Conjunctivitis	1	1
Duodenal ulcer	1	1
Swollen glands	1	1
Total	76	66

The list of diseases above shows at a glance the wide variety of diseases for which yeast has been used. Hawk and his co-workers concluded: Baker's yeast was found to be a useful remedy in the treatment of furunculosis, acne vulgaris, acne rosacea, constipation and in certain other cutaneous and gastro- intestinal conditions. "We consider that yeast is fully as successful as any other remedy in furunculosis, acne vulgaris, and acne rosacea. In many cases which came under our observation, the yeast treatment caused an improvement in the general physical condition of the patient quite unassociated with the improvement of the symptoms associated with the particular disease in question."

But even though a great many claims have been made in favor of yeast for certain diseased conditions there have also been many denials of benefits to be derived from yeast as a therapeutic. These contradictions range all the way from failure to notice any favorable effect up to assertions that the yeast itself caused ill effects.

Hess (1917) thought that there might be some help for infantile scurvy in yeast feeding because of the clinical similarity that existed between beriberi and scurvy, but he demonstrated that yeast had no value at all in the curing or prevention of scurvy. Ladd (1921) also tried yeast in infant feeding with the hope of securing greater gains and higher resistance against skin diseases but reported: "In only two out of ten cases was there an increased rate of gain when yeast was incorporated in the infant food, and in these, other factors in the feeding probably accounted for the difference. In the other eight cases, the yeast was apparently inert, with the one exception that when given raw, it produced a definite fermental diarrhea. There was no clinical evidence that the general condition or appetite of the babies were better during periods when the yeast was given as one of her experimental babies contracted furunculosis from another in spite of the yeast, she suggests that there is a danger of depending on vitamin sources too much for maintaining the health of the infant while the other factors in proper nutrition are slighted.

A number of workers especially during the war period when the food problem was acute in all sections of the world, suggested that yeast be used as a partial substitute for meat in the diet. Salomon (1916) showed that yeast increased the uric acid excretion, observing that 10 grams of yeast caused the same increase that was caused by 100 grams of meat so advises that patients with gout or uric acid stones should not be given yeast.

Fernbach (1909) and Hayduck (1910), though differing in regard to the properties of the substances, found that yeasts elaborate materials in their cultures which act poisonously and hinder their growth. Whether these yeast poisons would have any deleterious effects on man or animals was not studied.

In an attempt to answer charges that certain common yeasts were pathogenic, Katherine Golden (1896) found that the common yeasts she used were not harmful to rabbits and guinea pigs either when fed or injected subcutaneously; that many of them readily passed through the intestinal tract without being destroyed; and that most of those introduced into the circulation were destroyed in a few days.

Groover, (1916) found, however, that a number of throat infections were caused by certain varieties of yeasts and suggests that a careful study should be made of these organisms in regard to pathogenicity and when a pathogenic type was discovered that it should be completely described and classified to avoid confusion and danger.

Yeast therapy hasnot been confined to human diseases, but has been used also for animals. In 1905 Mitrowitch,in Germany,examined a patent yeast preparation called"Furonculine" which was used in treatment of certain animal diseases. He reported that a number of bacilli and streptococci were obtained from the substance and that the material proved to be pathogenic for mice and rabbits after administration by the intra-peritoneal or subcutaneous methods. He also stated that in his practice a number of cases of animal diseases have occurred in which he tried "furonculine" without any satisfactory results. The remedy appeared to have no beneficial effect in the treatment of rabbits artifically inoculated with streptococci and among 26 horses treated for contagious coryza one died of pyemia, while the majority of the rest had to be treated by surgical methods.

Wolf and Lewis (1919) announced their results as follows: With a view to a possible explanation of the therapeutic value claimed for yeast in infectious diseases, the effect of the feeding of yeast on the production of antibodies to sheep blood cells in rabbits was studied. From the results obtained it seemed that yeast does not act by increasing antibody formation in the rabbit. On the contrary, it may even cause a reduction in the amount of antibodies formed as compared with those of the control animals. Yeast was also found to be lacking in laxative value.

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3. Vitamin B and the endocrine glands.

Owing to the fact that the changes in the endocrine glandsare so marked following a deficiency in B vitamin many investigators have thought that this vitamin was related particularly to the development and activity of these glands. While the work of McCarrison (1919a) showed the extent to which the endocrines might be impaired from a deficiency, the work of Dutcher and Wilkins (1921) in producing growth in atrophied testes of cockerels, which have been on a rice diet, by the addition of alfalfa showed the advantages to certain endocrines of adding B vitamin. In this latter case the birds gained in weight for some time on the rice diet but their testes atrophied and were induced to increase again in weight by the addition of a small amount of alfalfa.

Such results together with a few experiments of his own on "orypan", led Uhlman (1919) to announce that the vitamins should be considered as regulators of tone throughout the body.

Garssini and Mancine (1921) in summing up the pathogenic and therapeutic relationships of the vitamins, expressed their belief that the physiological role of the vitamins is to regulate the trophic exchanges in synergic connection with the trophic regulatory function of the products of the glands of internal secretion.

Voegtlin and Meyers (1920) thought their work showed a similarity between vitamin B and secretin close enough to suggest that they might be the same. They asserted that the antineuritic vitamin from yeast stimulated pancreatic and biliary flow in the dog.

After trying to repeat the work of Voegtlin and Meyers as far as demonstrating the identity of B vitamin and secretin, Anrep and Drummond (1921) declared that yeast extract does not cause secretion of pancreatic juice as does secretin. Furthermore, secretin can be extracted from the intestinal tract of a cat that is showing the so-called polyneuritic condition to a very marked degree.

They also called attention to the fact that vitamin B has a powerfully curative effect on polyneuritic animals when given by the mouth, whereas secretin has no action on the secretion of pancreatic juice when so administered. They conclude that the suggestion of Voegtlin and Meyers that vitamin B and secretin are identical could not be supported.

The work of Downs and Eddy (1921) likewise failed to support that of Voegtlin and Meyers.

Cowgill and Mendel (1921) have probably done the most thorough work on the relation of vitamin B to the secretion of the digestive glands and they conclude: "There is no direct relation between vitamin B and the secretory function of the pancreas, liver and salivary glands. The hypothesis that vitamin B functions to stimulate these glands to secretion is not supported by the experimental results obtained in this investigation."

The relation of vitamin B to reproduction and lactation, in some way, at least, has been suggested by Sherman and Smith (1922a) after their complete review of the data: "It is however, at least suggested by the work of McCarrison and of Drummond, as well as by some unpublished observations upon breeding rats made by one of us, that vitamin B may be an important factor in reproduction and that successful reproduction and lactation may demand a higher concentration of vitamin B in the diet than is needed for the maintenance of health or even for the support of normal growth."

4. <u>Summary</u>. A review of nutritional literature shows that we have an abundance of natural foods which, when properly balanced, will satisfy all the needs of the animal organism. But there are a few regions in which the population is suffering from acute deficiency diseases, some in which a study of the diet will show are in grave danger because of the partial deficiencies. The general trend of the milling industry, with the public clamoring for whiter flour and the mill owners constantly seeking more value from by-products, has led to a milling process which deprives the great cereal eaters of their share of mineral and vitamin

factors. These partial deficiencies are the more serious because their manifestations are not clear cut and do not cause a population so affected to correct them. As a result we have a host of the minor ills that come from loss of general vitality such as poor teeth, with all its attendant troubles, physical inefficiency and early arrival of senility.

Yeast has been shown to be a rich source of protein and cases are reported where it has been used considerably as a substitute for meat without any harmful results. This might offer a solution for furnishing a supply of good protein and B vitamin to regions whose diets are deficient because of economic or war-time conditions. The literature is contradictory, however, as to the benefits to generalhealth from yeast feeding.

Yeast therapy has been practiced to some extent for centuries, principally for certain skin and gastro-intestinal disturbances, but also for a number of other diseases. The evidence, however, is not conclusive either for or against this practice. The published reports seem to be divided on the subject, some claiming that the yeast has given very positive results in several skin disturbances; some suggesting that the yeast may help in some cases but is not to be depended upon; some that the yeast will do no harm but also no good; while still others state that their work has shown definite harm fromthe use of yeast. The author questioned eighty physicians in the city of Minneapolis, including gynecologists, dermatologists, pediatricians and general practitioners concerning the use of yeast therapy, and the replies were divided somewhat as the published reports described above, but only eight of the group asserted that yeast therapy had any recognized position in clinical medicine.

It seems, that,in the face of such conflicting evidence and opinions, yeast therapy must still be considered in the experimental stage until more conclusive data can be presented to substantiate its use.

Investigators have only a very limited knowledge of the endocrine glands and the seemingly very important relationships of their secretions.

It would, therefore, be impossible to state the importance of vitamins to these glands or to their secretions. Some relation seems to exist, however, between vitamin B and the endocrine organs. Rations deficient in B have resulted in very serious atrophy to the endocrine glands with the exception of the adrenals which undergo an enlargement but whose histology presents a degenerative condition. Likewise, when a diet has been deficient in B and the endocrines are atrophied they again grow when B is added to the diet. This would appear to indicate that the growth and development at least of the endocrines is in some way related to the presence of vitamin B in the diet. The evidence is conflicting as far as the effect of vitamin B on the secretory activity of the endocrines.

There also seems to be an indication that there is some relation between the amount of B vitamin in the diet and the animal's reproducing abilities. And it has been suggested that lactation may also require more vitamin B than ordinary needs demand.

The literature appears to be lacking in conclusive evidence of relation between vitamin B and the activity of the endocrines. However, it is so rich in suggestive experimental results that it is possible that the physiologists may in the not too distant future find an intimate relationship existing between the body "hormones" and the vitamins or so-called "food hormones".

V. YEAST IN RELATION TO MILK SECRETION

In reviewing the literature in reference to milk secretion we will be guided by the fact that our interest is more in methods of increasing milk secretion than in the mechanism of the increase. We will, however, mention the theories of milk secretion and some of the views on the effect of the composition of the food on the composition and quantity of the milk.

1. Theories of milk secretion.

Physiologists have tried to explain the secretion of milk for a long time but, aside from the fact that they have more or less disproved some ideas and have determined certain things that effect the secretion, they are a long way from having satisfactorily explained this process. It is generally accepted that the process is a secretion rather than an excretion but this latter view has also been suggested.

Fleishman (1891) thought the whole process was controlled by fat secretion.

Bitting (1901) suggested that milk was a true secretion rather than an excretion because the excretory organs find their material already synthesized in the blood and merely cast them off while the mammary glands synthesize their products from the materials they find in the blood.

Physiologists have differed considerably as to the mechanism of mammary stimulation, that is, whether the stimulation was a chemical one from the reproductive organs, a nervous one from the central nervous system, or both. Basch (1910) showed clearly by his report of the Blazek sisters that it was partly, at least, a process of stimulation from internal secretions. These twins had a common circulation but separate nervous systems; yet pregnancy and parturition in one was followed by a secretion of the mammaryglands of both.

Hammond and Hawk (1916) believed the process of milk secretion was affected by the internal secretions of a number of the endocrine organs. They reported the work of Ott and Scott to the effect that an exciting effect on milk secretion was obtained by injection of extracts of pituitary, pineal, thymus and mammary glands and of corpus luteum; but inhibiting effect from adrenalin, iodothyrin, spleen and pancreas extracts and extract of the ovary minus the corpus luteum.

Mathews (1920) leans somewhat to the same view stating, "It is clear that their (the mammae) development must be stimulated in some way by the ovary. The corpus luteum has the power of giving a marked stimulation to the activity of the mammary glands as do also extracts of the wall of the uterus after parturition while extracts of the foetus have an inhibitory effect."

That the vitamins may also play a part in milk secretion, is intimated by Sherman and Smith (1922a) when they suggest that perhaps a higher level of B vitamin is required for lactation than is required in ordinary life.

2. Milk secretion as affected by the composition of the feed.

There has been almost an unlimited amount of opinion published on this question. From about 1870 down to the present a vast number of experimental feeding trials have been run for the purpose of solving the many problems concerned. Many false claims have been made and many erroneous statements have been broadcast to the extent that people in all sections of the country have gone to considerable inconvenience and expense in order to provide their cows with foods that would produce the right kind of milk. The more recent literature shows, however, that there may be extremely wide variations in the feed without altering the composition of the milk.

Practically all the investigators who have analyzed the character of the milk closely have found that the percentage of certain of the fatty acids in the feed is reflected in the composition of the butterfat, but, beyond this, there is much disagreement and confusion.

Wing and Foord (1900), Ingle (1901), Crowther (1903), Morgan, Berger and Fingerling (1904), Popp (1905), Thiel (1908), Avignet (1910), Vieth (1910), Hofmann and Hansen (1911), Grumme (1913), Hammond (1913), The Journal of Board of Agriculture of London in an editorial (1913), Lanzoni (1913) and others have claimed to be able to affect directly the percentage composition of the milk particularly the per cent of fat. On the other hand, the composition of the feed has little or no effect on the percentage composition of the milk according to Voit (1869) Jordan (1893), Speir (1894), Jordan, Jenter and Fuller (1901), Alleman (1913), Weiser (1914), Lauder and Fagan (1914), Annett (1915) and Taylor and Husband (1922).

It is difficult, indeed to correlate reports so contradictory as these and the difficulty is increased when the reports fail to include the calorific value of the food digested and absorbed. Moreover, when no account has been taken of the probable influence on the percentage composition of a change in the volume of milk secreted daily, except in the case of the fat, the difficulty is further increased.

3. Stimulating the rate of mammary secretion.

Methods of stimulating milk secretion have long been sought for, especially by breeders of purebred dairy stock, in an effort to make milk production records. Almost every imaginable way has been tried and the interpretations of results have been almost as varied as the methods. The feeders of dairy cows on official test have vied with one another in an attempt to locate more mysterious procedure by which they hoped to increase the fat per cent in the milk and also increase the yield over the limited space of time, while the official test was being run. But, as in the reports on the effect of the composition of the feed on the composition of the milk, we find in these reports great divergencies of opinions concerning the value of various substances in stimulating the rate of milk flow. Various drugs, inorganic salts and extracts of endocrine glands have been tried, with some workers reporting positive and others negative results for the same substances.

The cases are common, of course, where the milk flow was decreased by feeding a ration which failed to meet the needs of the cow for maximum production, and where, it is obvious, we would expect to find an increase when a more suitable ration was fed. This possibility that the control ration was either incomplete or insufficient makes much of the work unreliable.

Some of the more common substances reported for increasing milk are as follows: Klutentreter (1894), 80 parts basic phosphate of lime, 2½ parts of albumin, 2½ parts of egg yolk, and 15 parts of powdered sugar; Merkel (1906) fennel; Fingerling (1903) fennel; Fingerling (1907) NaCl; Fingerling (1909) malt sprouts, palm-nut cake and cocoanut cake; Renner (1911) dried brewer's grains; Fingerling (1911) molasses.

4-22-8M

As the physiologists suspected some relation between the reproductive glands and mammary secretion, extracts of some of these glands were also tried. They may be considered somewhat in the same class as drugs so will be included with them. Some of the reports which have received attention are: Lane-Claypon and Starling (1906) extracts of ovary and uterus; Mackenzie (1912) extracts of pituitary body, corpus luteum, pineal body, involuting uterus and the lactating mammary gland; Houssay, Guisti and Maag (1913) pituitrin; Guisti (1913) extracts of hypophysis, corpus luteum, parotid, mammary glands, spleen, lymphatic glands, thyroid, thymus, fetus and uterus; Hill and Simpson (1914) extracts of pituitary gland; Maxwell and Rothera (1915) pituitrin; Hammett and McNeile (1917) dessicated placenta; Hill (1917) pituitrin; Guiliani (1918) nucleoproteins injected into udder; Hays and Thomas (1920) air-slaked lime.

Wilms (1919) thought that mother's milk acted as a galactagogue but this was disproved by Palmer and Eckles (1918) who stated: their experiments indicate that injection of cow's milk does not exert the function of a galactagogue toward the secretory system of the cow.

McCandlish (1919) tried out quite a large number of drugs supposed to exert galactagogue properties but found that none of them could be relied on to increase either the per cent of fat or the quantity of milk. He observed great individual variations, however, and it may be that in some cases striking results could be obtained.

That dried yeast might have some qualities which would lead to increased milk production is indicated by the work of Renner (1914), which showed that yeast gave a larger yield of milk and fat than did palm kernel cake or rape seed cake. Cranfield and Taylor (1916) showed that dried yeast was also superior to cottonseed meal for milk production.

In practically all the cases where special substances such as drugs were used, the increase was transitory and usually followed by a corresponding decrease. These substances could, therefore, hardly be considered as agents to be profitably used to increase milk production.

4. Summary.

Physiologists seem to be generally agreed that the development and activity of the mammary glands are controlled to a certain extent, at least by chemical stimuli of some sort from the reproductive glands and that secretions from a number of the endocrine glands may be related to the activity of the mammae.

The composition can be changed to certain minor extents by the composition of the feed. The percentage composition, however, remains much the same over a period of days regardless of the feed as long as nutrients sufficient to supply the needs of the animal are supplied. The quantity of the milk, likewise, is affected very little by the composition of the feed providing the ration is balanced and made up of palatable foods. Many differences occur between individual milkings but these are comparatively slight when compared with the average over several days.

Many methods have been tried to stimulate milk secretion but most of those which were satisfactory at all, have been very briefly transitory and followed by a corresponding decrease.

Some reports favor yeast as a means to stimulate milk production but they do not show that the experimental animals used were receiving suitable rations before the addition of the yeast. This might be explained on the basis that yeast as a concentrated source of protein might furnish the additional food required and so increase the milk yield.

None of the reports show conclusively that any particular substance or substances will cause a higher production of milk or butter fat than would be obtained by feeding liberally with a properly balanced and complete diet.

VI. YEAST IN RELATION TO THE VITAMIN B CONTENT OF THE MILK

There has been for several years considerable controversy regarding milk as a source of water-soluble B vitamin. Some have declared it a very poor source while others have considered milk as one of the richest. Most of the workers, however, agree that there is a variation in the water-soluble B vitamin content in different samples of milk. Osborne and Mendel (1920) have shown that milk at best was not one of the richest sources of B as 15-20 cc were required to get normal growth in a rat while only 0.2 grams yeast extract gave normal growth. In a later paper they report that only .04 gm of extract were required.

McCollum (1918b) did not think the low B content of milk was as important as the possibility of a low A content in the milk because of the plentiful supply of B from other sources, but he did think that milk from some rations might have such a low content of A and B as to endanger the health of the young.

Some investigators have maintained that there must be a plentiful supply of B vitamin in the ration or else the lactation could not take place but this has been disproved. Andrews (1912) found women in the Philippines whose diet was so lacking in B that they came down with beriberi and still their milk secretion persisted. McCollum and Simmonds (1918c) found this same condition in rats that kept on milking even though the ration was very deficient in B.

It seems then that lactation may go on even with a low supply of B in the ration, so, from the standpoint of safety for the infant life of the country, we are interested in the question of whether or not the vitamin content of the milk is affected by the diet. This effect has already been shown quite clearly.

Andrews (1912) reported that dogs fed on milk from beriberi women developed signs of mammalian polyneuritis. Similarly, McCollum, Simmonds and Pitz (1916) announced that the dietary essential water-soluble B was not found in the milk unless it was in the diet of the mother.

The year 1920 brought out a number of reports that confirmed these earlier suggestions by very carefully controlled experimental work. Hart, Steenbock and Ellis (1920) reported a marked superiority in the antiscorbutic potency of summer milk over that produced on winter feed. Hess, Unger, and Supplee (1920) noted that the antiscorbutic potency of milk differed with the amount of the antiscorbutic substances in the diet and that there was little if any storing of these materials in the body. Dutcher, Kennedy and Eckles (1920) observed that spring milk was better than the milk from certain poor winter rations in both fat-soluble and water-soluble B vitamins. Later, Dutcher, Eckles, Dahle, Mead and Schaeffer (1920) reported that spring milk was superior to winter in antiscorbutic and nutritive properties. Furthermore, there was a tendency for the nutritive properties of the milk to stay good for four to eight weeks after the cows had been put on a vitamin-poor winter ration, but the nutritive superiority of the spring milk became evident at once when the cows were placed on green grass. The work of Hughes, Fitch and Cave (1920) also showed that the water-soluble B content of the milk tended to vary with the amount of B in the ration.

These results appear reasonably conclusive and we find them accepted by Sherman and Smith (1922b) who state: "Since the total amount of B vitamin in the tissues is relatively small, the concentration in which it appears in the milk is largely dependent upon the vitamin content of the mother's food." McCollum (1922a) after a comprehensive review of the available data concludes similarly, "It seems certain that neither of these dietary essentials (fat-soluble A and water-soluble B) is present in abundance in milk unless the diet of the lactating mother serves as the source."

Most of the investigators have had difficulty in raising successive generations of rats where yeast was used as the sole source of vitamin B. Many of them suspected, however, that this trouble might be due to some other fault in the diet. Mattill (1921) found he could obtain a fourth generation on a ration of dried whole milk, salt mixture, and five per cent yeast and where the yeast was taken out the rats on the same diet became pregnant but their young were small and died in a few days. This superiority of the yeast rations might also be due to some factor other than vitamin B, but, there is also the possibility that the milk from the rats without the yeast was devoid of vitamin B or some other nutritive property which would be furnished in the milk from a yeast diet.

Most investigators seem to be agreed that milk is not a constant source of water-soluble B vitamin and when milk is used as such a source in experimental work the ration of the cow should be known. Cows on pasture have produced milk considerably more potent in antineuritic and growth-promoting properties than cows receiving a vitamin-poor winter ration.

Apparently there is a plentiful supply of B vitamin in the good types of dairy rations, but in certain localities, where the stock is fed largely on milling byproducts such as gluten-feed or hominy, we might expect the ration to be somewhat deficient in B vitamin. It seems to have been quite definitely shown that the vitamin B content of the milk is dependent up to a certain limit on the amount of this factor in the diet of the lactating animal. There is a possibility that insome regions, where the source of feeds might be limited to vitamin-low products, some yeast preparations might be used to keep up the vitamin B content of the milk. Now that we feel reasonably sure the character of the ration influences the vitamin B content of the milk, it remains for us to find out how much we can alter this factor and how important the changes might be to the young in both animals and man.

VII. RESUME

Popular interest in the "vitamin theory" has grown to such a point that the public is permiting itself to be exploited in a variety of ways. People are eating attractively labeled concoctions of "concentrated vitamins" in the hope of regaining "lost vigor, youthful vitality, girlish complexions" and, in short, many physical weaklings, made so by inheritance, disease or dissipation, are looking to these mysterious dietary factors with the same hope that lured Ponce de Leon in his vain search for the "fountain of youth." To be true, nutritional experiments have shown us that there are certain classes or combinations of substances called vitamins, of unknown chemical composition, which are of profound importance in the preservation of animal life. The so-called "vitamin theory" is now quite generally accepted in nutrition studies. The sources of certain vitamins as well as the vitamin requirements of some species of animals have been determined approximately. But, we still know little about the differences in vitamin requirements of various species. Before we can go much further in determining the physiological importance of the vitamins, we should know more of their whereabouts and chemical composition. We have come to a point, however, where it seems justifiable to say that the vitamins cannot be looked to for the solution of all nutritional disorders; but, rather, they are only one group of the many dietary factors, all of which must be properly balanced for the highest efficiency in the animal body.

There have been, in the past, great quantities of material thrown out of breweries, wine-presses and distilleries as waste which might have been used profitably. In the hope of finding some use of these wastes, especially waste yeast from breweries, a great many feeding experiments on livestock have been run in Germany and a few in other countries. The yeast has been found, in general, to be a concentrated source of protein food and when properly prepared has been found to be a good feeding stuff. Further than this the yeast has not been shown to possess any special feeding value.

The field of knowledge concerning the mechanism and causative agents of growth is still very limited. Experiments have shown, however, that growth can be controlled to a certain extent by nutrition. It can be inhibited by under-nutrition or else, with an ample diet, be permitted to proceed at a normal rate to the limits established by inheritance. In order to maintain this normal growth rate, the diet apparently must contain a plentiful supply of water-soluble B vitamin. The endocrine glands also seem to be related to growth. Some workers have shown a relation between the development of the endocrine glands and the amount of water-soluble B vitamin present in the diet. They suggest, therefore, that this vitamin is related to growth, indirectly, by its action on the endocrine organs. Whether vitamin B stimulates growth by aiding the digestive processes or by stimulating the action of the glands of internal secretion still remains to be proven. Yeast has been shown to be a potent source of vitamin B so its addition to diets deficient in thisfactor has been followed by growth stimulation.

The use of yeast in experimental work as a source of vitamin B has attracted the public as though the supposed value of yeast in the human dietary were a new discovery. As a matter of fact, it has been used for centuries as a therapeutic. A host of claims have been made both for and against yeast in therapy. Some assert that yeast has shown positive curative properties in certain infections, while others profess to have observed infections which were the result of yeast therapy. Physicians seem to be divided on the question; most of them claiming that yeast is harmless; a few prescribing it sincerely; and, a still smaller number spiritedly opposing its use. The more recent workers have experimented with the hope that the administration of yeast might improve health by checking bacterial decomposition in the colon and lessening auto-intoxication. Their usual conclusion has been that yeast, as far as could be observed, was without effect either good orbad. In the face of such conflicting evidence and claims, yeast therapy must still be considered in the experimental stage.

The study of lactation has generally been undertaken from either of two rather different viewpoints, the physiological and the commercial. The physiologist has tried to determine either the method of elaboration of the different constituents of milk and their origin or else the extent to which the milk flow is affected by the internal secretions. The commercial or agricultural point of view has centered its interest in determining what methods of feeding would induce a cow to give the maximum yield of milk with the greatest per cent of butterfat. Both classes of workers have carried on a great number of experiments, from which it would appear that certain minor variations in the composition of the milk can be affect by dietary changes. Some changes in the percentage of certain fatty acids and some slight transitory changes in yield and percentage of butterfat can be effected by certain drugs and extracts of endocrine glands. But, on the other hand, it seems that where a cow is receiving a properly balanced diet in sufficient amounts, no known methods of feeding will increase the total yield of milk or butterfat. Although yeast has not been thoroughly tested for galactagog properties, there is little reason for supposing it would have any such value.

As a factor in increasing the vitamin B content of the milk, however, yeast may have more possibilities. The work done so far seems to indicate that the vitamin B in the milk comes from the food and that the amount present in the milk is dependent to a certain extent on the amount supplied in the diet. Inasmuch as yeast is a potent source of B vitamin, its addition to rations whose content of this factor is low, might give an increase in the vitamin B content of the milk and thereby safeguard the nursing young from a deficiency of this growth-promoting factor.

The literature, in general, would indicate that: yeast is a potent source of water-soluble B vitamin and, as such, would be valuable when a highly concentrated source of this factor is required: dried yeast from breweries and yeast cultures has been used with good results as a high protein feed for livestock; yeast has not been proven to be a factor in giving any improvement in general health over that resulting from a proper dietary, nor has its positive value as a therapeutic been proven; yeast has been proven valuable as a growth-promoting substance when added to rations deficient in B vitamin; yeast has not been shown to be a stimulator of milk secretion over and above that produced by liberal, properly balanced rations; and, although not yet demonstrated it does not seem impossible that the addition of yeast to a ration low in B vitamin might increase the potency of this factor in the milk.

EXPERIMENTAL WORK

I. OBJECT OF EXPERIMENT

The nutritional requirements of different species of animals have generally been considered approximately the same. Some of the more recent findings, however, indicate that this assumption is not entirely correct. The work of Hart, Halpin, and McCollum (1917) showing that different species differ in their mineral requirements, and of Osborne and Mendel (1918) showing the same is true of vitamin requirements, have made it quite clear that we cannot assume the requirements of one species will hold for all. With this point in view, a number of experiments have been made to determine whether the vitamin requirements, as shown for rats, will hold for other species, especially the larger domestic animals.

The vitamin requirements of the bovine have not yet been determined so our primary purpose was to contribute to the knowledge of these requirements. Inasmuch as yeast, a potent source of water-soluble B vitamin, is available in large quantities as a waste product from breweries and yeast factories, its use was deemed advisable and practical in our experiments. Moreover, in view of the widespread interest manifested in the use of yeast in the human dietary, it was considered desirableto ascertain whether its addition to the rations of dairy cattle would be accompanied by any favorable results.

The specific purpose in adding yeast to the rations was to determine its effect in: (1) stimulating growth of calves, (2) preserving the health of calves, (3) increasing the milk flow of cows, and (4) increasing the vitamin B content of the milk.

Our aim in carrying on this work was not to determine the effect of yeast feeding on the chemical changes in the digestive juices nor the bacteriological condition of the intestinal tract. It was, rather, to determine the effects of using yeast as a supplement from the viewpoint of the feeder of dairy cattle. The results were to be measured from the practical feeder's standpoint: on growth, as indicated by increase in weight and height; on health, as indicated by general appearance, vigor and freedom from calf diseases; and, on milk production, as indicated by the daily milk sheet. Further, the effect of the addition of yeast on the vitamin B content of the milk was to be tested by feeding the milk to experimental rats.

The rations ordinarily fed to calves and cows in the better dairy herds include such feedstuffs as alfalfa, clover, rutabagas, corn, oats, barley and oilmeal, substances which are good sources of vitamin B. If the requirements of cattle for this factor approximate those of albino rats, there would be little danger of a deficiency occurring. If this assumption is correct the experiments reported in this thesis should indicate whether the addition of an extra amount of this vitamin, in a potent source like yeast, would have any favorable effects.

II. PLAN OF EXPERIMENT

A. Calves

1. General Statement

It was planned to raise groups of calves to the age of six months according to the common practice:

1. Skimmilk to six months supplemented by hay and grain.
2. Whole milk to six months supplemented by hay and grain.
3. Whole milk to about sixty days, a grain mixture and hay.

The first of these is the most generally used on dairy farms. The latter two are less common and were tried out with intermittent periods of yeast*-feeding by Wilbur (1921) apparently with negative results so were not repeated.

On account of its importance, the first system was tried out in the

*A baker's yeast, dried.

following three ways:

1. Yeast was added during the year to the rations of half the calves born in the University purebred dairy herd. These calves were otherwise raised in the ordinary manner.
2. A second group composed of grade calves was fed skimmilk, alfalfa hay and a grain mixture of corn, wheat, bran and oilmeal. The rations of half these calves were supplemented with yeast.
3. The rations of a third group consisted of skimmilk, prairie hay and a grain mixture of corn and oats. The rations of half of this group were likewise supplemented with yeast.

It was thought the data from these three groups, together with that obtained by Wilbur (1921) would give information covering the common calf-feeding practices in dairy herds.

2. Animals used.

Experiment I. The University purebred dairy calves were taken as they were born and arranged in pairs as near as possible according to breed, sex and age so that those receiving yeast would be comparable to those used as controls. A detailed description of these animals is found in Table IX.

Experiment II. For this lot eight grade Holsteins of uniform size, averaging about twenty days in age, were purchased from a dealer. These are designated Y-1, Y-2, etc., the first three being used as controls; they are described in Table IX.

Experiment III. This work included eight grade Holstein heifer calves purchased from the same dealer and were likewise closely matched in size and weight. They are designated Y-9, Y-10, etc., the first four being controls. This lot is also described in Table IX.

All these calves averaged close to normal size, had good appetites and appeared to be vigorous and thrifty.

3. Rations used.

Experiment I. The calves from the University purebred herd received their daily rations according to the following plan:

(1) Whole milk from birth to three months.

a. Holstein - 9 lbs. increased ½ lb. per week to 14 lbs.

b. Guernsey - 6 lbs. increased ½ lb. every 2 weeks up to 7½ lbs.

c. Jersey - 6 lbs. increased ¼ lb. per week up to 9 lbs.

d. Ayrshire - 7 lbs. increased ¼ lb. per week up to 10 lbs.

(2) Skimmilk from three months to six months.

This was used to replace the whole milk at the rate of a pound a day, the replacement being spread over a period of seven to fourteen days according to the amount fed.

(3) Grain was fed as soon as the calves would take it.

a. Two weeks to two months - ground corn and whole oats, ad libitum.

b. Two to six months - ground corn and ground oats ad-libitum.

(4) Roughage was also fed ad libitum.

a. Birth to two months - mixed clover and timothy.

b. Two to six months - alfalfa.

(5) Yeast was fed from the age of two weeks to six months at the rate of 100 gm. per day. This yeast preparation was a mixture of cornmeal and yeast, which, calculated from its analysis by the division of Agricultural Biochemistry, University of Minnesota, and the pure yeast analysis in Jago (1895) contained about three per cent yeast.

This product showed, however, according to the division of Dairy Bacteriology, University of Minnesota, a yeast cell count per gram equal to that of the same dry weight of ordinary baker's yeast.

Experiment II. The calves in this lot were fed according to the generally approved skimmilk system as follows:

(1) Whole milk fed at the rate of nine pounds per day from birth to thirty days of age.

(2) Skimmilk was then used to replace the whole milk at the rate of one pound a day for nine days. After this the skimmilk was increased to sixteen pounds at the rate of one pound every ten days for seven periods, and then maintained at that amount until the close of the experiment.

(3) Grain was fed ad libitum. The mixture included ground corn four parts, wheat bran one, and oilmeal one.

(4) Roughage was also fed ad libitum. This was a good grade of alfalfa cut into four inch lengths for convenience in weighing.

(5) Dried yeast as previously mentioned was added to the rations of five of this lot. It was fed in amounts sufficient to make up ten per cent of the dry matter in the ration.

Experiment III. The rations for the third lot were essentially the same as for the second. Prairie hay was used instead of alfalfa and the grain mixture consisted of equal parts of ground corn and oats. Four in this lot received yeast as a supplement to the ration.

4. Feeding methods.

The feeding was carefully supervised throughout the experiment. The calves were fed twice a day, about 6 p.m. and 6 a.m. Feeding the milk gave little trouble as the supply was obtained from the main barn from that slightly warmed in preparation for feeding the calves in the purebred herd. The grain was supplied once a day but was restricted when the calves showed any signs of loss of appetite. Soiled grain was removed, weighed back and discarded. Hay was kept in the boxes all the time, the coarse and soiled portion being removed frequently so the calves would eat as much as possible. All the refused material was weighed back before discarding. The yeast was fed in the milk for about two months. At this time the calves were eating enough grain so that the yeast could be included in the mixture.

5. Care and shelter.

The purebred herd calves were kept under excellent conditions, similar to those on the better breeding farms in this section of the country. They were left with their mothers the first day in order to get the colostrum in the new milk. Their navels were treated with iodine soon after birth and they were under the treatment of the veterinary division when any abnormal conditions occurred. The pens were roomy, comfortably warm except for a few days in the winter, well-lighted, properly ventilated and were cleaned daily. To avoid any of the dangers of careless feeding, the herdsman fed these calves throughout the experimental period.

The calves on the experimental rations were kept in individual stalls in the experimental barn but were turned out when the weather permitted. This barn, however, was cold and poorly ventilated so there was constant danger of lung infections. To protect the calves from the cold as much as practicable, the stalls were cleaned daily and heavily bedded. These calves were watched closely for any digestive disturbances, skin affections and lice, and, when necessary, were treated promptly by the veterinary division.

6. Collection of data.

Feed statements were filled out daily and the complete records for the entire experiments are found in Tables XV-XXX.

The animals were weighed every ten days and for three successive days every thirty days. The average of the weights obtained during the three-day period was taken to compensate for the daily variations. To secure more accurate results the weighing was always done at the same time of day, that is, before the morning feeding.

Heights at the withers were measured every thirty days as the gains for ten day periods would in some cases be no larger than the experimental error. Three measurements were taken, the animals being moved between measurements to avoid errors caused by different ways of standing. The measuring was continued until three figures within a 1 cm. limit were obtained, the average of which was taken as the true height.

Using increase in weight and height as a measure of growth was based on the advice of Mendel (1918), Eckles (1918) and McCandlish (1922) which show that these measurements are the best indications of the rate of growth in large animals.

The calves were observed daily by the feeder and the author to note any changes in their general health as indicated by their general appearances. They were also watched for changes in their gastro-intestinal condition as indicated by appetite and character of the feces.

Cows

1. General statement

The rations commonly fed to high producing cows in good dairy herds supposedly contain sufficient amounts of water-soluble B vitamin providing the needs of large animals are proportionate to those of the albino rats. Silage is high in yeasts so would contain some B, while the grains such as gound whole corn, wheat bran and similar products contain the germ and the other portions of the seed supplied with this vitamin. The aim then in these experiments was to add a surplus of the water-soluble B in a rich source (yeast) to the ration of a number of high producing cows to ascertain whether the addition would lead to increased milk production, either through galactagog properties, or, indirectly by causing the cows to eat more or use their feed more efficiently.

It was further planned to feed the milk from a group of cows to albino rats to see whether the vitamin B content of the milk could be increased by the addition of yeast to the cow ration. The results of this latter experiment have not yet been interpreted so will not be reported here.

2. Animals used.

A lot of eight purebred, high producing cows was selected for this purpose. The cows were paired according to breed, stage of lactation and production as nearly as practicable and are described in more detail in Table X. It was considered advisable to have them in the middle of their lactation periods where the effects of feed on milk production are more pronounced and where the lactation curve is the steadiest. They were all apparently in good physical condition, reasonably high in flesh and feeding well.

3. Rations used.

The basal rations used were those generally accepted as well-balanced and complete by dairymen who can raise the crops they need and buy the necessary supplements. They consisted of alfalfa hay, corn silage, beet pulp, and a grain mixture (corn 2, oats 2, wheat bran 2, and oilmeal 1) with salt and steamed bonemeal added at intervals. The experimental rations were the same as the basal with 25 gm. of dried yeast added per pound of milk produced.

4. Feeding methods.

These animals were fed at the same time and in the same manner as the other cows in the purebred dairy herd. They were fed twice a day and all refused feed weighed back. The feed was all of good quality as it came from the supply used in the purebred herd. The feeding schedule was figured out so that a large surplus over the requirements in both protein and energy was supplied at all times. In an attempt to determine whether the yeast was an appetite stimulator, the cows were encouraged by all the usual means to eat as much as possible even though they increased in weight.

The yeast was added according to the so-called "reversal" or "alternate" plan. The cows were divided into two groups, V-a and V-b, and placed on the basal and experimental rations as follows:

Group V-a

1		2		3	
Preliminary	Experimental	Preliminary	Basal	Preliminary	Experimental
10 days	30 days	10 days	30 days	10 days	30 days

Group V-b

1		2		3	
Preliminary	Basal	Preliminary	Experimental	Preliminary	Basal
10 days	30 days	10 days	30 days	10 days	30 days

The same ration was fed during the preliminary as in the period following so that the cows would have an opportunity to become accustomed to the change from basal to experimental ration and vice versa. The use of a preliminary period also precluded the danger of residual effects carrying over from one period to another. The data collected during the preliminary periods were not included in calculating the final results of the experiments.

5. Care and shelter.

The cows were kept under splendid conditions with the exception that they were not permitted to go on grass. The dairy barn is modern in every way, clean, bright, roomy, well-ventilated and reasonably free from flies. When the weather permitted all were turned out in a barren lot for exercise and sunlight. They were cared for by an experienced herdsman and given prompt treatment when necessary, by the veterinary division. While the experiment was in progress, two of the cows reacted positively to the tuberculin test, and for this reason were removed to a quarantine barn, where the surroundings were possibly no so pleasant but where they had roomy box stalls and were given equally as good care.

6. Collection of data.

A complete record was kept of all feed consumed and of milk and butter-fat produced. The cows were weighed at ten day intervals. A constant composite sample was made of the milk of each cow and tested every ten days. The cows were observed daily by the author and any change in appearance, actions, milk production or appetite was recorded by the feeder.

DISCUSSION OF DATA

The discussion of the data obtained in these experiments is divided into two main divisions, (1) the work on calves, and (2) the work on cows. The report of the calf-feeding includes:

(a) a brief experimental history of the animals.

(b) the effect of yeast on the growth of calves.

(c) the effect of yeast on the health of calves.

The data reported on the cows gives:

(a) a brief history of the animals.

(b) the effect of yeast as a stimulator of milk production.

A. Experiments on Growth of Calves

Histories of experimental calves.

In discussing the experimental records, the calves are considered according to groups as follows:

Ia -- purebred calves used as controls for the first experiment.

Ib -- purebred calves receiving yeast.

IIb -- grade calves used by Wilbur (1921) receiving whole milk, good ration and yeast.

IIIa -- grade calves used as controls for second experiment on skimmilk plus good ration.

IIIb -- grade calves receiving yeast on skimmilk plus good ration.

IVa -- grade calves receiving skimmilk plus poor ration and used as controls for third experiment.

IVb -- grade calves receiving skimmilk plus poor ration and yeast.

Group la -- The records of gain in weight and height for this group are contained in Tables XI and XII.

Calf 19, an Ayrshire heifer, 110 per cent normal in weight at birth, dropped to 91 at one month and then gradually increased to 96 per cent at the finish. Her height started at 100 per cent normal and finished at 104. She was a normal acting calf throughout the experiment.

102 -- Jersey bull. This calf started at 100 per cent normal in weight, dropped to 85 at 22 days and then gained until he was 111 per cent at the finish. He started at 99.7 per cent normal in height and finished at 104. His sex would account for him being above normal because the normal curves were calculated for heifers.

144 -- Jersey heifer. This calf started at 98 per cent normal in weight, dropped to 92 at one month of age, and finished at 101. She was practically normal in height and appearance throughout the experiment.

320 -- Holstein bull. This bull started at 101 per cent normal in weight but had a setback during his first month, as he contracted "pinkeye" and dropped to 93. He soon recovered, however, and went up to 129 per cent at five months and finished at 123. His height was 102 per cent normal at the start and 104 at the finish. His large gain over the normal weight could also be explained by his sex.

362 -- Holstein heifer. This animal was a large, thrifty animal with a strong appetite and lots of vigor throughout the six months of the experiment. She started at 112 per cent normal in weight and finished at 117. Her height was 4 per cent above normal at the start and 3.2 per cent above at the finish.

365 -- Holstein heifer. This animal was almost the opposite of 362, being 17 per cent under normal in weight at birth and finishing at 97. She was somewhat more excitable than the others, had scours from her second week to the sixth, and was never as thrifty appearing a calf as the others. Her height want from 97 to 98 per cent.

366 -- Holstein heifer. This heifer started about the same as 365, being 15 per cent below normal in weight, but she was thrifty and went up to 109 in the fourth month, finishing at 104. Her height was normal at the start and 103.9 per cent normal at the finish.

367 -- Holstein heifer. This heifer started about the same as 365 and 366, being 15 per cent below normal in weight. Unlike them she never did reach normal. She went up to 99 per cent during the first month but finished at 88. Her height was only 2 per cent below normal at the start but dropped to 95.7 per cent at the finish. She was a rather excitable animal and lacked the smoothness in her appearance which was characteristic of the rest of the group.

502 -- Guernsey bull. This one when compared to the normal for Jerseys (in the absence of normal figures for Guernseys) was 140 per cent normal in weight at birth and dropped to 91 at the finish. The Guernseys were evenly

paired according to sex and number of individuals so were compared to the breed to which they are most similar. He started at 105 per cent in height and finished at 97.8 per cent normal. Althought he suffered no noticeable digestive disturbances, he lacked the thrift and vigor exhibited by the calves of the other breeds.

516 -- Guernsey bull. This bull was compared to the same standard as 502. He was 40 per cent above normal at birth but dropped steadily and finished at 88 per cent. His height was 6.8 per cent above at the start and just normal at the finish. He scoured severely in his third month and, like 502 lacked the thrift shown by the other calves.

526 -- Guernsey heifer. This heifer was compared to the same normal as the two bull calves and showed a more rapid growth rate than either of them. She started at 158 per cent normal in weight and finished at 113. Her height was 8.8 per cent above normal at the start and 4.9 above at the finish. She was a tall strong calf with the vigor and thrift which generally characterizes the Holstein calves.

Group 1b. The records of weights and gains for this group are contained in Tables XIII and XIV.

8 -- Ayrshire bull. This bull was a strong,spirited calf who showed his masculinity at an early stage by resisting all efforts to handle him. He started at 101 per cent normal in weight but dropped to 91 during his second month owing to a stubborn case of scours which had run about a week before the yeast-feeding was started and continued about a week afterwards. He appeared normal through the rest of the experiment and finished at 95.9 per cent normal. In build he was a broad blocky calf, so in spite of starting at 106 per cent normal in height, he finished at 101.2.

17 -- Ayrshire heifer. This animal was the first animal put on the yeast experiments. She was started at three months of age when her weight was only 86 per cent normal but she finished five months later at 122 per cent. Her height was normal at the start and finish.

18 -- Ayrshire heifer. She appeared strong but was only 74 per cent normal in weight at the start of the experiment. She was a good feeder and gained steadily until she reached 95 per cent at the end of six months. Her height, however, was only 1.5 per cent below normal at the start and finished at 100.3

142 -- Jersey heifer. This calf was in general appearance, activity and strength, a fair representative of her breed. She started at 90 per cent normal in weight and finished at 102. Her height was 101 per cent normal at the start, varied a little up and down and finished at 99.0.

143 -- Jersey heifer. This thrifty calf started at 89 per cent normal in weight but finished at 105. Her height was nearly normal throughout, starting at 101 and finishing at 100.

145 -- Jersey heifer. This Jersey was much the same as the other two, following the normal fairly close in both weight and height. She started at 95 and 103 per cent in weight and height respectively and finished at 101 and 100.

301 -- Holstein bull. This strong bull was about the same amount above normal all along. He started at 110 per cent normal in weight and finished at 108. His height went from 108 at the start to 105.2 per cent at the finish.

363 -- Holstein heifer. She was the largest and strongest calf in the group. Her weight was 128 per cent normal at both the start and the finish. In height she was 8 per cent above normal at the start and 7.4 per cent above at the finish.

364 -- Holstein heifer. She started at 98.8 per cent normal in weight but dropped to 94 during the second month, perhaps as the result of some digestive disturbances. She went up, however, to 107 per cent at the close of the experiment.

Her height was 2 per cent above normal at both start and finish.

500 -- A Guernsey bull. This bull, when compared to Jersey normals, followed much the same course as the two Guernsey bull calves in Group Ia. His weight went from 138 per cent normal at birth down to 100 at the close of the experiment. His height started at 107 and finished at 103. Like the Guernseys in the other group, he lacked vigor shown by the Holsteins, Aryshires and Jerseys.

513 -- Guernsey bull. This animal followed calf 500 somewhat both in weight and height. He started at 125 per cent normal in weight but dropped to 90 at the finish. His height, starting at 105, also dropped and finished at 100 per cent normal. A severe case of scours during his third, fourth and fifth weeks might explain his failure to maintain the normal rate of growth.

524 -- Guernsey heifer. This animal like 526 in group Ia, was a big strong calf, far outstripping the two bulls, 500 and 513, in growth and vigor. Her weight was 138 per cent normal at the start and 120 at the finish, while her height was 115 at the start and 109 per cent at the finish.

The calves in Groups Ia and Ib, taken as a whole, could be considered as fair representatives of the calves in good pure-bred herds. They were even slightly better than the normal, owing, perhaps, to their good care and feeding. The results obtained from the experiment with these animals, therefore, should be of interest to any breeder who might contemplate feeding yeast as a growth stimulator or as a calf tonic.

Group IIb --- Grade Holstein heifer calves.

A summary of the gains made in weight and height by this group is contained in Table II; a record of the energy consumed per pound of gain is contained in Table LXIII.

22 -- She started at 88 per cent normal in weight and finished at 118. She also gained in her rate of growth in height, starting at 99 and finishing at 103 per cent normal.

24 -- This calf,a rapidly growing heifer, started at 101 and 102 per cent normal in weight and height respectively, and finished at 126 and 106 per cent.

530 -- This animal went from 92 per cent normal in weight to 118, and from 99 per cent normal in height to 102.

This group of calves was fed whole milk and all the grain and hay they would eat and as a result made by far the largest gains of all the groups. They are included so that the average of the growth of calves raised by different methods could be obtained. All of the group received yeast as a supplement to their rations for intermittent periods. They were healthy, and would probably represent the calves raised by breeders who force extra growth in young animals by whole milk feeding.

Group IIIa --- Grade Holstein heifer calves.

A record of the feed consumed by the calves of this group is found in Tables XV, XVI, XVII; growth in weight and height in Tables XXXI-XXXIII; nutrients in ration in Tables XLVII-XLIX; and energy consumed per pound of gain in Tables LXIV.

Y-1.--This heifer was a strong, thrifty calf throughout the experiment. She started at 105 per cent normal in weight and finished at 111. Her height was about normal all along.

Y-2 --This animal started at 103 per cent normal in weight and was 108 per cent normal at the age of 148 days when she contracted tubercular pneumonia and died within 48 hours. Her height was normal as far as she went. She appeared to be quite strong and healthy up until the day she took sick. She had reacted positively to the intradermal tuberculin test two weeks before, but seemed, outwardly to be in good condition.

Y-3 -- This calf was characterized by her strong appetite, expecially for roughage, and her rapid gains in weight. She started with her weight 107 per cent normal and finished at 113. Her height, however, was always a little below normal, starting at 99 per cent and finishing at 98.

Group IIIb --- Grade Holstein heifer calves.

The records of the feed consumed by the animals of this group are found in Tables XVIII-XXII; growth in weight and height in Tables XXXIV-XXXVIII; nutrients in ration in Tables L-LIV; and energy consumed per pound of gain in Table LXIV.

Y-4 -- This heifer had a case of scours the first four days of the experiment which gave her somewhat of a setback. She did not have the appetite shown by the calves in group IIIa and was more excitable than the others. Her weight started at 110 per cent normal but was only 100 at the finish. Her height was close to normal throughout, starting at 100.6 and finishing at 99.3 per cent.

Y-5 -- This calf was the outstanding animal in this group as far as thrifty appearance, vigor and growth were concerned. She started at 118 per cent normal in weight and finished at 116.8, while her height started at 102, increased at about the normal rate and finished at 102 per cent.

Y-6 -- This heifer was the opposite of Y-5 as far as healthy appearance went. She contracted a cold from lying below an open window on a cold, rainy night and had scours for about two weeks. She never looked as thrifty as the other calves in the group and never quite reached the normal in weight after her cold was cured. She started at 104-103 per cent normal in weight and height, respectively, and finished at 97 and 99.

Y-7 -- This animal like most of the other calves of this group had a poor appetite for roughage until about four months of age. She did quite well during the test, starting at 98 per cent normal in weight and finishing at 105. Her height did not keep up a corresponding rate as it started at 103 and finished at 99.8.

Y-8 -- This calf, although appearing to be in good health grew at about the same rate as Y-6 until the twelfth period of the experiment, after which she was taken off because she reacted positively to the intradermal tuberculin test. She started at 105 and 104 per cent normal in weight and height respectively and finished at 96 and 101.

Group IVa --- Grade Holstein heifer calves.

The record of the feed consumed by the animals of this group are found in Tables XXIII-XXVI; growth in weight and height in Tables XXXIX-XLII; nutrients in ration in Tables LV-LVIII; and energy consumed per pound of gain Table LXV.

Y-9 -- This heifer caught a slight cold in shipment but this abated and she appeared to be in good health for the duration of the experiment. She reacted positively, however, to the intradermal tuberculin test in the fourteenth period and was moved to a quarantine barn. The infection did not seem to hinder her growth for she went from 99 per cent normal in weight to 108 and 99 per cent normal in height to 102.

Y-10 -- This animal started at 106 per cent normal in weight, varied between that and 95 and finished at 100. Her height was 96 per cent normal at the start and, after varying a little, finished at 96. She had slight digestive disturbances, due perhaps to the exposure in shipping and in addition had an abcess on her jaw during the sixth period which had to be lanced. She did not seem to be as thrifty as the other animals of the group.

Y-11 -- This animal was a fairly thrifty calf starting with the same digestive disturbance as the others of this group. A mange on her neck and head during the fourth, fifth and sixth periods seemed to affect her appetite a little. She went up from103 per cent normal in weight at the start to 110 in the seventh period, but during a severe attack of scours in the twelfth period, dropped to 96 per cent and finished the experiment at 101. Her height was 100 per cent normal

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at the start and 101 at the finish. She reacted positively to the intradermal tuberculin test in the fourteenth period and was moved to the quarantine barn.

Y-12 -- This heifer was just about an average calf, starting at 103 per cent normal in weight, varying from 96 to 107 and finishing at 106 per cent. Her height went from 98 per cent at the start to 101 at the finish. She had the same digestive disturbance as the others, and, in addition reacted positively to the intradermal tuberculin test in the third period. She was moved to the quarantine barn where it was extremely cold for about two weeks and where she was confined to a box stall until the end of the experiment. She was maintained on the experiment because it was thought that the infection had made only a small start and furthermore, one of the experimental animals reacted positively at the same time so the two were used as checks on each other.

Group IVb --- Grade Holstein heifer calves.

The records of the feed consumed by the animals in this group are found in Tables XXVII-XXX; growth in weight and height in Tables XLIII-XLVI; nutrients in ration in Tables LIX-LXII; and energy consumed per pound gained in Table LXV.

Y-13 -- This animal had the same digestive disturbance which affected all the calves in Group IVa and reacted positively to the intradermal tuberculin test for the fourteenth period. She started at 103 per cent normal in weight, descended to 93 in the fourth period and then went up to 109 at the finish. She also gained over the normal in height, having started at 100 per cent and finished at 102.8.

Y-14 -- This calf had the most severe digestive disturbance of the group as a result of which she dropped from 105 per cent normal in weight at the start down to 86 in the second period. She reacted positively to the intradermal tuberculin test the next period and was moved to the same quarantine barn as Y-12 of Group IVa. The infection did not seem to interfere very much with her growth, because within 20 days after she recovered from the scours, she went up to 108 per cent normal in weight and finished at 104. Her height was 3 per cent below normal at the start and normal at the finish.

Y-15 -- This heifer was the largest calf in this group. She started at 114 per cent normal in weight, dropped to 104 during the period when the skimmilk was replacing the whole milk and then went up to 110 in 10 days. She was above normal at the start and 104.8 at the finish. She was the most thrifty calf in the group and the easiest to handle.

Y-16 -- This heifer although troubled for three weeks with the digestive disturbances which attacked all these calves was the most rapid growing animal of the group. She started at 99 per cent normal in weight but finished at 109. Her height started 100 per cent normal and finished at 102.

The calves in groups IIIa, IIIb, IVa, IVb considered as one lot were a splendid bunch of grades. They were strong, thrifty, smooth appearing and averaged above normal in both weight and height even though seven of the sixteen reacted positively to the tuberculin test. Their quarters were cold, damp and poorly ventilated but there was only one case of pneumonia.

Discussion of results on growth of calves.

Groups Ia and Ib

The purebred herd calves varied considerably in age so were best considered when compared to the normal for the particular age of each one. In doing this the actual weights and heights have been compared to the normal and computed on a percentage basis. Thus, we have been speaking and will continue to speak throughout the discussion in terms of "per cent normal" which means the percentage the actual weight or height is of the normal as worked out by Eckles (1920).

The purebred calves making up Groups Ia and Ib varied a good deal individually in their rates of gain in weight and height as is readily seen in Table I.

TABLE I

SUMMARY OF WEIGHTS, HEIGHTS AND GAINS
GROUP Ia and Ib

Animal	Per cent normal in weight		Per cent normal in height		Average gain per month	
	Start	Finish	Start	Finish	Weight	Height
Group Ia	Per cent	Per cent	Per cent	Per cent	lbs.	cm.
19	91.0	96.0	103.2	104.3	40.2	5.83
102	85.2	111.8	103.2	104.3	43.5	6.10
144	92.9	101.3	101.9	101.1	38.2	4.70
320	93.9	129.3	102.6	104.5	67.0	5.47
362	101.0	119.9	104.0	104.8	57.7	5.25
365	76.0	99.1	97.2	98.8	47.5	5.30
366	93.6	109.8	100.6	105.5	49.5	6.17
367	99.1	88.1	98.0	95.7	39.2	4.30
502	116.6	89.0	105.0	96.0	27.0	3.00
516	122.3	88.1	100.2	100.1	22.7	3.03
526	128.8	117.5	108.8	105.9	40.5	4.52
Average	100.0	104.5	102.2	101.9	43.0	4.88
Group Ib*						
8	95.5	101.6	106.4	101.7	67.0	4.15
17	86.6	122.4	100.9	100.5	51.0	3.33
18	74.1	95.1	96.5	100.3	42.5	4.60
142	90.8	102.7	101.5	99.0	46.5	3.42
143	96.7	105.6	101.3	100.4	43.5	4.40
145	95.6	104.0	103.0	101.1	37.0	4.42
301	109.8	109.9	108.1	105.1	47.0	4.67
363	116.1	128.7	108.1	109.0	56.7	5.72
364	94.1	107.3	102.7	101.8	49.0	4.95
500	110.4	100.6	104.6	103.5	33.0	3.96
513	110.6	96.6	105.2	100.9	30.5	3.95
524	134.9	119.0	115.1	110.8	38.5	4.92
Average	101.2	107.8	104.6	102.8	45.3	4.37

* Receiving 100 gm. dried daily

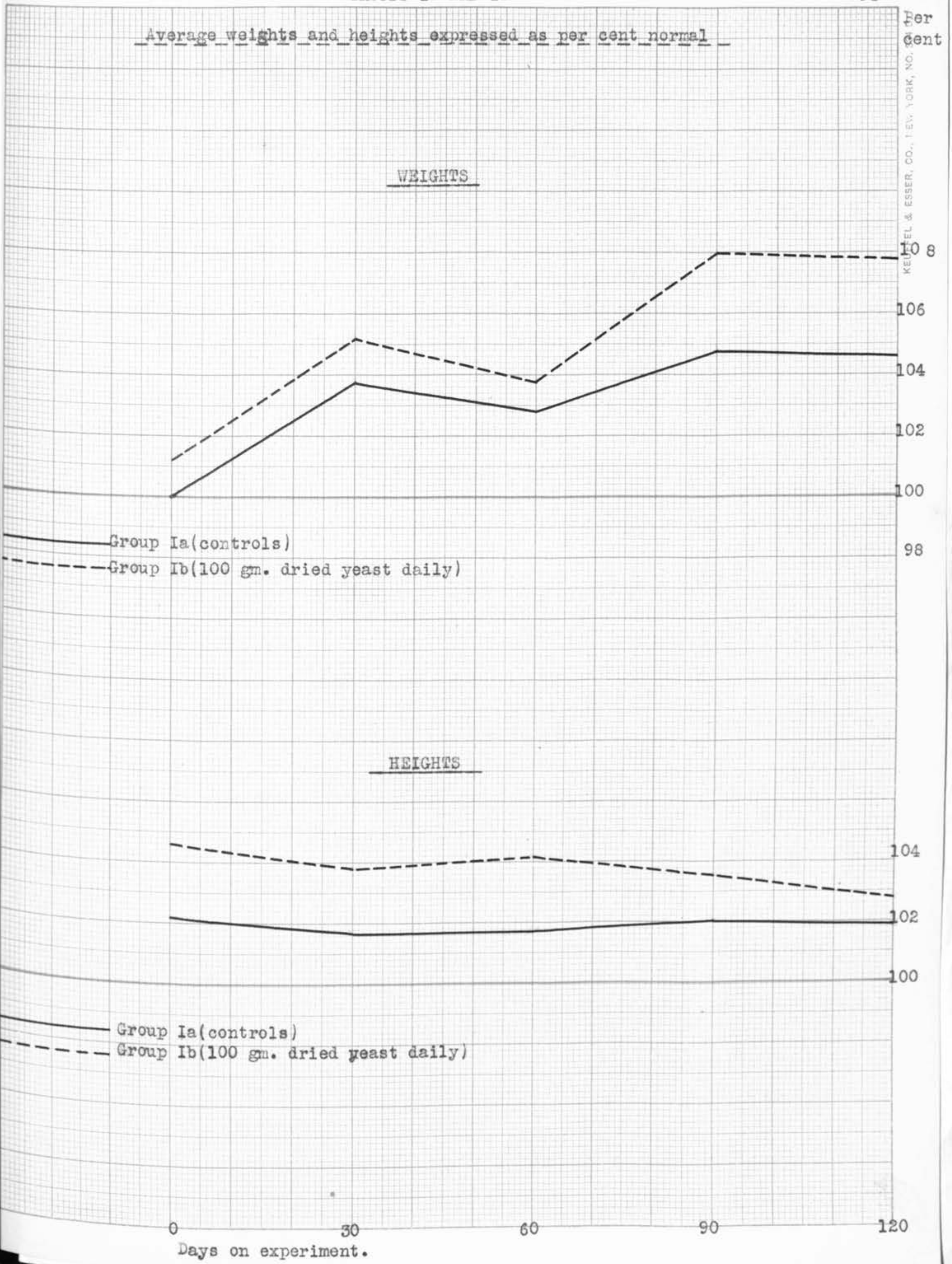
Some in both groups were above normal at the start and above normal at the finish, some were above at the start and below at the finish; some were below at the start and finish both; while still others were below normal at the start and above at the finish. This would seem to indicate that the yeast-feeding had no pronounced effect on the growth of the calves in these two groups. There were also wide differences in the gains made per month in both groups; the gains made in one group differing as much as they do in the other. If the gains made by one group were uniformly larger than those made by the other, it would indicate that the yeast caused the difference.

Group Ia averaged 100 per cent normal in weight at the start and 104.5 at the finish, a gain over the normal of 4.5 per cent. Group lb, on the other hand, averaged 101.2 at the start and 107.8 at the finish or a gain over the normal 6.6 per cent. The average for the yeast -fed calves then is 2.1 per cent higher above the normal than the average of the controls. The average gain in weight per month for group Ia was 43 pounds while that of group Ib was 45.3 pounds, giving an advantage to the yeast fed over the controls of 2.3 pounds.

The gains in height do not show the same tendency. Group Ia averaged 102.2 per cent normal at the start and 101.9 at the finish or a loss of 0.3 per cent of gain over the normal; Group Ib averaged 104.6 at the start and 102.8 at the finish or a loss of 1.8 per cent over the normal, giving an advantage to the control animals over the yeast fed of 1.5 per cent. Similarly the average of group Ia in gain in height per month, 4.88 cm., exceeded the gain of Group Ib, 4.37 cm., by 0.51 cm.

The averages of the two groups for weight and height expressed in per cent normal did not vary a great deal from their original relation as is seen in fig. 1.

FIGURE 1.
GROUPS Ia AND Ib



The weights of group Ia stayed for three months the same distance above the weights of group Ib but the difference increased during the last three months. The heights of the two groups held somewhat the same relation as did the weights for the first three months but, during the last two months, the difference in heights lessened about the same amount as the difference in weights increased.

The results from feeding the groups Ia and Ib seem to indicate in this case that the use of yeast as a supplement to a good ration consisting of whole milk for the first three months and skimmilk for the next three, both supplemented with a liberal grain mixture and leguminous hay, did not give any appreciable stimulation to the growth rate. If the small differences noted were considered significant, they would indicate that yeast*feeding resulted in a diminished rate of growth in height but an increased rate of growth in weight.

Group IIb.

The data on the calves of this group was obtained by Wilbur (1921). They were grade Holstein heifer calves put on experiment at the age of 27 days and fed for 156 days. No control animals were used so we have only the comparison with the normal for their gain in weight and height. They were thrifty calves and, as they received an almost ideal ration, (whole milk supplemented by alfalfa hay and grain), grew faster than the normal both in weight and height. Table II shows a summary of their gains in weight and height while fig. 2 shows the course of the gains during the intermittent periods of yeast feeding. The group averaged 94.3 per cent normal in weight at the start and finished 121.1 per cent normal, a gain compared to the normal of 26.4 per cent. The average in height went from 100.4 per cent normal to 104.1 per cent or a gain compared to normal of 3.7 per cent. The gains per month were 57.9 pounds and 5.24 cm. in weight and height respectively. These gains were larger than the gains made by either of the groups Ia or Ib but the differences cannot be attributed entirely to the yeast feeding for two reasons. First, the animals in this group were fed a liberal supply of whole

* A baker's yeast, dried.

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TABLE II

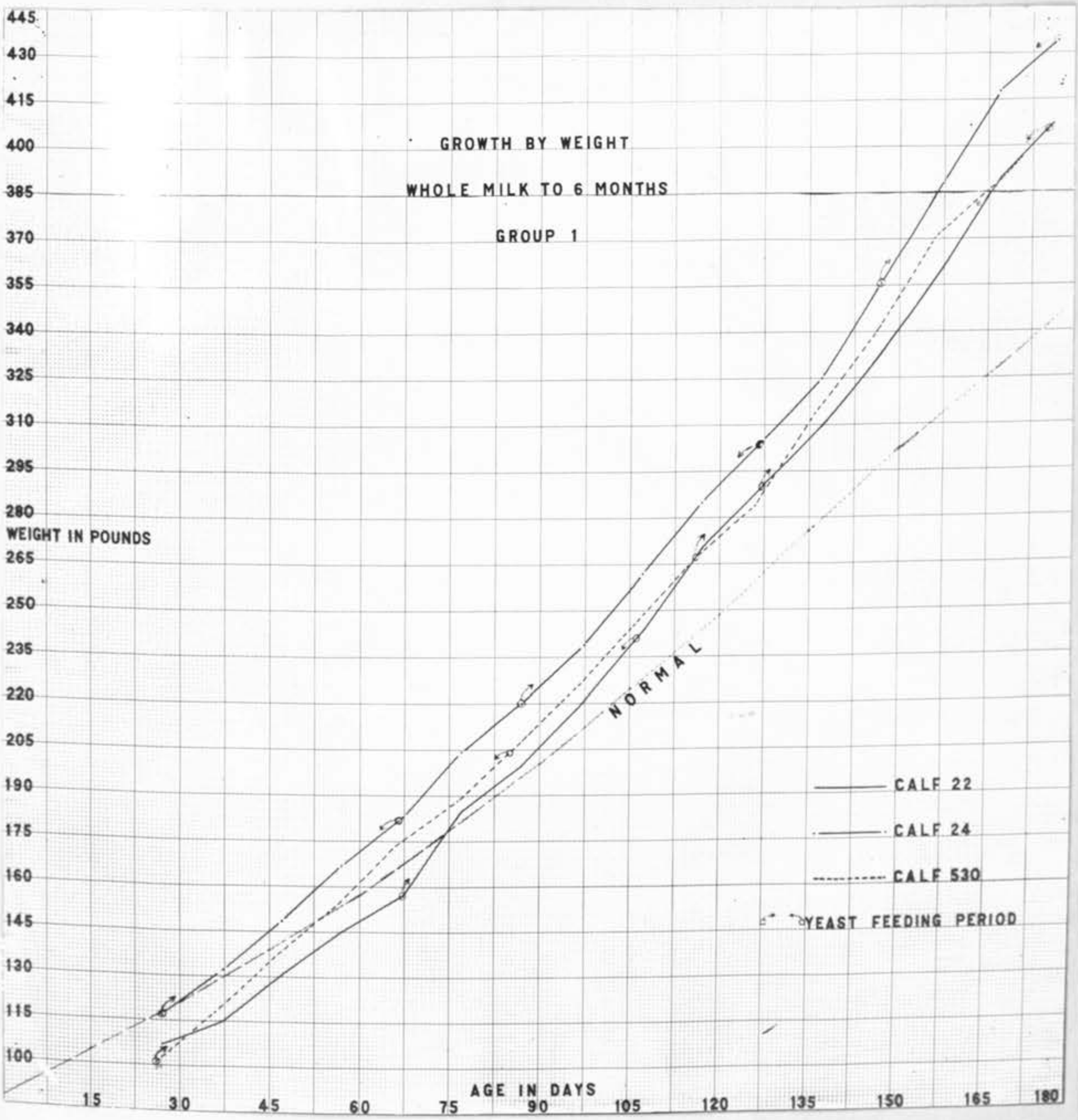
SUMMARY OF WEIGHTS, HEIGHTS AND GAINS
GROUP IIb*

Animal	Per cent normal in weight		Per cent normal in height		Average gain per month	
	Start	Finish	Start	Finish	Weight	Height
	Per cent	Per cent	Per cent	Per cent	lbs.	cm.
22	88.9	118.9	99.5	103.4	57.3	5.38
24	101.7	126.3	102.3	106.0	59.1	5.16
530	92.3	118.1	99.6	102.9	57.3	5.20
Average	94.3	121.1	100.4	104.1	57.9	5.24

* Taken from thesis for M.S. degree by J.W. Wilbur, University of Minnesota, 1921. Tables 5, 8, and 11.

These calves were fed whole milk, grain (corn 4, wheat bran 1 and oilmeal), alfalfa hay and 20 to 30 gm. of dried baker's yeast. They were kept on experiment about 5 months.

FIGURE 2 *



The calves in this group exceeded the normal curve at an early age. They contunued to increase above normal until the age of 180 days, when all were above the normal figure. The growth by weight was apparently unaffected by the feeding of yeast.

* Taken from Wilbur, J.W., Thesis--"The Relation of Vitamines to the Growth of Calves", 1921, graph 4.

milk throughout the experiments. Second, the animals in group IIb received yeast during intermittent periods without falling off any in the rate of growth between these periods. Unless, therefore, the effects carried completely over from one yeast-feeding period to the next, the extra rate of growth could not be due to the yeast alone.

Groups IIIa and IIIb.

These groups received a very good ration which consisted of skimmilk, alfalfa hay and a grain mixture of ground corn four parts, wheat bran one and oilmeal one. The calves in group IIIa, Y-1, Y-2 and Y-3 were used as controls for the calves in Group IIIb, Y-4, Y-5, Y-6, Y-7 and Y-8.

There was considerable difference between individuals as is shown in Table III, but the animals in Group IIIa all had a higher per cent normal weight at the finish than at the start while of those in Group IIIb, only one of the five showed a higher per cent normal in weight at the finish than at the start. Only two, however, of the five in Group IIIb were below normal in weight at the finish. The averages for the two groups show that Group IIIa gained 6 per cent faster than normal in weight during the experiment while Group IIIb lost 4.4 per cent of its gain over the normal.

All the animals in both groups were lower in height, when compared to the normal, at the finish than they were at the start. Group IIIa lost 0.6 per cent of its gain in height over the normal while Group IIIb lost 1.9 per cent.

The gains in weight and height per month likewise indicate an advantage for the controls. Group IIIa gained on the average 45.2 pounds and 4.73 cm in weight and height respectively while Group IIIb gained 42.2 pounds and 4.47 cm.

The number of animals used in these two groups was not large enough to warrant putting much significance on the average unless the individuals all showed the same tendencies. When the individuals are considered, it is notable that only one of the yeast-fed lot (excluding the gains made by the animals Y-2 and

TABLE III

SUMMARY OF WEIGHTS, HEIGHTS AND GAINS
GROUPS IIIa AND IIIb*

Animal	Per cent normal in weight		Per cent normal in height		Average gain per month	
	Start	Finish	Start	Finish	Weight	Height
Group IIIa	lbs.	lbs.	cm.	cm.	lbs.	cm.
Y-1	105.8	111.3	101.4	100.9	50.4	4.68
Y-2	103.1	107.5	100.9	100.4	33.3	4.96
Y-3	105.1	113.0	99.0	98.1	51.9	4.55
Average	104.6	110.6	100.4	99.8	45.2	4.73
Group IIIb						
Y-4	110.8	100.3	100.6	99.3	42.3	4.53
Y-5	118.0	116.8	102.4	102.2	51.6	4.83
Y-6	104.9	97.9	103.6	99.8	42.0	4.23
Y-7	98.4	105.2	103.3	99.8	48.0	4.28
Y-8	105.8	96.1	104.0	101.2	27.3	4.52
Average	107.6	103.2	102.3	100.4	42.2	4.47

* Receiving dried yeast as 10 per cent of ration

Y-8, which were taken off because of tuberculosis) made as great gains in weight as did those in the control groups, and, further, that this same calf, Y-5 was the only one of the yeast-fed group to attain the gains in height made by the control animals.

The general course of the growth curves (fig. 3 and 4) show much the same relationships between the two groups as the weight and height summaries. The curves represent the gain in weight (fig. 3) and height (fig.4) in per cent normal from the first ten day period to the sixteenth. All the animals in Group IIIa were above normal in weight by the middle of the third period and remained above throughout the experiment. Only one of the calves in Group IIIb, Y-5, stayed above normal in weight. The heights of the two groups did not show any definite tendency for a group. Both groups fell off some during the period when the change was made from whole to skimmilk, went up at the middle of the experiment and then fell off somewhat at the end of the experiment. The averages of the two groups show, when plotted, that the heights did not follow quite the same course as did the averages of the weights. The difference at the start was reduced somewhat in the first periods increased slightly about the middle of the experiment, and then reduced practically to nothing at the close.

It is not impossible that the choice of animals in this case resulted in the greater gains being made by the control group, but this might also be said of the previous case where the yeast fed animals, Group lb, showed a superiority over the controls in Group Ia. The differences between Groups IIIa and IIIb would indicate a stronger point against the value of yeast than the favorable effect indicated by the small difference between Groups Ia and Ib. If the two groups IIIa and IIIb alone were considered, yeast would appear to be a hindrance to growth.

FIGURE 3.
GROUPS IIIa AND IIIb

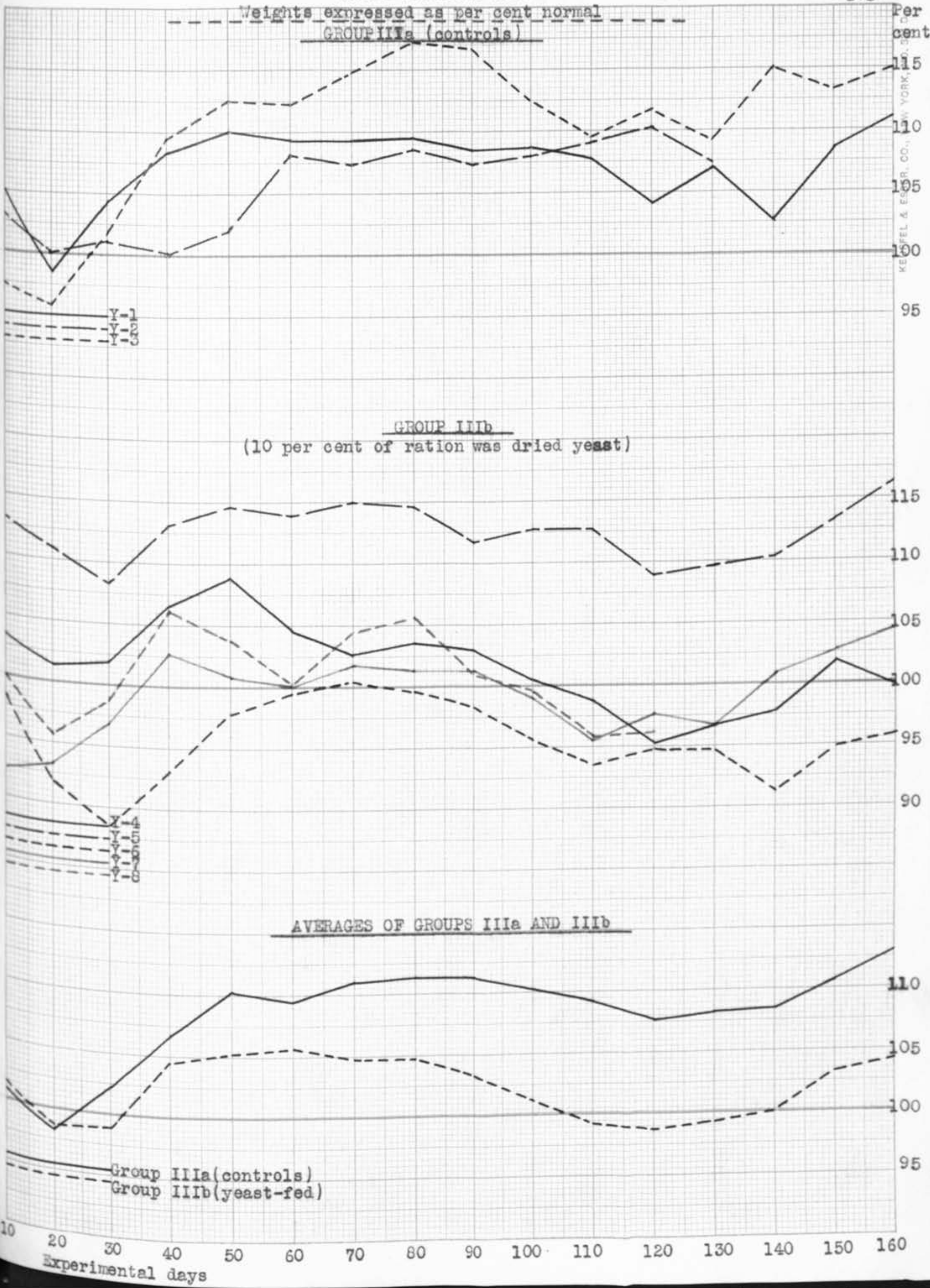
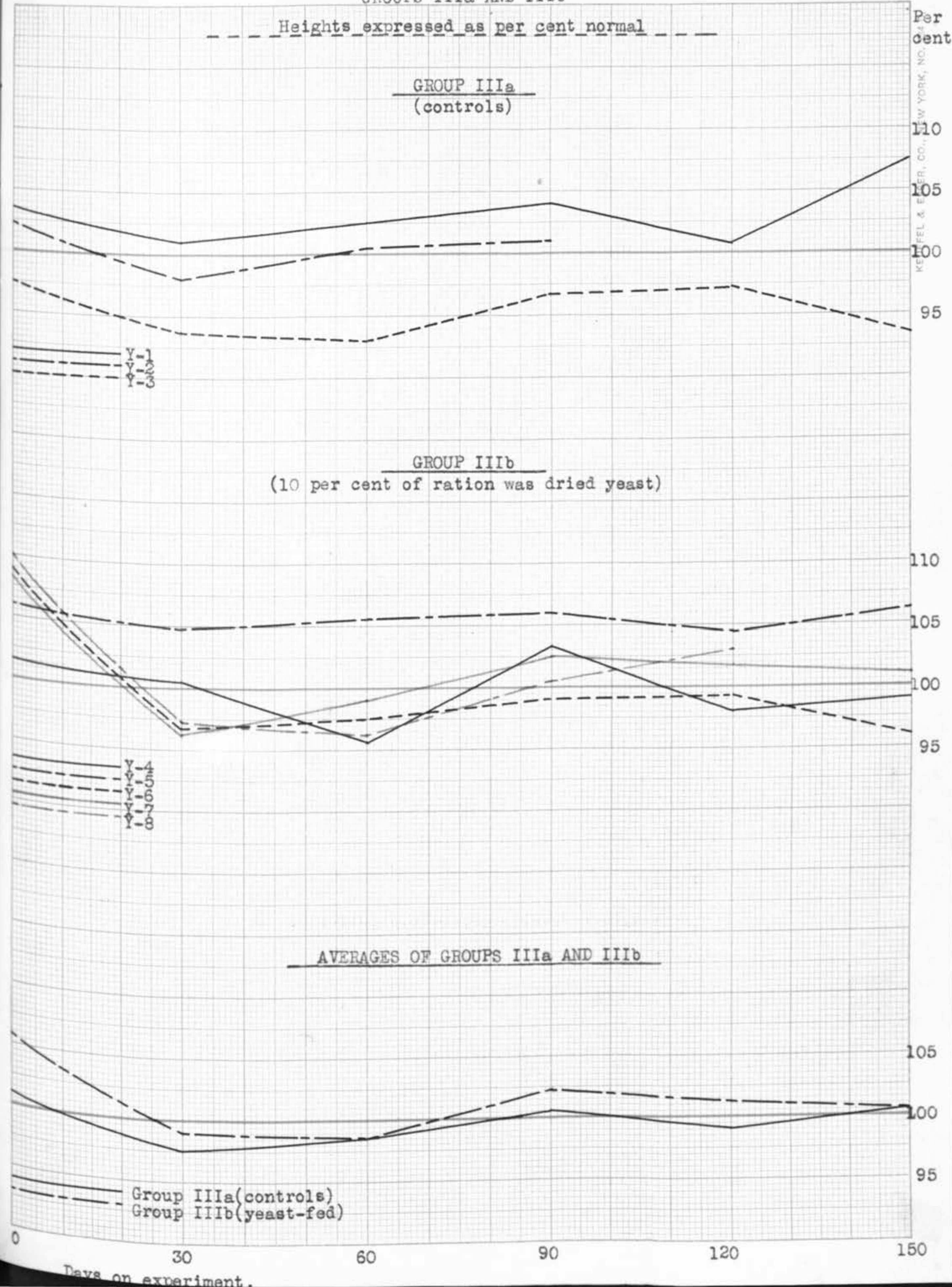


FIGURE 4.

GROUPS IIIa AND IIIb



Groups IVa and IVb.

These two groups were fed under much the same system as the Groups IIIa and IIIb but were given prairie hay in place of alfalfa and a grain mixture of corn and oats instead of the corn four parts, bran one, oilmeal one mixture. This ration is inferior to the one fed groups IIIa and IIIb in the amount and quality of proteins and in the amount of calcium and phosphorus compounds. It is used, however, by a great many dairymen in regions where leguminous hay is not plentiful and where feeds such as bran and oilmeal are not considered economical.

The individuals in these two groups varied widely, as did the calves in Groups Ia and Ib. When compared to the normal in weight (See Table IV) some in both groups went up and some went down, the averages of the two groups showing a slight advantage for Group IVb. Group IVa, started at 103.3 per cent normal in weight and finished at 104.3, a gain over the normal of one per cent, while Group IVb started at 105.5 and finished 108.4, a gain of 2.9 per cent over normal. This would indicate, if the groups were large enough to make the averages significant, that the yeast fed calves gained 1.9 per cent more over the normal in weight than did the controls.

The heights of the two groups showed about the same tendency, Group IVa averaging 98.7 per cent normal at the start and 100.4 at the finish, while Group IVb started at 100.0 and finished at 102.5

The gains per month ran about the same way, Group IVa gaining 47.1 pounds and 4.93 cm. in weight and height respectively, while Group IVb averaged 48.3 pounds and 5.09 cm in weight and height.

The general directions of the growth curves of the two groups in weight when compared to the normal were somewhat the same. All the calves in both groups took a drop because of digestive disturbances at the start and during the change from whole to skimmilk in the fourth period, rose again at about the middle of the experiment and then gradually descended at the close. It will be noticed, however,

TABLE IV

SUMMARY OF WEIGHTS, HEIGHTS AND GAINS
GROUP IVa AND IVb*

Animal	Per cent normal in weight		Per cent normal in height		Average gain per month	
	Start	Finish	Start	Finish	Weight	Height
Group IVa	lbs.	lbs.	cm.	cm.	lbs.	cm.
Y-9	99.3	108.5	99.8	102.2	50.1	5.12
Y-10	106.7	100.3	96.5	96.9	43.5	4.52
Y-11	103.6	101.9	100.3	101.5	48.8	5.22
Y-12	103.7	106.7	98.1	101.2	48.0	5.22
Average	103.3	104.3	98.7	100.4	47.1	4.93
Group IVb						
Y-13	103.4	109.4	100.2	102.8	49.5	5.10
Y-14	105.1	104.0	97.2	100.5	46.2	5.12
Y-15	114.5	111.4	101.9	104.8	47.4	55.20
Y-16	99.3	109.1	100.8	102.1	50.4	4.96
Average	105.5	108.4	100.0	102.5	48.3	5.09

* Receiving dried yeast as 10 per cent of ration (dry basis)

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FIGURE 5.
Groups IVa and IVb

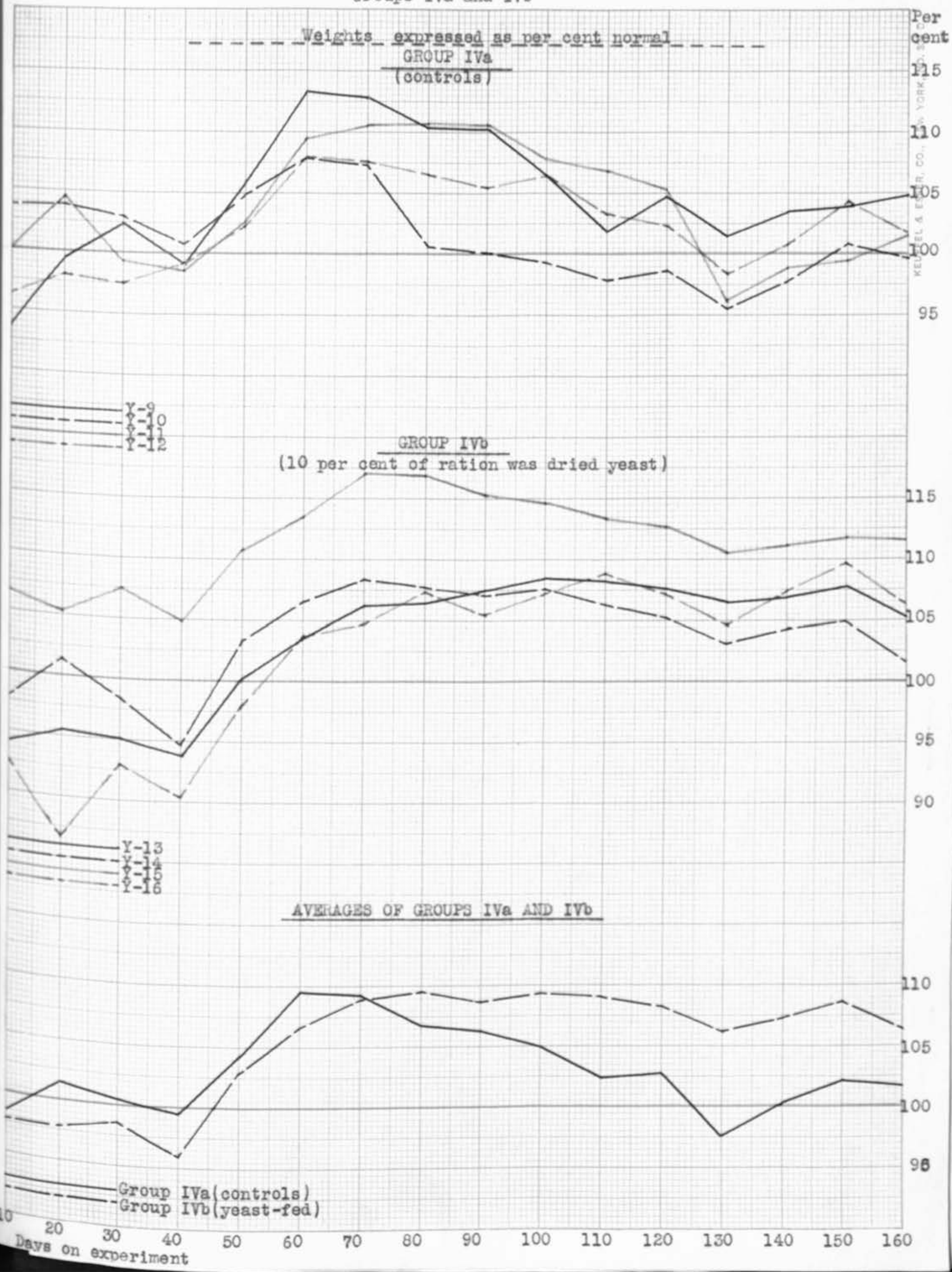
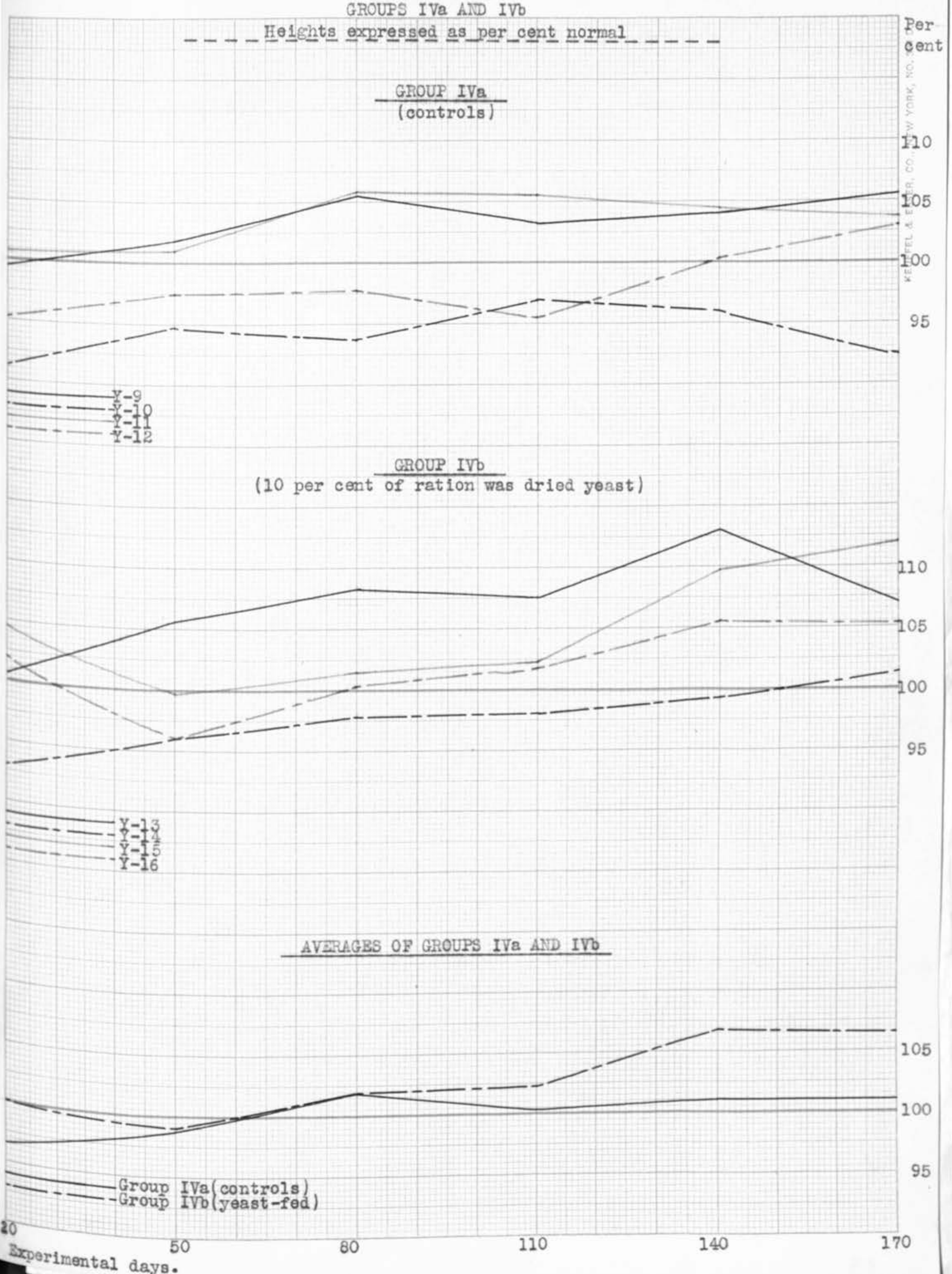


FIGURE 6.
GROUPS IVa AND IVb



that the calves in Group IVb all stayed above normal while three of Group IVa went below normal near the end and the fourth went very close to normal. The average curves show that Group IVb started below Group IVa, received a sharper setback during the change from whole to skimmilk, but in spite of this, passed Group IVa at about the middle of the experiment and finished well above.

The heights did not run in such a uniform direction as did the weights. The curves in fig. 6 showing the growth in height compared to normal for the two groups indicate that the heights varied considerably according to the individual. Most of the animals in Group IVb were farther above the normal at the close of the experiment than were the calves in Group IVa. The averages for the two groups in height would indicate that the two groups gained at about the same rate until the last two months, at which time the yeast-fed animals forged ahead of the controls.

The results obtained from these two groups show a slight superiority in the rate of growth in both weight and height by the yeast-fed animals. The differences between the two groups, however, are too small to be significant and could be attributed to chance in choosing the individuals with the same degree of justice as the differences between Groups IIIa and IIIb in favor of the controls might be considered the result of individual differences.

General discussion of results.

Considering the animals in these seven groups according to the experiment in which they were used, we find that: (1) in the University purebred herd where the calves were raised under normal conditions on a well-balanced, liberal ration, those receiving yeast as a supplement gained slightly faster in weight on the average than did the controls but slightly less in height; (2) a group of grade Holstein heifer calves fed liberally on whole milk, alfalfa hay and a grain mixture of corn, bran and oilmeal did not grow faster during the periods when they received yeast as a supplement to their ration but grew faster throughout the entire experiment than any other group; (3) in a group of grade Holstein heifers fed on skimmilk, alfalfa hay, and grain mixture of corn, bran and oilmeal, those receiving yeast in addition made less gains in both weight and height than did the controls; (4) of the grade Holstein calves fed on a ration of skimmilk, prairie hay and grain mixture of corn and oats, those receiving a yeast supplement made gains in both weight and height slightly greater than those made by the controls.

The averages of all these groups (Table V) show that the animals receiving yeast made slightly greater gains in weight, but, on the other hand, they made slightly less gains in height.

Some workers have suggested that vitamin B would make possible more efficient use of food so the energy consumed per pound of gain was also computed for three yeast-fed groups (IIb, IIIb and IVb) and two control groups (IIIa and IVa), Tables LXIII, LXIV and LXV -- see Appendix. The results of these computations did not seem to indicate any correlation between yeast feeding and the amount of energy consumed per pound of gain. The summaries of the averages of the different groups in Table VI show that Group IIb, the fastest growing group, used 3.49 therms of energy per pound of gain; Group IIIa, controls for the skimmilk plus good ration experiment used 2.64 therms per pound of gain while the yeast-fed calves, Group IIIb, used 2.84; and, in the fourth experiment, Group IVa, the controls, used 2.89 therms per pounds of gain while Group IVb used 2.87.

Of the four groups, IIIa, IIIb, IVa and IVb on experimental rations in our experiments, the controls used slightly less energy per pound of gain. Further, if Group IIb is included as it was in calculating the average gains on weight and height the average for the control animals would show a decidedly lower energy consumption per pound of gain in weight.

Wilbur (1921) also fed a group of calves on a skimmilk, alfalfa hay and good grain mixture using a yeast* supplement during intermittent periods, with

* A baker's yeast, dried.

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TABLE V

TOTAL SUMMARY OF AVERAGES OF WEIGHTS, HEIGHTS AND GAINS FOR ALL CALF GROUPS

Group with number of calves	Per cent normal in weight		Per cent normal in height		Average gain per month	
	Start	Finish	Start	Finish	Weight	Height
	lbs.	lbs.	cm.	cm.	lbs.	cm.
Ia (11)	100.0	104.5	102.2	101.9	43.0	4.88
Ib* (12)	101.2	107.8	104.6	102.8	45.3	4.37
IIb* (3)	94.3	121.1	100.4	104.1	57.9	5.24
IIIa (3)	104.6	110.6	100.4	99.8	45.2	4.73
IIIb* (5)	107.6	103.2	102.3	100.4	42.2	4.47
IVa (4)	103.3	104.3	98.7	100.4	47.1	4.93
IVb* (4)	105.5	108.4	100.0	102.5	48.3	5.09
Average for "a" groups	101.5	105.4	101.1	101.2	44.2	4.86
Average for "b" groups	102.3	108.6	102.8	102.4	46.7	4.62

* Yeast added to ration.

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TABLE VI

TOTAL SUMMARY OF ENERGY CONSUMED PER POUND GAINED
GROUPS IIb*, IIIa, IIIb*, IVa AND IVb*

Group with number of animals	Total gain weight	Total energy consumed	Energy consumed per pound gain
	lbs.	therms	therms
IIb* (3)	294	1027.7	3.49
IIIa (3)	257	685.9	2.64
IIIb* (5)	239	678.4	2.84
IVa (4)	267	773.8	2.89
IVb* (4)	276	794.1	2.87
Average of "a" groups	262	736.1	2.78
Average of "b" groups *	265	804.2	3.01

* Dried yeast added to ration

apparently no effect on the gains in weight during the periods of yeast-feeding (see fig. 7). To another group, he fed skimmilk supplemented with grain and hay for 60 days and then grain and hay alone. To the rations of these he added yeast for intermittent periods with no apparent effect on the increase in weight (fig. 8).

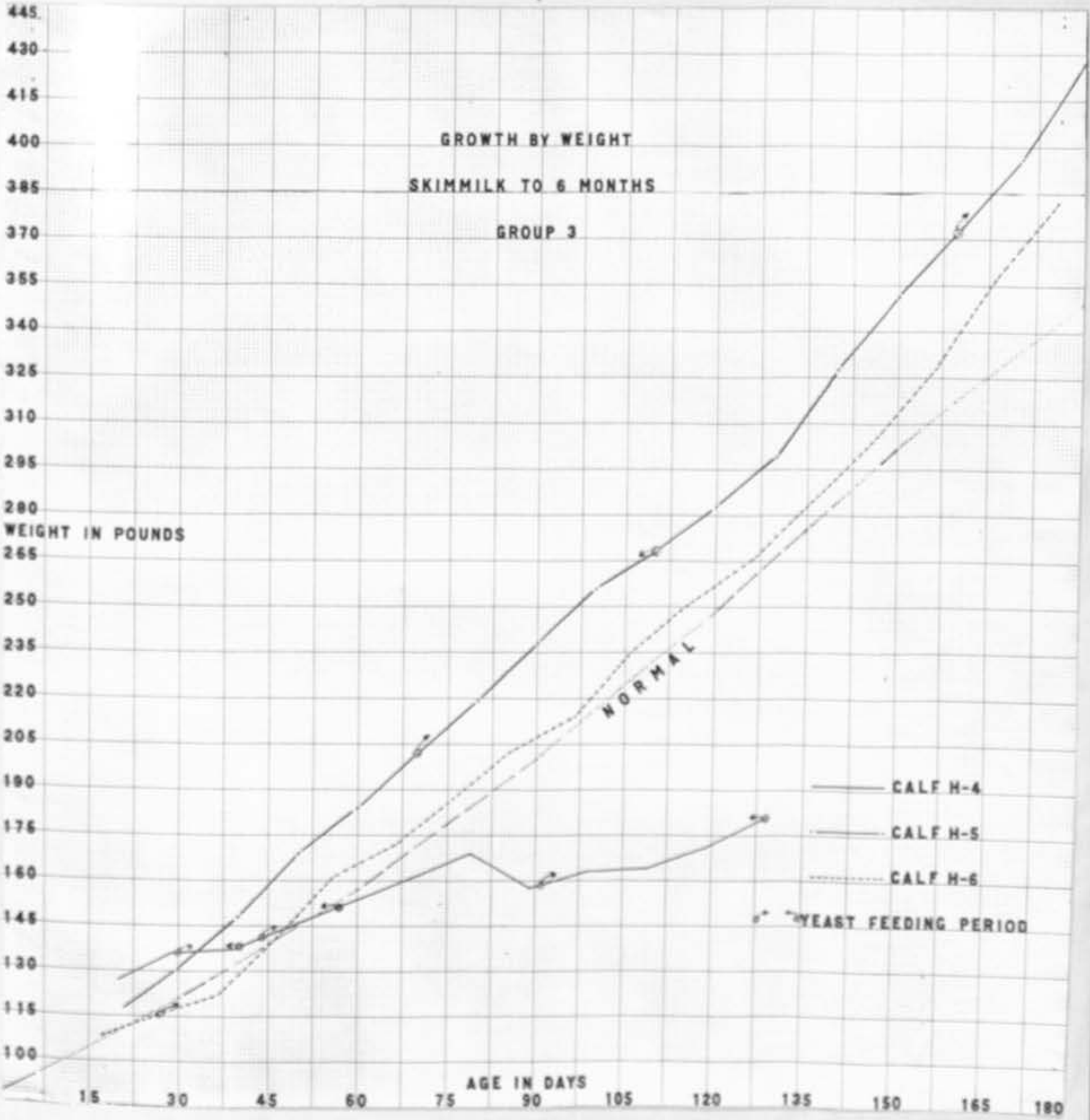
Summary.

The total results would seem to indicate that supplementing the rations which were fed to the calves used in these experiments with yeast did not result in an increase in the rate of growth in weight and height.

B. HEALTH OF CALVES

Yeast has been considered by some investigators to be an important adjuvant to the human dietary from the standpoint of improving the condition of the lower intestinal tract. Moreover, it is a well-known fact that a great deal of difficulty is experienced in calf raising when the calves are from one to six weeks old. Whether it is the unnatural diet the calf receives, because it is taken away from its mother; whether it is the overfeeding of milk owing to the high production of the mother or whether it is entirely due to infectious organisms or a combination of these three factors is not known. It is known, however, that digestive disturbances, indicated by diarrhea and foul odor of the feces, are extraordinarily common when the calf if passing through this so-called critical age. It was suggested by Wilbur (1921) that, "The yeast possibly aids in maintaining excellent health in young animals." This with the reported advantages of using yeast in the human diet, led us to believe that yeast might be a factor in preventing or curing some of the calf digestive disorders, either directly as a therapeutic or by increasing the resistance of the calf. The observations on the several groups of calves used in our experiments did not seem to indicate that yeast-feeding exerted any particularly noticeable effect upon the health of the calves.

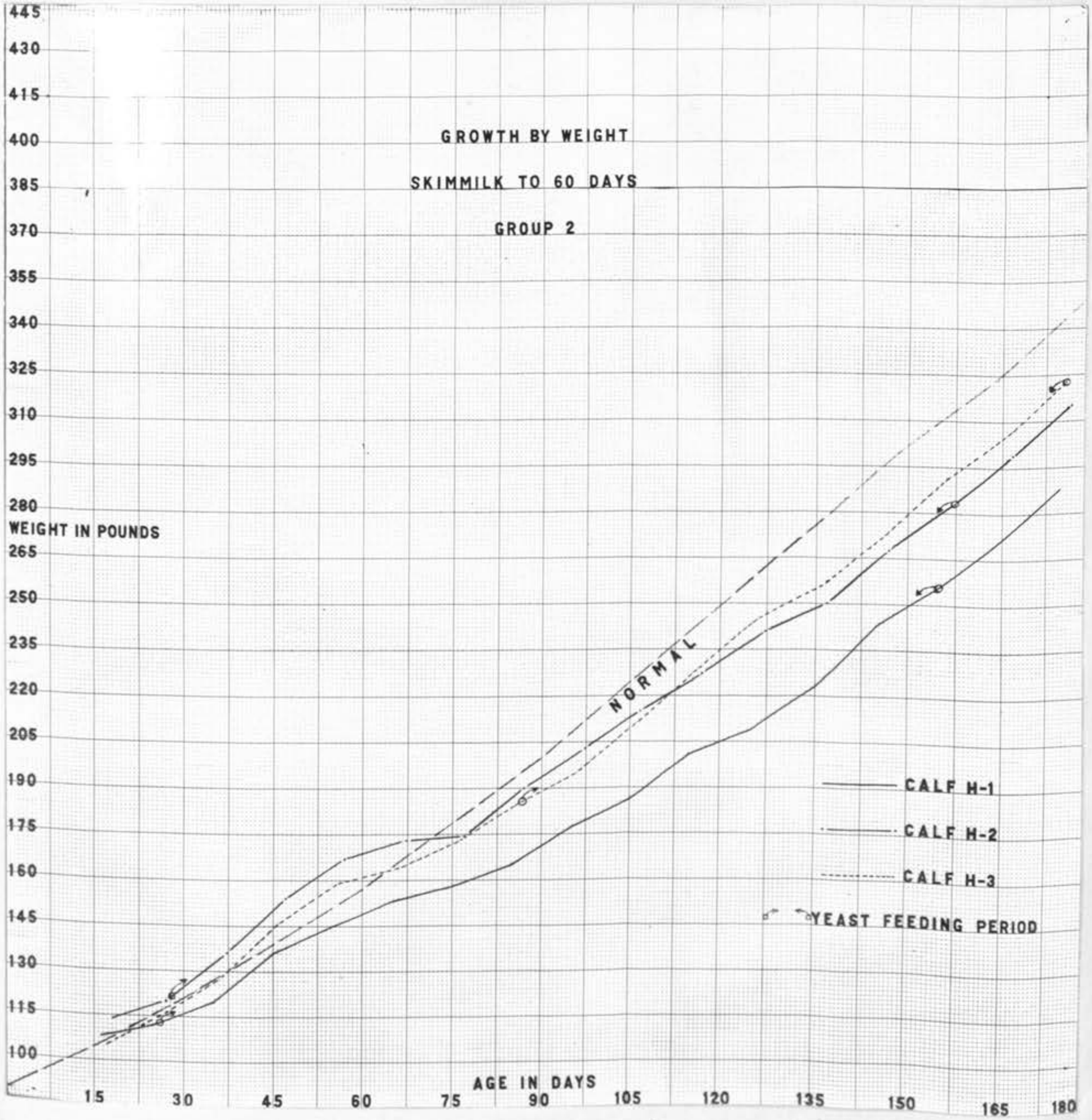
FIGURE 7



The curves of the two healthy animals exceeded the normal curve at an early age, and remained above the normal throughout the experiment. The short curve, which falls abruptly below the normal, is that of the animal which contracted pneumonia. The growth by weight was apparently unaffected by the feeding of yeast.

* Taken from Wilbur, J.W., Thesis--"The Relation of Vitamines to the Growth of Calves", 1921, graph 6.

FIGURE 8 *



The effect of weaning at an early age appears in a striking manner in these curves. All of the animals fell below normal during the weaning period, and the six or seven succeeding periods. The growth by weight was unaffected by the feeding of yeast.

* Taken from Wilbur, J.W., Thesis--"The Relation of Vitamines to the Growth of Calves", 1921, graph 5.

Groups Ia and Ib. -- University pure-bred calves.

The three calves in each of these two groups had scours but none of them had new cases after they were receiving a yeast supplement. Calf 320, on e of the control animals, had a mild case of scours during the time he had pinkeye, but this lasted only a few days, after which he appeared normal throughout the remainder of the experiment. Calf 365, another control animal, had the most severe disturbance of all the purebred calves. The disorder lasted for 27 days and left her in a very weakened condition. She recovered and practically regained the normal weight after having been as low as 76 per cent normal. A third control animal, Calf 516 had a mild case of scours when about 10 weeks old but recovered quickly.

Calf 8, one of the experimental animals, had a severe intestinal disturbance accompanied by feces of a watery consistency, for about a week before being put on experiment, but this condition disappeared after the yeast was fed for six days. Another experimental animal, Calf 513 had a similar disorder and was apparently cured in about the same space of time as Calf 8. Whether these two cases were cured so promptly as a result of the yeast being added to the ration cannot be definitely stated, but the calves showed sudden improvement the second day of the experiment. A third experimental animal, calf 364, had a mild scouring condition for two days before the experiment started but this appeared to be relieved the second day of the yeast-feeding.

The observations on these two groups seemed to indicate a possibility of diminishing the prevalence calf-scours by the use of yeast as a dietary supplement.

The smooth appearance of the first two animals put on the yeast-feeding experiments seemed to indicate that the yeast in some way improved the general health of the animal, but as the work progressed and more animals were added, it became increasingly clear that as far as general appearance was concerned, there was no difference between the yeast fed animals and the controls.

Groups IIIa and IIIb -- Grade Holstein heifers on skimmilk "good ration".

Both these groups were, in general, healthy throughout the experiment. Y-6, one of the experimental animals was the only one to exhibit any noticeable digestive disorders, and which were probably the result of a cold contracted at the start of the experiment. The trouble continued for three weeks after the yeast-feeding started so the yeast did not seem to possess any remarkably curative properties in this case. Y-2, one of the controls, a thrifty appearing calf, contracted tubercular pneumonia when the experiment had been running 130 days and died in 48 hours. As all but three of the calves in the experimental barn reacted positively to the tuberculin test about three months later, the death of Y-2 could hardly be attributed to the lack of yeast. Furthermore, Calf Y-8, one of the experimental animals, reacted positively to the tuberculin test at the same time as Calf Y-2 and was taken off the experiment.

In general, the control animals in this experiment, including Y-2 up to two days before her death, were more thrifty appearing than the yeast fed group. As far as the controlable factors were concerned, the only difference between the two groups was that the calves in Group IIIb received yeast as a supplement to their rations. If then, the general appearance of the calves were taken as a criterion of the effect of yeast-feeding, the results would indicate that yeast might have injured the health of the calves in Group IIIb. Plates 1 to 7 show however, there was little difference in appearance between the calves of the two groups at the close of the experiment.

Groups IVa and IVb. -- Grade Holstein heifers on skimmilk "poor ration".

All the animals in both these groups had slight digestive disturbances during the first two weeks of the experiment. The disorders may have been caused by the exposure in shipment and the interference with the feeding hours. The yeast-fed group seemed to suffer just as much as the controls. In fact, Calf Y-14 one of the yeast-fed group, had the most severe case. This animal was quartered in the coldest corner of the experimental barn and may have had more difficulty in throwing off the disturbance because of the exposure.

Y-11, one of the controls, was the only animal of both groups to have any noticeable digestive derangement after the first month of the experiment. She went off feed suddenly in the twelfth period and suffered from an acute diarrheal condition for about 36 hours, after which, her recovery was almost as sudden as the onset of the disorder. Y-10 another one of the controls had an abscess on her jaw which had to be operated upon but this could hardly be attributed to the lack of yeast.

One of each group, Y-12 and Y-14, reacted positively to the tuberculin reaction during the fourth period, and were moved to a quarantine barn. Their general appearance was as good, however, as that of the other calves on this experiment. Three more, Y-9 and Y-11 of the controls and Y-13 of the experimental animals, reacted positively in the thirteenth period but appeared thrifty throughout.

Considered as groups, the yeast-fed lot in this third experiment seemed to be more thrifty throughout most of the feeding test but at the close there was very little if any noticeable difference in the general appearance of the two groups.

Summary.

A review of the six groups in the three experiments shows that: (1) in the first experiment, which included the purebred calves, there seemed to be no difference in the general health of the calves between the yeast-fed animals and the controls, (2) the control animals in the second experiment appeared to be more thrifty than the yeast-fed lot and suffered less from intestinal disorders, and (3) the yeast-fed calves in the third experiment were more thrifty than the controls most of the time but suffered equally as much fromdigestive derangements.

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These results would seem to indicate that yeast failed to exert any particularly noticeable advantageous effects on the health of the calves in these experiments.

C. Experiments on Cows

The cows used in these experiments were divided into two groups and the data will be presented according to this grouping. Group Va includes cows 120, 301, 317 and 320, while Group Vb includes 102, 306, 333 and 500. Yeast was added to the rations of the two groups in alternate periods according to the "reversal" system so each group acted as a control for itself. They will not be spoken of, therefore, as "controls" and "experimental animals".

Histories of experimental animals.

Group Va.

120 -- purebred Jersey. This cow was a fairly high-producing animal having produced 278 pounds of butterfat in her first lactation period. The experiment started when she was four years old and included the sixty-seventh to the one-hundred-seventy-seventh days of her lactation period. She aborted a six months calf at the start of her last lactation period but was pronounced sound a week later. She was bred at the start of the experiment and was due to calve again 158 days after the end of the experiment. Her physical condition appeared to be good for she carried a medium amount of flesh at the start and gained sixty pounds during the experiment.

301 -- purebred Holstein. This cow was one of the highest producers in the University herd. She was thirteen years old and had produced the following amounts of butterfat during her eight lactation periods: 278,514; 474,502; 818, 554, 424 and 377 pounds respectively. She was producing about forty pounds of milk at the start and thirty-five at the end of the experiment, which included the ninety-eighth to the two-hundred-eighth days of her lactation period. She did not seem to be in excellent physical condition, being low in flesh and lame in the hind quarters and reacted positively to the tuberculin test about the middle

of the experiment. Nevertheless, she was a good feeder and gained sixty-five pounds during the experiment. It was necessary to pinch out a yellow body on the forty-fourth day of the experiment. She was bred three days later but did not become pregnant so was open at the close of the experiment.

317 -- purebred Holstein. This animal, a large, high-producing cow, was in her third lactation period. In her first lactation period she produced 614 pounds of butterfat and 443 in the second, this latter being cut short by an abortion. She was six years old and her 195th to 305th days of her lactation period were included in the experiment. Her general appearance indicated that she was in fine condition and as she was a good feeder, she gained 142 pounds in weight during the test. She was due to calve again in 42 days after the close of the experiment.

320 -- purebred Holstein. This cow was a fairly high producer, having produced 235, 535 and 347 pounds of butterfat during her first three lactation periods. Her production was about 28 pounds of milk at the opening of the experiment on her 307th day of lactation and 26 pounds a day at the close which was the 417th day of her lactation period. She was in good flesh at the start and, although she reacted positively to the tuberculin test in the middle of the experiment, was a heavy feeder and gained 50 pounds before the finish. The fetal membranes did not pass away after her last parturition so she was treated with uterine massage and therapogen flushing daily for three weeks. She was bred after a lapse of time sufficient to make her safe from infectious abortion and was due to calve 102 days after the close of the experiment.

Group Vb.

102 -- purebred Jersey. This cow was not a very high producer at the time of the experiment but had been in the past. In her first five lactation periods she produced 394, 615, 529, 415 and 160 pounds of butterfat. She was producing 13 pounds of milk a day on her 43d day of lactation at the start of the experiment, and, at the close 120 days later was producing 8.7 pounds. Her udder

was infected with a streptococcic mastitis during the second, third and fourth ten-day periods of the experiment. Furthermore, it was necessary to rupture cysts in her ovaries during the second period. Her production fell off but little following these affections and she gained 100 pounds in weight during the 120 experimental days. She was not with calf at the close of the experiment.

306 -- purebred Holstein. This was a splendid individual in type and production. She had dropped six calves, aborted twice, and had produced during seven lactation periods: 280, 304, 616, 611, 746 and 305 pounds of butterfat. She was in her twelfth year of age and the 191st to the 301st days of her lactation period during the experiment. Her appearance seemed to indicate that she was in good condition and she gained 100 pounds during the 120 days of the experiment. After several failures, she succeeded in becoming pregnant at the opening of the experiment and was due to calve 165 days after the close.

333 -- purebred Holstein. This cow was a medium high milker having produced 303 pounds of butterfat during her first lactation period. She was 4 years old and in the 184th to the 294th days of her lactation period during the experiment. Her general appearance indicated that she was in good health and she gained 100 pounds from the beginning to the end of the test. She was with calf at the opening of the experiment and was due to calf 42 days after the close.

500 -- purebred Guernsey. This was a high-producing, steady individual. In her six lactation periods she had produced: 264, 328, 367, 652, 506, and 240 pounds of butterfat, the last period being only 295 days. The experiment started when she was 12 years old and included the 42d to the 152d days of her lactation period. The fetal membranes did not completely pass away after her last parturition so she was treated with uterus massage and flushing with therapogen at four day intervals for a month. She was affected with footrot during the tenth ten-day period but seemed otherwise to be in good health and gained 50 pounds during the experiment. She was not bred until two weeks before the close of the experi-

ment so pregnancy would not have any effect on the results in her case.

Summary.

These cows, in general, were high producing, healthy animals, and could be considered as fairly representative of the high-producing cows in dairy herds. They were on experiment around the middle of their lactation periods so should have been expected to show the effects of any galactagog substances added to their rations.

Discussion of results on milk production

The object in adding yeast to the rations of a group of high producing purebred cows was to ascertain whether this addition would induce any increase in the milk yield. If the yeast possessed galactagog properties we should expect the milk flow to increase either through actual stimulation of the mammary glands or by stimulating digestive and assimilative efficiency. The former might cause an increased appetite to compensate for the increased secretion while the latter might make an increased secretion possible by furnishing the mammary glands and their associated organs with more nourishment. Our purpose was not to determine which of these two processes followed the addition of yeast. It was rather, to determine the effect by adding yeast alternately to the rations of two groups of cows according to the "reversal plan", as follows:

Group Va

1		2		3	
Experimental Ration		Basal ration		Experimental ration	
Preliminary period	Experimental period	Preliminary period	Experimental period	Preliminary period	Experimental period
10 days	30 days	10 days	30 days	10 days	30 days

Group Vb

1		2		3	
Basal Ration		Experimental Ration		Basal Ration	
Preliminary period	Experimental period	Preliminary period	Experimental period	Preliminary period	Experimental period
10 days	30 days	10 days	30 days	10 days	30 days

The only difference between the feeds was that the experimental ration included 25 gm. dried yeast per pound of milk produced daily.

The lactation curve for a large number of mature cows (Eckles and Warren,1918) shows that there is a gradual falling off in milk flow throughout the greater part of the lactation period. There is a rise following parturition and a sudden fall some time previous to the next time of calving, but the fall is quite uniform around the middle of the period. If then, the production of a group of cows were recorded for three successive months, near the middle of the lactation period, we would expect the average daily yield for the second month to be about equal to the average of the first and third. On the other hand, when a group of cows fed as Group Va, where yeast was added to the ration during the first and third periods, we would expect the average of these two periods to be higher than the second, providing the yeast exerted any stimulatory effect on the milk flow. Similarly, with cows fed as those in Group Vb, where yeast was added to the rations during the middle period, we should expect the average daily yield during this period to be higher than the average for the first and third.

The average daily milk yields shown in Table VII show that the yeast did not seem to exert the effect to be expected of galactagog substances.

Milk production by groups and individuals.

Group Va_ The records of feed consumed by the cows in this group are contained in Tables LXVI-LXIX; production in Tables LXXIV-LXXVII; and nutrients in ration in Tables LXXXII-LXXXV.

TABLE VII

SUMMARY OF PRODUCTION BY PERIODS
GROUPS Va and Vb

Animal	Milk per day			Butterfat per day		
	First 30-day period	Second 30-day period	Third 30-day period	First 30-day period	Second 30-day period	Third 30-day period
Group Va	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
120	24.46*	22.47	19.95*	1.181*	1.115	1.035*
301	39.84*	37.80	37.85*	1.135*	1.026	1.097*
317	23.06*	20.64	11.75*	0.872*	0.752	0.503*
320	27.41*	27.13	26.78*	0.922*	0.877	0.918*
Average	28.69*	26.51	24.08*	1.027*	0.942	0.888*
Average for three periods		26.42			0.949	
Group Vb						
102	10.99	8.46*	8.73	0.509	0.428*	0.456
306	33.89	32.17*	31.91	1.190	1.024*	0.988
333	34.20	31.32*	26.05	1.077	1.024*	0.875
500	32.57	29.13*	26.57	1.232	1.115*	1.078
Average	27.91	25.27*	23.31	1.002	0.897*	0.849
Average for three periods		25.49			0.916	

* Receiving 25 gm. dried yeast per lb. of milk

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Cow 120, showed a slightly higher yield during the period she received no yeast than she did, on the average, during the two yeast-feeding periods.

Cow 301, however, showed a somewhat higher yield on the average during the periods she received yeast than she did during the check period.

Cow 317 passed into the period of sudden fall in milk flow which precedes parturition so the average for the two yeast-feeding periods was considerably below the yield during the check period. This could be expected and would not indicate that the yeast did not act as a stimulator of milk secretion. It does indicate, however, that yeast did not prevent the falling off which is characteristic of a lactation curve preceding parturition.

Cow 320 acted in about the same way as did 120, that is, her milk flow during the check period was slightly higher than the average of the two yeast-feeding periods.

The averages of this group for the three periods show that the milk yield was a little higher during the check period than it was during the two yeast-feeding periods, but, that the butterfat yield was slightly less during the check period.

Group Vb -- The records of feed consumed by the cows in this group are contained in Tables LXX - LXXIII production in Tables LXXVIII-LXXXI; and the nutrients in the rations in Tables LXXXVI-LXXXIX.

The cows in this group were fed the ordinary herd ration with yeast as a supplement during the second experimental period.

Cow 102 produced considerably less per day during the yeast-feeding period than during the other two. She had maintained quite a uniform production for some time owing to the fact that she had reached a low plane in her yield and was not carrying a calf. She was infected with a streptococcic mastitis at the end of the first period, which caused a falling off in milk flow. This reduction in yield extended into the yeast-feeding period so the decrease should not be attributed entirely to the yeast.

Cow 306 also milked slightly more during the check periods on the average than she did in the period when she was receiving yeast.

Cow 333, like 317 of Group Vb ran into the sharp decline in production, which is characteristic previous to parturition, during the third experimental period. This probably was a factor in making the average of the first and third periods lower than the second or yeast-feeding period.

Cow 500 was like 102 and 306 in that she produced slightly less during the yeast-feeding period than she did during the two check periods.

The averages for Group Vb in the three periods show the yield of both butterfat and milk a little higher during the check periods than during the yeast-feeding period.

Energy consumption.

The suggestion that yeast might increase the efficiency of the digestive and assimilative processes suggests in turn the possibility of economy of production being increased by the use of yeast. The records of the energy consumed per pound of milk produced during the yeast-feeding periods, when contrasted with the same for the check periods (Table VIII) do not indicate that yeast had any effect onthe energy consumption. As a matter of fact, the average of the two groups shows that a slightly larger amount of energy was consumed per pound of milk produced, during the yeast-feeding periods than during the check periods. The individuals varied, as would be expected, because of differences in body size and the amount of milk produced. The variation between the energy consumption during the yeast-feeding check periods is too small, however, to be significant. Consequently in this experiment there was no correlation between yeast-feeding and the amount of energy consumed per pounds of milk produced.

Summary.

The individual cows in the two Groups, Va and Vb, varied somewhat in their productions, but, in general, their curves of lactation were unaffected by

TABLE VIII

SUMMARY OF MILK YIELD AND ENERGY* CONSUMED
GROUPS Va AND Vb

Animal	Periods of yeast** feeding			Periods of no yeast feeding		
	Total milk	Total energy	Energy per lb. of milk	Total milk	Total energy	Energy per lb. of milk
Group Va	lbs.	therms	therms	lbs.	therms	therms
120	1232	1026	0.83	674	521	0.77
301	2330	1519	0.65	1134	742	0.65
317	1044	1132	1.08	619	586	0.94
320	1625	1239	0.76	813	643	0.79
Average	1557	1229	0.78	810	623	0.76
Group Vb						
102	253	368	1.52	596	737	1.23
306	965	740	0.76	1974	1405	0.71
333	939	693	0.73	1807	1279	0.70
500	873	645	0.73	1773	1242	0.70
Average	757	616	0.81	1470	1165	0.79
Grand average	1157	922	0.79	1140	894	0.78

* Calculated from Armsby, H.P.-- Nutrition of Farm Aniamls, The MacMillan Co. N. Y. 1917, p.715

** Received 25 gm. dried yeast per lb. milk the yeast-feeding (see fig.19). The average production for both groups during the yeast feeding was slightly lower than during the check periods but not enough to indicate that yeast inhibited milk secretion. The energy consumed per pounds of milk produded, likewise, seemed to be unaffected by the addition of yeast to the ration. It is evident, therefore, in these experiments, that supplementing the rations with dried yeast had no effect on the milk production.

GENERAL SUMMARY

The vitamin B requirements for the bovine have not yet been determined. In the absence of these determinations, the assumption was made at the start of the experiments that the bovine requirements for this vitamin approximated those of the albino rat. If this assumption is correct, the rations fed to calves and cows in good dairy herds contain an adequate supply of this factor. The general purpose of the experiments, then, was to ascertain what effect the addition of an extra amount of B vitamin (using dried yeast as a source) would have on the following:-

(1) the growth of calves,

(2) the health of calves,

(3) milk production of cows,

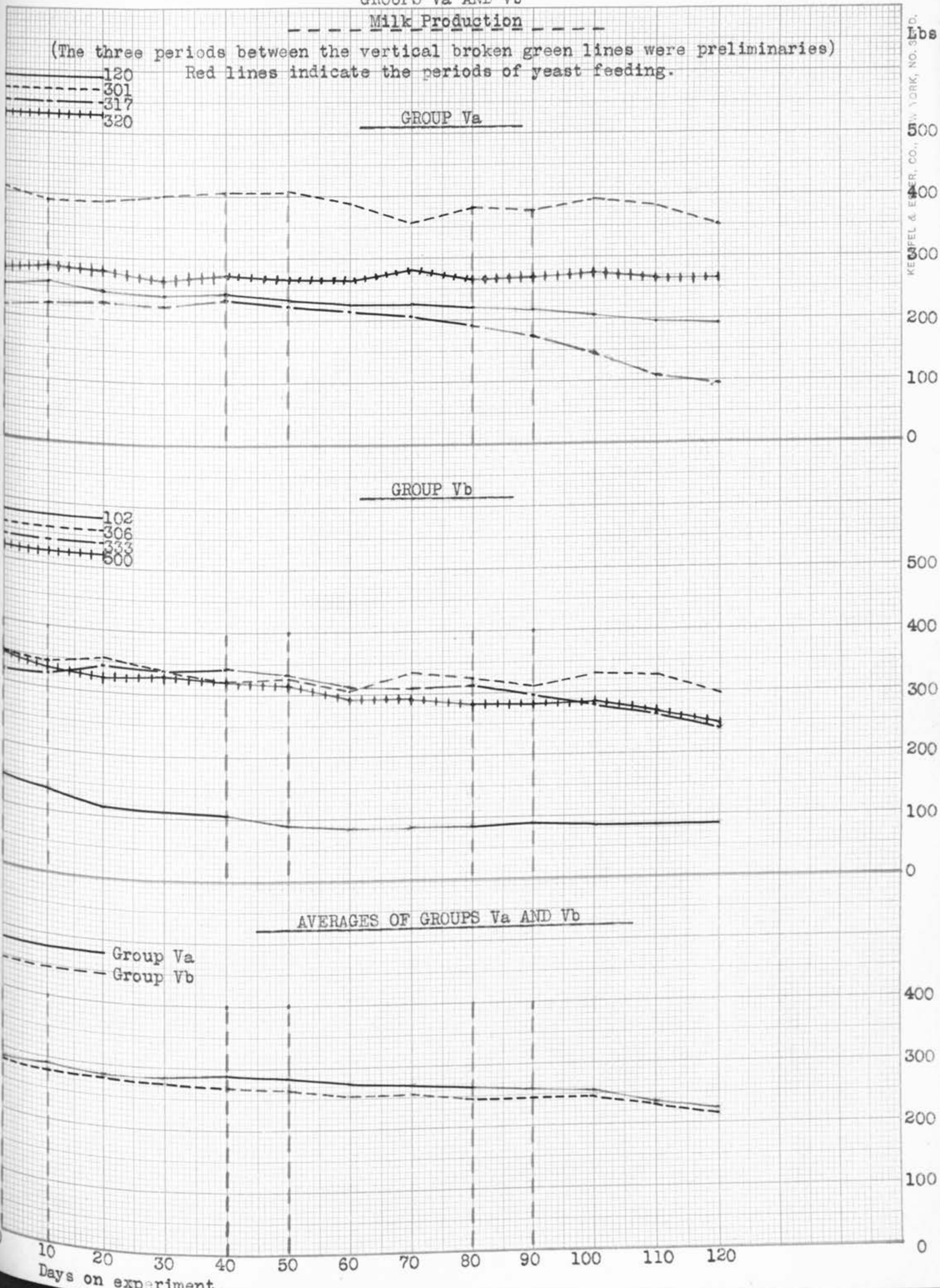
(4) the vitamin B content of milk.

To determine the effect on the growth of the calves the following experiments were carried out:

(1) Yeast was added to the ration of twelve of the University purebred dairy calves raised otherwise in the same manner as the other calves. The growth of these calves was compared with that of eleven others raised in the same manner which did not receive yeast. There was no difference between these two groups.

(2) Five of a lot of eight grade Holstein calves receiving skim-milk, alfalfa hay and a good grain mixture were given a dried yeast

FIGURE 9.
GROUPS Va AND Vb



supplement composing 10 per cent of the dry matter in their rations. The yeast-fed calves grew no faster than the control animals.

(3) Eight grade Holstein heifer calves were fed skimmilk, prairie hay and a poor grain mixture. Four of these received a yeast supplement making up 10 per cent of the dry matter in their rations. No significant difference was observed between the rates of growth of those receiving the yeast and the others.

The effect of yeast on the health of the calves was determined by their general appearance and the prevalence of sickness. There was no noticeable difference in general appearances of the two groups and the yeast-fed calves suffered equally as much from illness as did the control animals.

To measure the effect on milk production, the rations of two groups of four purebred, high-producing cows were supplemented with yeast during alternate periods according to the "reversal" system. There was no increase in production during the yeast-feeding periods.

The experiment to determine what effect the addition of yeast to the ration would have upon the vitamin B content of the milk consisted in feeding two cows the ordinary herd ration and two others a ration of straw, beet pulp, gluten feed and a small amount of oats. One of each of these two pairs was given a yeast supplement in addition. The milk produced was fed to albino rats at different levels to ascertain how much was needed to satisfy their B vitamin requirements. The work has not been finished at this writing but the completion of the test on several rats indicated that there was no striking difference between the milk produced by the cows receiving yeast and that yielded by the control animals.

C O N C L U S I O N S

1. The addition of vitamin B_1 in the form of dried yeast to the supply of this factor already present in the rations ordinarily fed on dairy farms, did not influence the rate of growth in young calves.

2. No effect was observed on the health of calves as a result of supplementing their rations with dried yeast.

3. Adding a dried yeast preparation at the rate of twenty-five grams per pound of milk produced, to a ration commonly fed to cows in good dairy herds did not increase the yield of milk or butterfat.

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A P P E N D I X

TABLE IX
DESCRIPTION OF CALVES ON EXPERIMENT

Number	Breed	Sex	Age at start	Experiment
Group Ia			days	days
19	Ayrshire	Female	31	120
102	Jersey	Male	22	120
144	"	Female	30	120
320	Holstein	Male	24	120
362	"	Female	20	120
365	"	"	11	120
366	"	"	9	120
367	"	"	28	120
502	Guernsey	Male	26	120
516	"	"	9	120
526	"	Female	29	120
Group Ib				
8	Ayrshire	Male	20	120
17	"	Female	95	120
18	"	"	67	120
142	Jersey	"	121	120
143	"	"	76	120
145	"	"	21	120
301	Holstein	Male	16	120
363	"	Female	16	120
364	"	"	13	120
500	Guernsey	Male	21	120
513	"	"	18	120
524	"	Female	22	120
Group IIb				
22	Holstein	Female	27	156
24	"	"	27	156
530	"	"	26	154
Group IIIa				
Y-1	Holstein	Female	19	170
Y-2	"	"	18	120
Y-3	"	"	17	170
Group IIIb				
Y-4	Holstein	Female	16	170
Y-5	"	"	21	170
Y-6	"	"	18	170
Y-7	"	"	19	170
Y-8	"	"	18	120
Group IVa				
Y-9	Holstein	Female	23	170
Y-10	"	"	27	170
Y-11	"	"	25	170
Y-12	"	"	23	170
Group IVb				
Y-13	Holstein	Female	28	170
Y-14	"	"	28	170
Y-15	"	"	31	170
Y-16	"	"	21	170

The small b indicates groups receiving yeast, while a means control group.
Ia and Ib are the purebred herd calves-the other groups are grades.
IIb received whole milk plus good ration; IIIa and IIIb received skimmilk plus good ration; IVa and IVb received skimmilk plus poor ration.

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TABLE X

DESCRIPTION OF COWS ON EXPERIMENT

Number	Breed	Age	Calved before experiment	Due to calve after experiment
Group Va		years	days	days
120	Jersey	4	77	158
301	Holstein	13	108	open
317	"	6	205	42
320	"	6	317	102
Group Vb				
102	Jersey	12	53	open
306	Holstein	11	201	165
333	"	4	194	42
500	Guernsey	12	52	open

The small a indicates experimental group which was on yeast first and last experimental periods, while b indicates control group which was on yeast only during second period.

TABLE XI

GROWTH IN WEIGHT EXPRESSED AS PER CENT NORMAL*
GROUP Ia**

Animal	Birth	Start	First month	Second month	Third month	Fourth month
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
19	110.3	91.0	93.0	93.8	94.4	96.0
102	100.0	85.2	95.6	104.1	111.5	111.8
144	98.1	92.9	103.9	97.1	100.6	101.3
320	101.1	93.9	114.6	121.7	128.3	129.3
362	112.2	101.0	108.2	113.1	120.8	119.9
365	83.3	76.0	88.0	88.5	94.9	99.1
366	85.5	93.6	98.6	102.4	107.5	109.6
367	83.3	99.1	93.1	89.2	87.9	88.1
502	140.0	116.6	116.7	110.1	100.8	89.0
516	141.8	122.3	112.2	96.9	87.2	88.1
526	156.1	128.8	116.3	115.9	118.6	117.5
Average	110.3	100.0	103.7	102.9	104.7	104.5

* Eckles, C.H.--The Normal Growth of Dairy Cattle, Mo. Expt. Sta. Bul., 36, p. 8-13

** University Farm herd calves used as controls

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TABLE XII

GROWTH IN HEIGHT EXPRESSED AS PER CENT NORMAL*
GROUP Ia**

Animal	Start	First month	Second month	Third month	Fourth month
	Per cent	Per cent	Per cent	Per cent	Per cent
19	103.2	100.5	103.3	104.5	104.3
102	103.2	99.7	101.9	103.8	104.3
144	101.9	99.8	100.8	99.1	101.1
320	102.6	102.5	105.2	104.4	104.5
362	104.0	100.8	102.8	104.0	104.8
365	97.2	95.4	96.7	97.6	98.8
366	100.6	101.6	99.7	106.4	105.5
367	98.0	98.4	97.4	94.4	95.7
502	105.0	103.6	102.0	100.4	96.0
516	100.2	106.8	101.7	102.1	100.1
526	108.8	110.0	107.4	107.4	105.9
Average	102.2	101.7	101.7	102.1	101.9

* Eckles, C.H.--The Normal Growth of Dairy Cattle, Mo. Expt. Sta. Bul., 36, p. 8-13

** University Farm herd calves used as controls

TABLE XIII

GROWTH IN WEIGHT EXPRESSED AS PER CENT NORMAL *
GROUP Ib**

Animal	Birth	Start	First month	Second month	Third month	Fourth month
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
8	101.4	95.5	91.9	92.3	96.5	101.6
17	89.8	86.6	96.2	98.1	116.9	122.4
18	76.8	74.1	82.6	79.9	89.5	95.1
142	90.9	90.8	91.4	98.5	101.2	102.7
143	89.1	96.7	101.9	98.9	102.7	105.6
145	107.2	95.6	105.9	100.3	103.7	104.0
301	110.0	109.8	114.1	117.8	112.3	109.9
363	128.8	116.1	120.7	123.4	132.3	128.7
364	98.8	94.1	101.0	105.9	111.2	107.3
500	138.1	110.4	113.3	109.7	109.8	100.6
513	125.0	110.6	113.4	99.2	97.2	96.6
524	138.1	134.9	130.6	122.5	123.7	119.0
Average	107.8	101.2	105.2	103.8	108.0	107.8

* Eckles, C.H.--The Normal Growth of Dairy Cattle, Mo. Expt. Sta. Bul., 36, p. 8-13

** University Farm herd calves receiving 100 gm. dried yeast daily

TABLE XIV

GROWTH IN HEIGHT EXPRESSED AS PER CENT NORMAL *
GROUP Ib**

Animal	Start	First month	Second month	Third month	Fourth month
	Per cent	Per cent	Per cent	Per cent	Per cent
8	106.4	98.7	99.8	101.2	101.7
17	100.9	104.3	100.4	102.0	100.5
18	98.5	101.1	100.6	96.6	100.3
142	101.5	98.9	101.3	104.3	99.0
143	101.3	101.3	101.8	100.3	100.4
145	103.0	98.7	101.1	100.7	101.1
301	108.1	108.8	111.0	108.3	105.1
363	108.1	101.7	107.3	108.7	109.0
364	102.7	101.5	101.9	102.9	101.8
500	104.6	107.4	105.5	104.1	103.5
513	105.2	106.1	104.2	103.6	100.9
524	115.1	111.8	114.7	111.4	110.8
Average	104.6	103.8	104.1	103.6	102.8

* Eckles, C.H.-The Normal Growth of Dairy Cattle, Mo. Expt. Sta. Bul., 36, p. 8-13

** University Farm herd calves receiving 100 gm. dried yeast daily

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TABLE XV

FEED CONSUMED PER PERIOD
GROUP IIIa
CALF Y-1

10-day period	Whole milk	Skim milk	Grain*	Alfalfa hay	Gain in weight
	lbs.	lbs.	lbs.	lbs.	lbs.
1	83	0	1.5	0	10
2	45	45	3.0	2.0	4
3		100	9.0	3.0	20
4		106	22.5	6.0	19
5		118	24.0	13.5	18
6		130	24.0	22.5	14
7		132	28.5	15.0	16
8		140	27.0	16.5	18
9		149	25.5	24.0	16
10		160	27.0	27.0	18
11		160	30.0	30.0	17
12		160	30.0	19.5	8
13		160	31.5	31.0	28
14		160	35.5	35.0	3
15		160	40.0	36.5	35
16		160	40.0	40.0	26
17		160	40.0	41.0	16
Total	128	2445	439.0	362.5	286

*Grain mixture- 4 parts ground corn
1 part wheat bran
1 part linseed oilmeal (Old Process)

TABLE XVI

FEED CONSUMED PER PERIOD
GROUP IIIa
CALF Y-2

10-day period	Whole milk	Skim milk	Grain*	Alfalfa hay	Gain in weight
	lbs.	lbs.	lbs.	lbs.	lbs.
1	83	0	1.5	0	7
2	45	45	4.5	1.5	13
3		100	7.5	3.0	12
4		106	22.5	4.5	14
5		116	28.5	7.5	24
6		130	28.5	13.5	14
7		132	30.0	18.0	18
8		140	28.5	15.5	15
9		149	30.0	15.0	19
10		160	30.0	22.5	20
11		160	30.0	27.0	22
12 **		160	30.0	22.5	12
Total	128	1398	271.5	160.5	190

*Grain mixture - 4 parts ground corn
1 part wheat bran
1 part linseed oilmeal (Old Process)

** Died of tubercular pneumonia

12-21-6M

TABLE XVII

FEED CONSUMED PER PERIOD
GROUP IIIa
CALF Y-3

10-day period	Whole milk	Skim milk	Grain*	Alfalfa hay	Gain in weight
	lbs.	lbs.	lbs.	lbs.	lbs.
1	81	0	1.5	0.5	2
2	54	36	0.3	0.5	9
3		100	22.5	1.5	20
4		118	28.5	5.0	24
5		130	27.0	12.0	20
6		132	30.0	16.5	16
7		140	30.0	17.0	21
8		149	30.0	18.0	23
9		160	30.0	15.0	18
10		160	30.0	30.0	9
11		160	30.0	27.0	11
12		160	31.5	31.0	26
13		160	35.5	35.0	12
14		160	40.0	39.0	36
15		160	40.0	40.0	12
16		160	40.0	41.0	24
17		160	42.5	50.5	12
Total	135	2245	489.3	379.5	295

*Grain mixture- 4 parts ground corn
1 part wheat bran
1 part linseed oilmeal (Old Process)

TABLE XVIII

FEED CONSUMED PER PERIOD
GROUP IIIb
CALF Y-4

10-day period	Whole milk	Skim milk	Grain*	Alfalfa hay	Dried** yeast	Gain in weight
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1	83	0	1.5	0	1.3	3
2	45	45	4.5	1.5	1.1	9
3		100	9.0	3.0	1.1	13
4		106	21.6	1.5	3.5	19
5		118	24.3	.5	3.8	18
6		130	21.6	9.0	3.5	8
7		132	27.0	10.5	4.1	12
8		140	20.4	8.0	3.6	17
9		149	25.5	7.5	4.5	16
10		160	25.5	4.5	4.5	11
11		160	22.8	21.0	5.7	13
12		160	24.0	15.0	6.0	7
13		160	25.2	17.0	6.3	21
14		160	28.0	25.5	7.0	20
15		160	28.0	30.0	7.0	28
16		160	28.0	14.0	7.0	9
17		160	28.0	23.5	8.0	16
Total	128	2200	364.9	192.0	78.0	240

* Grain mixture- 4 parts ground corn
1 part wheat bran
1 part linseed oilmeal(Old Process)

** Corn meal preparation with about 3 per cent yeast

TABLE XIX

FEED CONSUMED PER PERIOD
GROUP IIIb
CALF Y-5

10-day period	Whole milk	Skim milk	Grain*	Alfalfa hay	Dried** yeast	Gain in weight
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1	83	0	1.5	0	1.3	6
2	45	45	4.5	1.5	1.1	11
3		100	9.0	1.5	1.1	9
4		106	23.0	3.0	3.6	21
5		118	25.7	5.0	3.9	19
6		130	25.7	13.5	3.9	15
7		132	25.7	12.0	3.9	19
8		140	24.3	19.0	4.3	18
9		149	21.7	15.0	3.8	12
10		160	25.5	12.5	4.5	20
11		160	22.5	28.5	5.7	21
12		160	24.0	25.5	6.0	9
13		160	25.2	29.5	6.3	21
14		160	28.4	35.0	7.1	19
15		160	32.0	36.5	8.0	28
16		160	32.0	34.0	8.0	28
17		160	32.0	41.0	8.0	17
Total	128	2200	383.0	313.0	80.5	293

* Grain mixture- 4 parts ground corn
1 part wheat bran
1 part linseed oilmeal (Old Process)

** Corn meal preparation with about 3 per cent yeast

TABLE XX

FEED CONSUMED PER PERIOD
GROUP IIIb
CALF Y-6

10-day period	Whole milk	Skim milk	Grain*	Alfalfa hay	Dried ** yeast	Gain in weight
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1	88		1.5	0	1.1	3
2	54	36	4.5	.5	1.1	3
3		97	5.4	0	1.7	6
4		108	14.9	3.0	2.7	18
5		111	24.3	6.0	3.8	21
6		124	27.0	3.0	4.1	17
7		138	25.5	7.0	4.5	16
8		149	25.5	6.0	4.5	14
9		160	24.3	7.5	4.3	13
10		160	22.8	24.0	5.7	10
11		160	24.0	25.5	6.0	11
12		160	25.2	31.0	6.3	20
13		160	28.0	32.0	7.0	16
14		160	28.0	31.5	7.0	5
15		160	28.0	14.0	7.0	26
16		160	28.4	35.0	7.1	18
17		160	32.0	39.0	8.0	21
Total	142	2203	369.3	265.0	81.9	238

* Grain mixture- 4 parts ground corn
1 part wheat bran
1 part linseed oilmeal (Old Process)

** Corn meal preparation with about 3 per cent yeast

TABLE XXI

FEED CONSUMED PER PERIOD
GROUP IIIb
CALF Y-7

10-day period	Whole milk	Skim milk	Grain*	Alfalfa hay	Dried** yeast	Gain in weight
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1	88		1.5	0	1.1	3
2	54	36	4.5	.5	1.1	12
3		100	10.8	0	2.3	16
4		118	14.9	2.5	2.7	21
5		130	20.0	1.5	3.3	11
6		132	25.7	3.0	3.9	13
7		140	21.5	6.0	4.0	18
8		149	21.7	6.0	3.8	13
9		160	24.3	4.5	4.3	19
10		160	24.0	18.0	6.0	11
11		160	24.0	19.5	6.0	9
12		160	25.2	26.0	6.3	23
13		160	28.0	26.0	7.0	14
14		160	28.0	30.0	7.0	29
15		160	28.0	32.0	7.0	22
16		160	28.4	33.5	7.1	22
17		160	32.0	39.0	8.0	17
Total	142	2245	362.5	248.0	80.9	273

* Grain mixture- 4 parts ground corn
1 part wheat bran
1 part linseed oilmeal (Old Process)

** Corn meal preparation with about 3 per cent yeast

TABLE XXII

FEED CONSUMED PER PERIOD
GROUP IIIb
CALF Y-8

10-day period	Whole milk	Skim milk	Grain*	Alfalfa hay	Dried** yeast	Gain in weight
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1	88	0	1.5	0	1.1	4
2	54	36	4.5	.5	1.1	6
3		100	14.9	1.5	2.7	16
4		118	21.6	.5	3.5	23
5		130	20.0	1.5	3.3	11
6		132	27.0	4.5	4.1	8
7		140	24.3	3.0	4.3	23
8		149	25.5	6.0	4.5	19
9		160	25.5	3.0	4.5	7
10		160	24.0	19.5	6.0	12
11		160	24.0	13.5	6.0	8
12***		160	25.2	17.5	6.3	18
Total	142	1445	262.0	71.0	47.4	155

* Grain mixture- 4 parts ground corn
1 part wheat bran
1 part linseed oilmeal (Old Process)

** Corn meal preparation with about 3 per cent yeast

*** Taken off because of positive tuberculin reaction

TABLE XXIII

FEED CONSUMED PER PERIOD
GROUP IVa
CALF Y-9

10-day period	Whole milk	Skim milk	Grain*	Prairie hay	Gain in weight
	lbs.	lbs.	lbs.	lbs.	lbs.
1	75		3.0	1.5	4
2	83		15.0	1.5	19
3	98		18.0	1.5	16
4	97	10	19.5	3.0	8
5	21	94	22.5	1.5	26
6		157	30.0	1.5	29
7		160	30.0	4.5	16
8		160	30.0	4.5	13
9		160	25.5	6.0	18
10		160	30.0	7.5	9
11		160	30.0	18.0	6
12		160	35.0	24.0	27
13		160	35.0	15.0	7
14		160	40.0	29.0	22
15		160	40.0	35.0	18
16		160	40.0	35.0	19
17		73	40.0	28.0 **	27
Total	374	5116	483.5	217.0**	284

*Grain mixture- 1 part ground corn
1 part ground oats
**10.5 lbs. was alfalfa hay by mistake of feeder.

TABLE XXIV

FEED CONSUMED PER PERIOD
GROUP IVa
CALF Y-10

10-day period	Whole milk	Skim milk	Grain*	Prairie hay	Gain in weight
	lbs.	lbs.	lbs.	lbs.	lbs.
1	75		1.5	3.0	8
2	83		9.0	3.0	13
3	98		10.5	1.5	11
4	97	10	13.5	3.0	10
5	21	94	24.0	0	22
6		157	30.0	1.5	21
7		160	30.0	4.5	16
8		160	27.0	6.0	02
9		160	30.0	9.0	15
10		160	30.0	18.0	15
11		160	30.0	28.5	14
12		160	35.0	28.5	20
13		160	35.0	26.0	6
14		160	40.0	31.5	22
15		160	41.0	37.5	26
16		160	33.0	40.0	10
17		73	34.5	41.0**	16
Total	374	1934	454.0	282.5**	247

*Grain mixture- 1 part ground corn
1 part ground oats

** 21 lbs. was alfalfa hay by mistake of feeder.

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TABLE XXV

FEED CONSUMED PER PERIOD
GROUP IVa
CALF Y-11

10-day	Whole milk	Skim milk	Grain*	Prairie hay	Gain in weight
	lbs.	lbs.	lbs.	lbs.	lbs.
1	75		6.0	3.0	7
2	83		10.5	6.0	18
3	98		12.0	6.0	5
4	97	10	19.5	4.5	12
5	21	94	30.0	10.5	21
6		157	30.0	12.0	28
7		160	30.0	9.0	19
8		160	30.0	15.0	18
9		160	30.0	18.0	18
10		160	30.0	27.0	12
11		160	30.0	27.0	16
12		160	35.0	28.5	14
13		160	20.5	14.0	-10
14		160	40.0	30.0	24
15		160	40.0	35.0	18
16		160	40.0	35.0	21
17		73	40.0	28.0**	15
Total	374	1934	473.5	308.5**	266

* Grain mixture- 1 part ground corn
1 part ground oats

** 10.5 lbs. was alfalfa hay by mistake of feeder

TABLE XXVI

FEED CONSUMED PER PERIOD
GROUP IVa
CALF Y-12

10-day	Whole milk	Skim milk	Grain*	Prairie hay	Gain in weight
	lbs.	lbs.	lbs.	lbs.	lbs.
1	75		6.0	1.5	2
2	83		6.0	4.5	14
3	98		10.5	6.0	11
4	97	10	16.5	3.0	15
5	21	94	25.5	6.0	23
6		157	30.0	10.5	22
7		160	30.0	14.0	15
8		160	30.0	9.0	16
9		160	30.0	15.0	14
10		160	30.0	9.0	21
11		160	30.0	18.0	10
12		160	30.0	16.5	15
13		160	33.5	15.0	6
14		160	35.0	24.0	23
15		160	35.0	22.5	27
16		160	38.5	21.0	7
17		73	40.0	24.5 **	32
Total	374	1934	456.5	220.0**	273

* Grain mixture- 1 part ground corn
1 part ground oats

** 14 lbs. was alfalfa hay by mistake of feeder

12-21-6M

TABLE XXVII

FEED CONSUMED PER PERIOD
GROUP IVb
CALF Y-13

10-day	Whole milk	Skim milk	Grain*	Prairie hay	Dried** yeast	Gain in weight
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1	75		1.3	4.5	1.0	0
2	83		5.1	4.5	2.0	13
3	98		9.0	6.0	2.7	11
4	97	10	7.7	3.0	2.4	11
5	21	94	14.1	6.0	3.3	25
6		157	19.2	9.0	4.8	21
7		160	24.0	9.0	6.0	22
8		160	22.9	13.5	5.6	18
9		160	24.0	15.0	6.0	20
10		160	24.0	24.0	6.0	21
11		160	22.5	28.5	7.5	19
12		160	26.3	25.5	8.7	17
13		160	26.3	25.0	8.7	14
14		160	30.0	30.0	10.0	18
15		160	30.0	35.0	10.0	20
16		160	30.0	31.5	10.0	6
17		73	30.0	35.0***	10.0	29
Total	374	1934	326.4	305.0***	104.7	285

* Grain mixture-1 part ground corn
1 part ground oats

** Corn meal preparation with about 3 per cent yeast

*** 17.5 lbs. was alfalfa hay by mistake of feeder

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TABLE XXVIII

FEED CONSUMED PER PERIOD
GROUP IVb
CALF Y-14

10-day period	Whole milk	Skim milk	Grain*	Prairie hay	Dried** yeast	Gain in weight
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1	72		1.3	1.5	1.0	3
2	83		2.6	0.5	1.5	-4
3	98		11.6	4.5	3.1	28
4	97	10	11.0	6.0	2.9	8
5	21	94	17.3	12.0	4.2	29
6		157	24.3	12.5	4.8	21
7		160	24.0	14.0	6.0	21
8		160	24.0	9.0	6.0	16
9		160	24.0	15.0	6.0	16
10		160	24.0	12.0	6.0	20
11		160	22.5	18.0	7.5	15
12		160	22.5	16.5	7.5	16
13		160	25.1	15.0	8.4	10
14		160	26.3	22.5	8.7	20
15		160	26.3	16.5	8.7	19
16		160	28.9	21.0	9.6	2
17		73	30.0	24.5***	10.0	23
Total	371	1934	345.7	221.0***	101.9	263

* Grain mixture- 1 part ground corn
1 part ground oats

** Corn meal preparation with about 3 per cent yeast

*** 14 lbs. was alfalfa hay by mistake of feeder

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TABLE XXIX

FEED CONSUMED PER PERIOD
GROUP IVb
CALF Y-15

10-day period	Whole milk	Skim milk	Grain*	Prairie hay	Dried** yeast	Gain in weight
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1	75		1.3	1.5	1.0	3
2	83		3.9	6.0	1.7	11
3	98		12.8	7.5	3.3	16
4	97	10	11.0	9.0	2.9	11
5	21	94	20.4	9.0	4.5	26
6		157	22.8	12.0	5.7	22
7		160	22.8	13.5	5.7	26
8		160	22.8	22.5	5.7	19
9		160	24.0	19.5	6.0	14
10		160	24.0	28.5	6.0	20
11		160	22.5	28.5	7.5	16
12		160	26.3	30.0	8.7	18
13		160	26.3	30.0	8.7	11
14		160	30.0	31.5	10.0	20
15		160	30.8	39.5	10.2	19
16		160	33.8	40.0	11.2	14
17		73	33.8	40.0***	11.2	14
Total	374	1934	369.3	385.0***	110.0	270

*Grain mixture- 1 part ground corn
1 part ground oats

** Corn meal preparation with about 3 per cent yeast

*** 20 lbs. was alfalfa hay by mistake of feeder

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TABLE XXX

FEED CONSUMED PER PERIOD
GROUP IVb
CALF Y-16

10-day period	Whole milk	Skim milk	Grain*	Prairie hay	Dried** yeast	Gain in weight
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1	75		2.6	3.0	1.0	2
2	83		2.6	6.0	1.5	23
3	98		6.4	10.5	2.2	0
4	97	10	11.0	4.5	2.9	7
5	21	94	16.6	9.0	3.8	26
6		157	22.8	13.5	5.7	25
7		160	24.0	12.0	6.0	17
8		160	24.8	16.5	6.0	23
9		160	24.0	18.0	6.0	13
10		160	24.0	23.5	6.0	21
11		160	22.5	27.0	7.5	24
12		160	26.3	28.5	8.7	15
13		160	26.3	26.0	8.7	11
14		160	30.0	31.5	10.0	25
15		160	30.8	39.5	10.2	25
16		160	33.8	40.0	11.2	05
17		73	33.8	40.0***	11.2	24
Total	374	1934	365.0	349.0***	107.6	286

* Grain mixture- 1 part ground corn
1 part ground oats

** Corn meal preparation with about 3 per cent yeast

***20 lbs. was alfalfa hay by mistake of feeder

TABLE XXXI

GROWTH IN WEIGHT AND HEIGHT COMPARED TO NORMAL*
GROUP IIIa
CALF Y-1

10-day period	Weight	Normal weight	Per cent normal	Height	Normal height	Per cent normal
	lbs.	lbs.		cm.	cm.	
Start	116	109.6	105.8			
1	126	119.9	105.0	77.7	76.6	101.4
2	130	131.8	98.6			
3	150	143.8	104.3			
4	169	155.8	108.4	82.2	81.8	100.4
5	187	169.9	110.0			
6	201	184.2	109.1			
7	217	198.5	109.3	87.5	86.6	101.0
8	235	214.7	109.4			
9	251	231.0	108.6			
10	269	247.3	108.7	93.3	91.8	101.6
11	286	264.9	107.9			
12	294	282.5	104.0			
13	322	300.2	107.2	96.6	96.3	100.3
14	325	316.1	102.8			
15	360	331.7	108.5			
16	386	347.4	111.1	103.8	100.7	103.0
17	402	360.9	111.3	102.8	101.8	100.9

*From Eckles, C.H.-- The Normal Growth of Dairy Cattle, Mo. Expt. Sta. Bul., 36, p. 8-13

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TABLE XXXII

GROWTH IN WEIGHT AND HEIGHT COMPARED TO NORMAL
GROUP IIIa
CALF Y-2

10-day period	Weight	Normal weight	Per cent normal	Height	Normal height	Per cent normal
	lbs.	lbs.		cm.	cm.	
Start	112	108.6	103.0			
1	119	118.9	100.0	77.1	76.4	100.9
2	132	130.6	101.0			
3	144	142.6	100.9			
4	158	154.6	102.1	81.0	81.6	99.2
5	182	168.5	108.0			
6	196	182.8	107.2			
7	214	197.1	108.5	86.7	86.5	100.2
8	229	213.1	107.4			
9	248	229.4	108.1			
10	268	245.7	109.0	92.0	91.6	100.4
11	290	263.1	110.2			
12	302	280.8	107.5			

* From Eckles, C.H.--The Normal Growth of Dairy Cattle, Mo. Expt. Sta. Bul., 36, p. 8-13

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TABLE XXXIII

GROWTH IN WEIGHT AND HEIGHT COMPARED TO NORMAL*
GROUP IIIa
CALF Y-3

10-day period	Weight	Normal weight	Per cent normal	Height	Normal height	Per cent normal
	lbs.	lbs.		cm.	cm.	
Start	113	107.5	105.1	73.9	74.6	99.0
1	115	117.9	97.5			
2	124	129.4	95.8			
3	144	141.4	101.8	77.7	79.7	97.5
4	168	153.4	109.5			
5	188	167.0	112.5			
6	204	181.4	112.4	82.4	84.7	97.2
7	225	195.7	114.9			
8	248	211.4	117.3			
9	266	227.7	116.8	88.6	89.7	98.7
10	275	244.1	112.6			
11	286	261.4	109.4			
12	312	279.0	111.8	93.5	94.5	98.9
13	324	296.7	109.2			
14	360	312.9	312.9			
15	372	328.6	113.2	96.5	98.9	97.5
16	396	344.3	115.0			
17	408	358.3	113.0	99.7	101.6	98.1

* From Eckles, C.H.-- The Normal Growth of Dairy Cattle, Mo. Expt. Sta. Bul., 36, p.8-13

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TABLE XXXIV

GROWTH IN WEIGHT AND HEIGHT COMPARED TO NORMAL
GROUP IIIb
CALF Y-4

10-day period	Weight	Normal weight	Per cent normal	Height	Normal height	Per cent normal
	lbs.	lbs.		cm.	cm.	
Start	118	106.5	110.8			
1	121	116.9	103.5	76.6	76.1	100.6
2	130	128.2	101.4			
3	143	140.2	101.9			
4	162	152.2	106.4	81.5	81.3	100.2
5	180	165.6	108.7			
6	188	179.9	104.5			
7	200	194.3	102.9	84.7	86.2	98.2
8	217	209.8	103.4			
9	233	226.1	103.0			
10	244	242.5	100.6	92.5	91.3	101.3
11	257	259.6	98.9			
12	264	277.2	95.2			
13	285	294.9	96.6	95.2	95.9	99.2
14	305	311.4	97.9			
15	333	327.0	101.8			
16	342	342.7	99.7	99.9	100.3	99.6
17	358	356.9	100.3	100.8	101.5	99.3

* From Eckles, C.H.--The Normal Growth of Dairy Cattle, Mo. Expt. Sta. Bul., 36, p8-13

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TABLE XXXV

GROWTH IN WEIGHT AND HEIGHT COMPARED TO NORMAL*
GROUP IIIb
CALF Y-5

10-day period	Weight	Normal weight	Per cent normal	Height	Normal height	Per cent normal
	lbs.	lbs.		cm.	cm.	
Start	132	111.7	118.0			
1	138	122.0	113.1	78.8	76.9	102.4
2	149	134.0	111.1			
3	158	146.0	108.2			
4	179	158.0	113.1	83.7	82.1	101.9
5	198	172.7	114.6			
6	213	187.0	113.9			
7	232	201.6	115.0	88.8	86.9	102.2
8	250	217.9	114.7			
9	262	234.3	111.8			
10	282	250.0	112.8	94.3	92.1	102.4
11	303	268.4	112.8			
12	312	286.1	109.0			
13	333	303.5	109.4	98.4	96.6	101.8
14	352	319.2	110.2			
15	380	334.9	113.4			
16	408	350.3	116.4	103.6	101.0	102.5
17	425	363.6	116.8	104.6	102.3	102.2

* From Eckles, C.H.--The Normal Growth of Dairy Cattle, Mo. Expt. Sta. Bul., 36, p. 8-13

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TABLE XXXVI

GROWTH IN WEIGHT AND HEIGHT COMPARED TO NORMAL*
GROUP IIIb
CALF Y-6

10-day period	Weight	Normal weight	Per cent normal	Height	Normal height	Per cent normal
	lbs.	lbs.		cm.	cm.	
Start	114	108.6	104.9	77.5	74.8	103.6
1	117	118.9	98.4			
2	120	130.6	91.8			
3	126	142.6	88.3	78.9	79.9	98.7
4	144	154.6	93.1			
5	165	168.5	97.9			
6	182	182.8	99.5	84.0	84.9	98.9
7	198	197.1	100.4			
8	212	213.0	99.5			
9	225	229.4	98.1	89.6	89.9	99.6
10	235	245.7	95.6			
11	246	263.1	93.5			
12	266	280.8	94.7	94.5	94.7	99.7
13	282	298.4	94.5			
14	287	314.5	91.2			
15	313	330.2	94.7	97.6	99.1	98.4
16	331	345.8	95.7			
17	352	359.6	97.9	101.5	101.7	99.8

* From Eckles, C.H.-- The Normal Growth of Dairy Cattle, Mo. Expt. S Sta. Bul., 36, p. 8-13

TABLE XXXVII

GROWTH IN WEIGHT AND HEIGHT COMPARED TO NORMAL*
GROUP IIIb
CALF Y-7

10-day period	Weight	Normal weight	Per cent normal	Height	Normal height	Per cent normal
	lbs.	lbs.		cm.	cm.	
Start	108	109.6	98.4	77.3	74.9	103.3
1	111	119.9	92.5			
2	123	131.8	93.3			
3	139	143.8	96.6	78.8	80.0	98.5
4	160	155.8	102.7			
5	171	169.9	100.6			
6	184	184.2	99.9	84.7	85.0	99.6
7	202	198.5	101.7			
8	215	214.7	101.1			
9	234	231.0	101.3	90.9	90.0	101.0
10	245	247.3	99.0			
11	253	264.9	95.5			
12	276	282.5	97.7	95.5	94.8	100.7
13	290	300.2	96.6			
14	319	316.1	100.9			
15	341	331.7	102.8	99.6	99.3	100.3
16	363	347.4	104.4			
17	380	360.9	105.2	101.6	101.8	99.8

* From Eckles, C.H.-- The Normal Growth of Dairy Cattle, Mo. Expt. Sta. Bul., 36, p. 8-13

TABLE XXXVIII

GROWTH IN WEIGHT AND HEIGHT COMPARED TO NORMAL*
GROUP IIIb
CALF Y-8

10-day period	Weight	Normal weight	Per cent normal	Height	Normal height	Per cent normal
	lbs.	lbs.		cm.	cm.	
Start	115	106.6	105.8	77.8	74.8	104.0
1	119	118.9	100.0			
2	125	130.6	95.7			
3	141	142.6	98.8	79.0	79.9	98.8
4	164	154.6	106.1			
5	175	168.5	103.8			
6	183	182.8	100.1	83.7	84.9	98.5
7	206	197.1	104.5			
8	225	213.0	105.6			
9	232	229.4	101.1	90.2	89.9	100.3
10	244	245.7	99.3			
11	252	263.1	95.7			
12	270	280.8	96.1	95.9	94.7	101.2

*From Eckles, C.H.--The Normal Growth of Dairy Cattle, Mo. Expt. Sta. Bul., 36, p. 8-13

TABLE XXXIX

GROWTH IN WEIGHT AND HEIGHT COMPARED TO NORMAL*
GROUP IVa
CALF Y-9

10-day period	Weight	Normal weight	Per cent normal	Height	Normal height	Per cent normal
	lbs.	lbs.		cm.	cm.	
Start	113	113.7	99.3			
1	117	124.6	93.9			
2	136	136.6	99.5	78.9	79.0	99.8
3	152	148.6	102.2			
4	160	161.3	99.2			
5	186	175.6	105.9	84.6	84.0	100.7
6	215	189.9	113.2			
7	231	204.9	112.7			
8	244	221.2	110.3	91.0	89.0	102.2
9	262	237.5	110.3			
10	271	254.3	106.5			
11	277	271.9	101.8	95.2	93.9	101.3
12	304	289.6	104.9			
13	311	306.7	101.4			
14	333	322.3	103.3	100.0	98.4	101.6
15	351	338.0	103.8			
16	370	352.9	104.8			
17	397	366.3	108.3	104.5	102.2	102.2

*From Eckles, C.H.--The Normal Growth of Dairy Cattle, Mo. Expt. Sta. Bul., 36, p. 8-13

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TABLE XL

GROWTH IN WEIGHT AND HEIGHT COMPARED TO NORMAL*
GROUP IVa
CALF Y-10

10-day period	Weight	Normal weight	Per cent normal	Height	Normal height	Per cent normal
	lbs.	lbs.		cm.	cm.	
Start	126	118.0	106.7			
1	134	129.4	103.5			
2	147	141.4	103.9	76.9	79.7	96.5
3	158	153.4	102.9			
4	168	167.0	100.6			
5	190	181.4	104.7	83.0	84.7	97.9
6	2111	195.7	107.8			
7	227	211.4	107.3			
8	229	227.7	100.5	87.5	89.7	97.5
9	244	244.0	100.0			
10	259	261.3	99.1			
11	273	279.0	97.8	93.4	94.5	98.8
12	293	296.7	98.7			
13	299	312.9	95.5			
14	321	328.6	97.6	97.3	98.9	98.3
15	347	344.3	100.7			
16	357	358.3	99.6			
17	373	371.6	100.3	99.5	102.6	96.9

*From Eckles, C.H.-- The Normal Growth of Dairy Cattle, Mo. Expt. Sta. Bul., 36, p.8-13

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TABLE XLI

GROWTH IN WEIGHT AND HEIGHT COMPARED TO NORMAL*
GROUP IVa
CALF Y-11

10-day period	Weight	Normal weight	Per cent normal	Height	Normal height	Per cent normal
	lbs.	lbs.		cm.	cm.	
Start	120	115.8	103.6			
1	127	127.0	100.0			
2	145	139.0	104.3	79.7	79.4	100.3
3	150	151.0	99.3			
4	162	164.2	98.6			
5	183	178.5	102.5	84.8	84.4	100.4
6	211	192.8	109.4			
7	230	208.2	110.4			
8	248	224.5	110.4	91.5	89.4	102.3
9	266	240.8	110.4			
10	278	257.8	107.8			
11	294	275.5	160.7	96.3	94.3	102.2
12	308	293.1	105.1			
13	298	309.8	96.1			
14	322	325.5	98.9	100.5	98.7	101.8
15	340	341.1	99.6			
16	361	355.6	101.5			
17	376	368.9	101.9	104.0	102.4	101.5

* From Eckles, C.H.--The Normal Growth of Dairy Cattle, Mo. Expt. Sta. Bul., 36, p.8-13

TABLE XLII

GROWTH IN WEIGHT AND HEIGHT COMPARED TO NORMAL*
GROUP IVa
CALF Y-12

10-day period	Weight	Normal weight	Per cent normal	Height	Normal height	Per cent normal
	lbs.	lbs.		cm.	cm.	
Start	118	113.7	103.7			
1	120	124.6	96.3			
2	134	136.6	98.0	77.5	79.0	98.1
3	145	148.6	97.5			
4	160	161.3	99.2			
5	183	175.6	104.2	83.2	84.0	99.0
6	205	189.9	107.9			
7	220	204.9	107.3			
8	236	221.2	106.6	88.2	89.0	99.1
9	250	237.5	105.2			
10	271	254.3	106.5			
11	281	271.9	103.3	92.3	93.9	98.2
12	296	289.6	102.2			
13	302	306.7	98.4			
14	325	322.3	100.8	98.5	98.4	100.1
15	352	338.0	104.1			
16	359	352.9	101.7			
17	391	366.3	106.7	103.6	102.2	101.2

* From Eckles, C.H.--The Normal Growth of Dairy Cattle, Mo. Expt. Sta. Bul., 36, p. 8-13

TABLE XLIII

GROWTH IN WEIGHT AND HEIGHT COMPARED TO NORMAL*
GROUP IVb
CALF Y-13

10-day period	Weight	Normal weight	Per cent normal	Height	Normal height	Per cent normal
	lbs.	lbs.		cm.	cm.	
Start	123	118.9	103.4			
1	123	130.6	94.1			
2	136	142.6	95.4	80.1	79.9	100.2
3	147	154.6	95.0			
4	158	168.5	93.7			
5	183	182.8	100.1	86.8	84.9	102.2
6	204	197.1	103.5			
7	226	213.0	106.1			
8	244	229.4	106.3	90.5	89.9	100.6
9	264	245.7	107.4			
10	285	263.1	108.3			
11	304	280.8	108.2	97.6	94.7	103.0
12	321	298.4	107.5			
13	335	314.5	106.4			
14	353	330.2	106.9	104.3	99.1	105.2
15	373	345.8	107.8			
16	379	359.6	105.3			
17	408	372.9	109.4	105.6	102.7	102.8

* From Eckles, C.H.--The Normal Growth of Dairy Cattle, Mo. Expt. Sta. Bul., 36, p. 8-13

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TABLE XLIV

GROWTH IN WEIGHT AND HEIGHT COMPARED TO NORMAL*
GROUP IVb
CALF Y-14

10-day period	Weight	Normal weight	Per cent normal	Height	Normal height	Per cent normal
	lbs.	lbs.		cm.	cm.	
Start	125	118.9	105.1			
1	128	130.6	98.0			
2	124	142.6	86.9	77.7	79.9	97.2
3	152	154.6	98.3			
4	160	168.5	94.9			
5	189	182.8	103.3	83.5	84.9	98.3
6	210	197.1	106.5			
7	231	213.0	108.4			
8	247	229.4	107.6	89.1	98.9	99.1
9	263	245.7	107.0			
10	283	263.1	107.5			
11	298	280.8	106.1	94.0	94.7	99.2
12	314	298.4	105.2			
13	324	314.5	103.0			
14	344	330.2	104.1	98.9	99.1	99.7
15	363	345.8	104.9			
16	365	359.6	101.5			
17	388	372.9	104.0	103.3	102.7	100.5

*From Eckles, C.H.--The Normal Growth of Dairy Cattle, Mo. Expt. Sta. Bul., 36, p.8-13

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TABLE XLV

GROWTH IN WEIGHT AND HEIGHT COMPARED TO NORMAL*
GROUP IVb
CALF Y-15

10-day period	Weight	Normal weight	Per cent normal	Height	Normal height	Per cent normal
	lbs.	lbs.		cm.	cm.	
Start	140	122.2	114.5			
1	143	134.2	106.5			
2	154	146.2	105.3	82.0	80.4	101.9
3	170	158.4	107.3			
4	181	172.7	104.8			
5	207	187.1	110.6	85.3	85.4	99.9
6	229	201.6	113.5			
7	255	217.9	117.0			
8	274	234.3	116.9	93.4	90.4	103.3
9	288	250.1	115.1			
10	308	268.4	114.7			
11	324	286.1	113.2	96.0	95.1	100.9
12	342	303.5	112.6			
13	353	319.2	110.5			
14	373	334.9	111.3	103.4	99.5	103.9
15	392	350.3	111.9			
16	406	363.6	111.6			
17	420	376.9	111.4	108.0	103.0	104.8

* From Eckles, C.H.--The Normal Growth of Dairy Cattle, Mo. Expt. Sta. Bul., 36, p. 8-13

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TABLE XLVI

GROWTH IN WEIGHT AND HEIGHT COMPARED TO NORMAL*
GROUP IVb
CALF Y-16

10-day period	Weight	Normal weight	Per cent normal	Height	Normal height	Per cent normal
	lbs.	lbs.		cm.	cm.	
Start	111	111.7	99.3			
1	113	122.2	92.4			
2	136	134.2	101.3	79.4	78.7	100.8
3	136	146.2	93.0			
4	143	158.4	90.2			
5	169	172.7	97.8	82.3	83.7	98.3
6	194	187.1	103.6			
7	211	201.6	104.6			
8	234	217.9	107.3	88.8	88.7	100.1
9	247	234.3	105.4			
10	268	250.1	107.1			
11	292	268.4	108.7	94.4	93.6	100.8
12	307	286.1	107.3			
13	318	303.5	104.7			
14	343	319.2	107.4	100.3	98.1	102.2
15	368	334.9	109.8			
16	373	350.3	106.4			
17	397	363.6	109.1	104.2	102.0	102.1

* From Eckles, C.H.--The Normal Growth of Dairy Cattle, Mo. Expt. Sta. Bul., 36, p. 8-13

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TABLE XLVII

NUTRIENTS*IN RATION
GROUP IIIa
CALF Y-1

10-day period	Digestible crude protein		Energy		Per cent of required energy consumed
	Consumed	Required	Consumed	Required	
	lbs.	lbs.	therms	therms	
1	3.21	4.29	27.8	32.7	85.0
2	4.04	4.39	35.7	33.3	107.2
3	5.50	4.66	24.7	34.3	72.0
4	7.70	5.55	34.3	36.1	95.0
5	8.74	5.79	37.1	36.9	100.5
6	9.76	5.89	40.5	37.3	108.7
7	9.58	6.09	41.8	37.9	110.1
8	9.83	6.32	41.9	38.7	108.2
9	10.76	6.56	44.2	39.5	111.9
10	11.63	6.79	47.6	40.3	118.1
11	12.32	7.02	51.0	41.1	124.8
12	11.20	7.15	47.4	41.9	113.2
13	12.31	7.33	52.9	43.0	123.0
14	13.51	7.49	57.2	43.9	130.1
15	14.22	7.61	61.3	45.6	134.5
16	14.36	7.81	62.5	48.5	128.9
17	14.47	7.95	62.9	50.4	124.6

* Armsby, H.P., Nutrition of Farm Animals, The MacMillan Co. N.Y., 1917, p. 713,715

TABLE XLVIII

NUTRIENTS* IN RATION
GROUP IIIa
CALF Y-2

10-day period	Digestible crude protein		Energy		Per cent of required energy consumed
	Consumed	Required	Consumed	Required	
	lbs.	lbs.	therms	therms	
1	3.21	4.22	27.8	32.3	86.0
2	4.18	4.45	35.9	33.7	106.5
3	5.30	4.79	23.4	34.5	67.8
4	7.53	5.26	33.6	35.5	94.6
5	8.58	5.73	38.3	36.7	104.3
6	9.35	5.82	41.1	37.0	110.8
7	10.08	6.04	44.0	37.8	116.5
8	9.91	6.26	42.8	38.5	111.1
9	10.35	6.49	44.8	39.3	113.9
10	11.52	6.76	48.5	40.2	120.6
11	12.00	7.04	50.0	41.2	121.2
12	11.52	7.21	48.5	42.3	114.7

* Armsby, H.P., Nutrition of Farm Animals, The MacMillan Co.,N.Y., 1917, p. 713, 715

TABLE XLIX

NUTRIENTS* IN RATION
GROUP IIIa
CALF Y-3

10-day period	Digestible crude protein		Energy		Per cent of required energy consumed
	Consumed	Required	Consumed	Required	
	lbs.	lbs.	therms	therms	
1	3.19	4.19	27.2	32.1	84.7
2	3.83	4.26	25.7	32.6	78.8
3	6.95	4.79	31.9	34.5	92.4
4	8.39	5.54	37.8	36.1	104.7
5	9.01	5.67	39.3	36.5	107.4
6	9.92	5.92	43.5	37.4	116.4
7	10.25	6.16	44.5	38.2	116.5
8	10.66	6.46	45.8	39.2	116.8
9	10.73	6.75	45.9	40.1	114.4
10	12.32	6.92	51.0	40.7	125.3
11	12.00	7.05	50.0	41.3	121.1
12	12.31	7.24	52.9	42.4	124.6
13	13.51	7.43	57.2	43.6	131.2
14	14.48	7.61	62.2	45.6	136.4
15	14.36	7.77	62.5	47.8	130.7
16	14.47	7.88	62.9	49.5	126.9
17	16.00	8.00	68.1	51.2	133.1

* Armsby, H.P., Nutrition of Farm Animals, The MacMillan Co., N.Y., 1917, p. 713,715

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TABLE L

NUTRIENTS* IN RATION
GROUP IIIb
CALF Y-4

10-day period	Digestible crude protein		Energy		Per cent of required energy consumed
	Consumed	Required	Consumed	Required	
	lbs.	lbs.	therms	therms	
1	3.34	4.26	28.7	32.6	88.0
2	4.18	4.35	25.9	33.1	78.2
3	5.58	4.53	25.8	34.0	75.8
4	7.33	5.39	35.0	35.7	98.0
5	7.34	5.70	35.4	36.6	96.5
6	8.30	5.75	37.1	36.8	100.7
7	9.15	5.89	41.7	37.3	111.9
8	8.40	6.08	36.9	37.9	97.3
9	9.34	6.31	42.4	38.7	109.6
10	9.41	6.49	42.5	39.3	108.3
11	10.91	6.65	46.8	39.8	117.5
12	10.73	6.79	46.2	40.3	114.7
13	10.83	6.98	48.1	40.9	117.5
14	12.12	7.20	53.9	42.2	127.6
15	12.60	7.44	55.4	43.6	126.9
16	10.90	7.58	49.9	45.2	110.4
17	11.91	7.66	53.2	46.3	114.7

* Armsby, H.P., Nutrition of Farm Animals, The MacMillan Co.,N.Y., 1917, p. 713,715.

TABLE LI

NUTRIENTS* IN RATION
GROUP IIIb
CALF Y-5

10-day period	Digestible crude protein		Energy		Per cent of required energy consumed
	Consumed	Required	Consumed	Required	
	lbs.	lbs.	therms	therms	
1	3.34	4.26	28.7	32.6	88.0
2	4.26	4.79	26.9	34.5	82.5
3	5.58	5.13	25.8	35.2	73.2
4	7.70	5.69	36.9	36.6	100.8
5	7.99	5.94	38.1	37.4	101.8
6	9.30	5.90	42.3	37.3	113.3
7	9.19	6.27	42.0	38.5	108.9
8	10.08	6.53	44.3	39.4	112.5
9	9.63	6.73	41.3	40.1	103.1
10	10.25	6.95	45.3	40.8	110.9
11	11.71	7.17	47.5	42.0	112.9
12	11.56	7.32	49.8	42.9	116.0
13	12.15	7.47	52.4	43.8	119.5
14	13.18	7.61	57.5	45.6	126.2
15	13.84	7.77	61.7	47.8	129.2
16	13.58	7.95	60.9	50.4	120.6
17	14.32	8.04	63.3	52.4	120.7

* Armsby, H.P., Nutrition of Farm Animals, The MacMillan Co., N.Y., 1917, p. 713, 715.

TABLE LII

NUTRIENTS* IN RATION
GROUP IIIb
CALF Y-6

10-day period	Digestible crude protein		Energy		Per cent of required energy consumed
	Consumed	Required	Consumed	Required	
	lbs.	lbs.	therms	therms	
1	3.47	4.21	30.3	32.2	94.0
2	4.12	4.25	28.0	32.5	86.1
3	4.52	4.36	17.3	33.2	52.1
4	6.03	4.79	26.6	34.5	77.1
5	7.68	5.13	36.5	35.2	103.7
6	8.16	5.60	39.3	36.3	108.1
7	8.91	5.84	41.3	37.1	111.2
8	9.19	6.04	41.9	37.8	110.9
9	9.55	6.22	42.3	38.4	110.3
10	11.19	6.38	47.7	38.9	122.6
11	11.56	6.52	49.8	39.4	126.4
12	12.31	6.73	52.9	40.1	131.9
13	12.86	6.98	56.5	40.9	138.1
14	12.81	7.10	56.3	41.6	135.4
15	10.90	7.25	49.9	42.5	117.4
16	13.18	7.47	57.5	43.8	131.2
17	14.11	7.60	62.6	45.5	137.5

* Armsby, H.P., Nutrition of Farm Animals, The MacMillan Co., N.Y.,
1917, p. 713,715.

TABLE LIII

NUTRIENTS* IN RATION
GROUP IIIb
CALF Y-7

10-day period	Digestible crude protein		Energy		Per cent of required energy consumed
	Consumed	Required	Consumed	Required	
	lbs.	lbs.	lbs.	lbs.	
1	3.47	4.12	30.3	31.7	95.5
2	4.12	4.24	28.0	32.4	86.4
3	5.40	4.63	23.1	34.2	67.5
4	6.33	5.33	27.5	35.6	77.2
5	7.33	5.50	33.3	36.0	92.6
6	8.25	5.66	38.9	36.5	104.5
7	8.53	5.88	38.7	37.2	103.8
8	8.67	6.08	38.2	37.9	100.8
9	9.23	6.30	40.2	38.6	104.1
10	10.72	6.50	47.2	39.3	120.1
11	10.92	6.64	47.7	39.8	120.0
12	11.78	6.86	50.2	40.5	123.8
13	12.07	7.08	53.9	41.5	130.0
14	12.65	7.30	55.8	42.8	130.4
15	12.81	7.53	56.1	44.5	126.1
16	13.02	7.67	57.0	46.5	122.5
17	14.11	7.80	62.6	48.3	129.5

* Armsby, H.P., Nutrition of Farm Animals, The MacMillan Co., N.Y., 1917, p. 713,715.

TABLE LIV

NUTRIENTS* IN RATION
GROUP IIIb
CALF Y-8

10-day period	Digestible crude protein		Energy		Per cent of required energy consumed
	Consumed	Required	Consumed	Required	
	lbs.	lbs.	therms	therms	
1	3.47	4.24	30.3	32,4	93.5
2	4.12	4.31	28.0	32.8	85.3
3	6.14	4.69	27.7	34.3	80.7
4	6.99	5.46	32.9	35.9	91.7
5	7.33	5.55	33.3	36.1	92.1
6	8.59	5.69	40.6	36.6	111.0
7	8.39	5.89	38.8	37.3	104.0
8	9.19	6.18	41.9	38.2	109.6
9	9.25	6.35	42.0	38.8	108.2
10	10.92	6.49	47.7	39.3	121.5
11	10.29	6.62	45,7	39.7	114.9
12	10.88	6.80	48.3	40.3	119.7

* Armsby, H.P., Nutrition of Farm Animals, The MacMillan Co., N.Y., 1917, p. 713,715

TABLE LV

NUTRIENTS* IN RATION
GROUP IVa
CALF Y-9

10-day period	Digestible crude protein		Energy		Per cent of required energy consumed
	Consumed	Required	Consumed	Required	
	lbs.	lbs.	therms	therms	
1	2.80	4.21	24.2	32.2	75.1
2	4.08	4.36	36.1	33.2	108.8
3	4.81	4.79	42.8	34.5	123.7
4	5.34	5.19	46.2	35.3	130.6
5	5.92	5.60	33.6	36.3	92.6
6	8.04	5.97	39.8	37.5	106.0
7	8.26	6.27	41.4	38.5	107.2
8	8.26	6.49	41.4	39.3	105.3
9	7.93	6.69	38.5	39.9	96.4
10	8.38	6.87	42.6	40.5	104.9
11	9.49	6.98	46.8	40.9	114.4
12	9.47	7.15	53.1	41.9	126.6
13	9.11	7.32	49.4	42.9	115.1
14	10.10	7.47	58.9	43.8	134.4
15	10.34	7.61	61.3	45.6	134.5
16	10.34	7.73	61.3	47.3	129.7
17	7.76	7.88	48.8	49.4	98.8

* Armsby, H.P., Nutrition of Farm Animals, The MacMillan Co., N.Y., 1917, p. 713, 715.

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TABLE LVI

NUTRIENTS* IN RATION
GROUP IVa
CALF Y-10

10-day period	Digestible crude protein		Energy		Per cent of required energy consumed
	Consumed	Required	Consumed	Required	
	lbs.	lbs.	therms	therms	
1	2.74	4.42	24.3	33.5	72.5
2	3.63	4.66	32.1	34.3	93.7
3	4.19	5.06	37.0	35.1	105.5
4	4.90	5.43	40.8	35.8	113.7
5	5.99	5.69	34.2	36.6	93.4
6	8.04	5.97	39.8	37.5	106.1
7	8.26	6.23	41.4	38.4	107.6
8	8.06	6.35	39.7	38.8	102.1
9	8.44	6.46	43.2	39.2	110.1
10	8.80	6.68	46.8	39.9	117.2
11	9.22	6.87	51.1	40.5	125.9
12	9.65	7.08	54.9	41.5	132.3
13	9.55	7.21	53.9	42.3	127.4
14	10.20	7.35	59.9	43.1	139.0
15	10.53	7.55	63.1	44.8	140.7
16	9.94	7.67	58.0	46.5	124.6
17	8.50	7.76	49.2	47.7	103.1

* Armbsy,H.P., Nutrition of Farm Animals, The MacMillan Co., N.Y., 1917, p. 713,715.

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TABLE LVII

NUTRIENTS* IN RATION
GROUP IVa
CALF Y-11

10-day period	Digestible crude protein		Energy		Per cent of required energy consumed
	Consumed	Required	Consumed	Required	
	lbs.	lbs.	therms	therms	
1	3.12	4.32	27.7	32.9	84.0
2	3.88	4.53	34.5	34.0	101.3
3	4.50	4.89	40.0	34.7	115.0
4	5.40	5.19	45.9	35.3	129.7
5	6.92	5.59	43.0	36.3	118.4
6	8.46	5.93	44.1	37.4	117.8
7	8.44	6.24	43.2	38.4	112.2
8	8.68	6.50	50.2	39.3	127.6
9	8.80	6.75	51.4	40.1	128.0
10	9.16	6.95	55.0	40.8	134.8
11	9.16	7.11	55.0	41.7	132.1
12	9.65	7.26	58.5	42.6	139.7
13	7.82	7.28	37.9	42.7	88.8
14	10.14	7.35	59.3	43.1	137.6
15	10.34	7.53	61.3	44.5	137.6
16	10.34	7.66	61.3	46.3	132.3
17	7.76	7.78	48.8	48.0	101.6

* Armsby, H.P., Nutrition of Farm Animals, The MacMillan Co., N.Y., 1917,.p.713, 715

TABLE LVIII

NUTRIENTS* IN RATION
GROUP IVa
CALF Y-12

10-day period	Digestible crude protein		Energy		Per cent of required energy consumed
	Consumed	Required	Consumed	Required	
	lbs.	lbs.	therms	therms	
1	3.06	4.26	27.3	32.6	83,9
2	3.43	4.38	30.4	33.3	91.5
3	4.37	4.63	38.8	34.2	113.5
4	5.51	5.06	43.0	35.1	122.4
5	6.35	5.58	37.7	36.2	104.2
6	8.40	5.89	39.6	37.3	106.3
7	8.64	6.13	45.2	38.1	118.6
8	8.44	6.35	43.2	38.8	111.2
9	8.68	6.56	45.6	39.5	115.4
10	8.44	6.79	43.2	40.3	107.2
11	8.80	7.01	46.8	41.0	114.1
12	8.74	7.13	46.2	41.8	110.5
13	8.97	7.24	48.3	42.4	113.7
14	9.47	7.38	53.1	43.3	122.5
15	9.41	7.58	52.5	45.2	116.0
16	9.65	7.69	54.5	46.8	116.5
17	7.85	7.83	47.2	48.7	96.9

* Armsby, H.P., Nutrition of Farm Animals, The MacMillan Co., N.Y., 1917, p. 713,715.

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TABLE LIX

NUTRIENTS* IN RATION
GROUP IVb
CALF Y-13

10-day period	Digestible crude protein		Energy		Per cent of required energy consumed
	Consumed	Required	Consumed	Required	
	lbs.	lbs.	therms	therms	
1	2.87	4.32	25.7	32.9	78.0
2	3.50	4.41	31.5	33.4	94.1
3	4.44	4.69	39.9	34.3	116.2
4	4.50	5.06	38.3	35.1	109.1
5	5.55	5.56	31.1	36.2	85.9
6	7.77	5.89	38.7	37.3	103.8
7	8.37	6.18	43.7	38.2	114.3
8	8.43	6.31	44.4	38.7	114.6
9	8.61	6.71	46.1	40.0	115.3
10	8.97	6.98	49.8	40.9	121.6
11	9.14	7.20	51.7	42.2	122.5
12	9.43	7.37	54.5	43.2	125.9
13	9.41	7.51	54.2	44.3	122.5
14	10.03	7.63	59.8	45.8	130.7
15	10.23	7.75	62.2	47.5	130.8
16	10.09	7.83	60.8	48.7	124.7
17	8.39	7.94	52.1	50.3	103.5

* Armsby, H.P., Nutrition of Farm Animals, The MacMillan Co., N.Y., 1917, p.713,715

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TABLE LX

NUTRIENTS* IN RATION
GROUP IVb
CALF Y-14

10-day period	Digestible crude protein		Energy		Per cent of required energy consumed
	Consumed	Required	Consumed	Required	
	lbs.	lbs.	therms	therms	
1	2.63	4.36	23.5	33.2	70.7
2	3.09	4.36	27.5	33.2	82.9
3	4.63	4.59	41.7	34.1	121.9
4	4.87	5.19	41.8	35.3	118.3
5	6.34	5.62	38.0	36.4	104.4
6	8.28	5.97	43.6	37.5	116.2
7	8.57	6.24	45.7	38.4	118.9
8	8.37	6.49	43.7	39.3	111.3
9	8.61	6.72	46.1	40.0	115.2
10	8.49	6.96	44.9	40.9	109.9
11	8.72	7.15	47.5	41.9	113.3
12	8.66	7.31	46.9	42.9	109.
13	8.89	7.44	48.7	43.6	111.6
14	9.31	7.55	52.9	44.8	118.8
15	9.07	7.69	50.8	46.7	108.8
16	9.54	7.75	55.4	47.6	116.2
17	7.74	7.83	47.2	48.7	96.7

* Armsby, H.P., Nutrition of Farm Animals, The MacMillan Co., N.Y., 1917, p. 715,713.

TABLE LXI

NUTRIENTS* IN RATION
GROUP IVb
CALF Y-15

10-day period	Digestible crude protein		Energy		Per cent of required energy consumed
	Consumed	Required	Consumed	Required	
	lbs.	lbs.	therms	therms	
1	2.75	4.69	24.5	34.3	71.2
2	3.44	4.93	30.9	34.8	88.7
3	4.88	5.39	44.0	35.7	123.1
4	4.99	5.63	43.1	36.4	118.2
5	6.30	5.89	38.1	37.3	102.3
6	8.26	6.22	43.4	38.4	113.2
7	8.42	6.53	44.4	39.4	112.5
8	8.79	6.84	48.0	40.4	118.6
9	8.79	7.06	48.0	41.4	115.9
10	9.19	7.23	48.4	42.4	114.1
11	9.14	7.41	51.7	43.5	119.0
12	9.61	7.55	56.3	44.7	125.7
13	9.61	7.63	56.3	45.9	122.4
14	10.09	7.75	60.8	47.5	127.9
15	10.49	7.87	64.8	49.3	131.4
16	10.84	7.98	68.2	50.9	133.9
17	9.17	8.03	57.9	52.1	111.1

* Armsby, H.P., Nutrition of Farm Animals, The MacMillan Co., N.Y., 1917, p. 713,715

TABLE LXII

NUTRIENTS* IN RATION
GROUP IVb
CALF Y-16

10-day period	Digestible crude protein		Energy		Per cent of required energy consumed
	Consumed	Required	Consumed	Required	
	lbs.	lbs.	therms	therms	
1	2.94	4.17	26.2	32.0	82.0
2	3.31	4.34	29.7	33.0	90.1
3	4.36	4.53	39.4	34.0	115.8
4	4.81	4.63	41.2	34.2	120.4
5	5.93	5.19	35.4	35.3	100.1
6	8.32	5.71	44.0	36.7	120.0
7	8.49	5.98	44.9	37.6	119.4
8	8.67	6.27	46.7	38.5	121.2
9	8.73	6.52	47.3	39.4	120.2
10	8.95	6.75	49.6	40.1	123.5
11	9.08	7.05	51.1	41.3	123.7
12	9.55	7.24	55.7	42.4	131.1
13	9.45	7.37	54.3	43.2	125.7
14	10.09	7.53	60.8	44.5	136.7
15	10.49	7.69	64.8	46.8	138.5
16	10.84	7.79	68.2	48.2	141.4
17	9.17	7.89	57.9	49.6	116.7

* Armsby H.P., Nutrition of Farm Animals, The MacMillan, Co., N.Y. 1917, p. 713,715.

TABLE LXIII

ENERGY CONSUMED PER POUND GAINED
GROUP IIb*

Animal	Total gain in weight	Total energy consumed	Energy consumed per pound grain
	lbs.	therms	therms
22	299	1057.2	3.53
24	308	1044.1	3.39
530	276	981.9	3.55
Average	294	1027.7	3.49

* Taken from thesis for M.S. degree by J.W. Wilbur, University of Minnesota, 1921. Tables 6,9,12, and 31. These calves were fed whole milk, grain (corn4, wheat bran 1 and oilmeal 1), alfalfa hay and 20-30 gm. dried baker's yeast. On experiment 5 months.

TABLE LXIV

ENERGY CONSUMED PER POUND GAINED
GROUPS IIIa AND IIIb*

Animal	Total gain in weight	Total energy consumed	Energy consumed per pound grain
Group IIIa	lbs.	therms	therms
Y-1	286	770.8	2.69
Y-2	190	478.7	2.51
Y-3	295	808.4	2.74
Average	257	685.9	2.64
Group IIIb*			
Y-4	240	704.9	2.93
Y-5	293	764.7	2.60
Y-6	238	736.7	3.09
Y-7	273	728.7	2.66
Y-8	155	457.2	2.94
Average	239	678.4	2.84

* Receiving dried yeast as 10 per cent of ration (dry basis)

TABLE LXV

ENERGY CONSUMED PER POUND GAINED
GROUPS IVa AND IVb*

Animal	Total gain in weight	Total energy consumed	Energy consumed per pound grain
Group IVa	lbs.	therms	therms
Y-9	284	766.2	2.69
Y-10	247	769.4	3.11
Y-11	266	817.1	3.07
Y-12	273	742.6	2.72
Average	267	773.8	2.89
Group IVb*			
Y-13	285	784.5	2.75
Y-14	263	745.9	2.83
Y-15	270	828.8	3.06
Y-16	286	817.2	2.85
Average	2 76	794.1	2.87

* Receiving dried yeast as 10 per cent of ration (dry basis)

TABLE LXVI

FEED CONSUMED PER PERIOD
GROUP Va
COW 120

10-day period	Alfalfa hay	Corn silage	Beet pulp	Grain**	Dried *** yeast
	lbs.	lbs.	lbs.	lbs.	lbs.
1*	67	242	30	110	14.4
2	70	222	30	110	14.4
3	75	222	30	107	14.3
4	73	239	30	108	13.7
5*	75	245	30	110	--
6	72	240	30	119	--
7	77	246	30	125	--
8	77	224	30	120	--
9*	75	206	30	113	12.2
10	72	208	30	111	12.0
11	73	212	30	111	11.1
12	70	210	30	110	10.6

* Preliminary period not figured in results.

** Grain mixture- 2 parts ground corn, 2 parts ground oats, 2 parts wheat bran, and 1 part linseed oilmeal (Old process).

*** Corn meal preparation with about 3 per cent yeast

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TABLE LXVII

FEED CONSUMED PER PERIOD
GROUP Va
COW 301

10-day period	Alfalfa hay	Corn silage	Beet pulp	Grain**	Dried*** yeast
	lbs.	lbs.	lbs.	lbs.	lbs.
1*	88	300	30	180	23.9
2	109	350	30	174	23.9
3	124	350	30	175	23.6
4	133	249	30	174	22.0
5*	134	350	30	172	--
6	140	348	30	169	--
7	133	350	30	170	--
8	135	345	30	170	--
9*	115	340	30	158	20.0
10	112	320	30	158	20.0
11	113	340	30	160	21.5
12	113	340	30	154	21.2

* Preliminary period not figured in results.

** Grain mixture- 2 parts ground corn, 2 parts ground oats, 2 parts wheat bran, and 1 part linseed oilmeal (Old process).

*** Corn meal preparation with about 3 per cent yeast.

TABLE LXVIII

FEED CONSUMED PER PERIOD
GROUP Va
COW 317

10-day period	Alfalfa hay	Corn silage	Beet pulp	Grain**	Dried*** yeast
	lbs.	lbs.	lbs.	lbs.	lbs.
1*	96	300	30	80	11.1
2	112	350	30	80	11.1
3	124	348	30	80	11.0
4	137	350	30	89	12.1
5*	147	350	30	90	--
6	136	350	30	96	--
7	134	350	30	100	--
8	134	350	30	100	--
9*	112	350	30	100	10.5
10	116	343	30	92	9.6
11	112	347	30	90	7.9
12	113	343	30	90	6.4

* Preliminary period not figured in results.

** Grain mixture- 2 parts ground corn, 2 parts ground oats, 2 parts wheat bran, and 1 part linseed oilmeal (Old process).

*** Corn meal preparation with about 3 per cent yeast.

TABLE LXIX

FEED CONSUMED PER PERIOD
GROUP Va
COW 320

10-day	Alfalfa hay	Corn silage	Beet pulp	Grain**	Dried*** yeast
	lbs.	lbs.	lbs.	lbs.	lbs.
1*	94	300	30	100	14.4
2	115	350	30	100	14.4
3	131	350	30	100	14.3
4	138	350	30	109	14.2
5*	136	350	30	110	--
6	138	350	30	121	--
7	137	350	30	125	--
8	133	350	30	125	--
9*	109	334	30	113	10.0
10	110	308	30	106	12.7
11	113	346	30	109	14.8
12	115	345	30	110	14.5

* Preliminary period not figured in results.

** Grain mixture-- 2 parts ground corn, 2 parts ground oats, 2 parts wheat bran, and 1 part linseed oilmeal (Old process).

*** Corn meal preparation with about 3 per cent yeast.

TABLE LXX

FEED CONSUMED PER PERIOD
GROUP Vb
COW 102

10-day period	Alfalfa hay	Corn silage	Beet pulp	Grain**	Dried*** yeast
	lbs.	lbs.	lbs.	lbs.	lbs.
1*	57	250	30	40	--
2	61	250	30	40	--
3	75	257	30	50	--
4	79	269	30	50	--
5*	86	280	30	50	5.5
6	84	264	30	46	5.3
7	73	250	30	48	4.4
8	77	246	30	50	4.4
9*	73	250	30	50	--
10	73	250	30	50	--
11	77	250	30	50	--
12	74	250	30	50	--

* Preliminary period not figured in results.

** Grain mixture- 2 parts ground corn, 2 parts ground oats, 2 parts wheat bran, and 1 part linseed oilmeal (Old process).

*** Corn meal preparation with about 3 per cent yeast.

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TABLE LXXI

FEED CONSUMED PER PERIOD
GROUP Va
COW 306

10-day period	Alfalfa hay	Corn silage	Beet pulp	Grain**	Dried*** yeast
	lbs.	lbs.	lbs.	lbs.	lbs.
1*	95	300	30	150	--
2	115	350	30	150	--
3	129	349	30	150	--
4	140	350	30	159	--
5 *	133	359	30	160	17.6
6	140	350	30	151	17.9
7	140	350	30	145	16.6
8	137	347	30	145	16.5
9*	135	350	30	158	--
10	140	350	30	150	--
11	137	350	30	160	--
12	125	350	30	153	--

* Preliminary period not figured in results.

** Grain mixture -- 2 parts ground corn, 2 parts ground oats, 2 parts wheat bran, and 1 part linseed oilmeal (Old Process).

*** Corn meal preparation with about 3 per cent yeast.

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TABLE LXXII

FEED CONSUMED PER PERIOD
GROUP VB
COW 333

10-day period	Alfalfa hay	Corn silage	Beet pulp	Grain **	Dried *** yeast
	lbs.	lbs.	lbs.	lbs.	lbs.
1*	97	300	30	150	--
2	116	350	30	150	--
3	126	347	30	130	--
4	138	350	30	139	--
5*	135	345	30	140	18.7
6	135	350	30	131	18.5
7	132	350	30	125	17.2
8	135	348	30	125	17.1
9*	127	350	30	137	--
10	132	345	30	134	--
11	129	346	30	123	--
12	116	338	30	116	--

* Preliminary period not figured in results.

** Grain mixture-- 2 parts ground corn, 2 parts ground oats, 2 parts wheat bran, and 1 part linseed oilmeal (Old process).

*** Corn meal preparation with about 3 per cent yeast.

TABLE LXXIII

FEED CONSUMED PER PERIOD
GROUP Vb
COW 500

10-day period	Alfalfa hay	Corn silage	Beet pulp	Grain**	Dried*** yeast
	lbs.	lbs.	lbs.	lbs.	lbs.
1*	72	250	30	174	--
2	56	250	30	177	--
3	71	246	30	180	--
4	79	281	30	180	--
5*	83	266	30	158	17.6
6	78	266	30	154	17.6
7	75	255	30	155	16.1
8	75	256	30	151	16.0
9*	73	244	30	159	--
10	74	241	30	158	--
11	72	252	30	160	--
12	67	252	30	145	--

* Preliminary period not figured in results.

** Grain mixture- 2 parts ground corn, 2 parts ground oats, 2 parts wheat bran, and 1 part linseed oilmeal (Old process).

*** Corn meal preparation with about 3 per cent yeast.

4-22-8M

TABLE LXXIV

WEIGHT AND PRODUCTION PER PERIOD
GROUP Va
COW 120

10-day period	Days in lactation	Weight at end of period	Milk	Per cent butterfat	Butterfat
	days	lbs.	lbs.		lbs.
**1*	67	884	262.6	5.4	14.18
2*	77	908	249.3	4.8	11.96
3*	87	950	240.5	4.8	11.54
4*	97	910	244.0	4.9	11.95
Average	87	922	244.6	4.8	11.81
**5	107	940	233.3	4.5	10.61
6	117	935	277.7	4.8	10.92
7	127	925	226.2	5.1	11.53
8	137	940	220.4	5.0	11.02
Average	127	933	224.7	5.0	11.15
**9*	147	933	213.0	4.8	10.33
10*	157	948	209.2	5.0	10.46
11*	167	934	195.0	5.1	9.93
12*	177	950	194.5	5.5	10.68
Average	167	944	199.5	5.2	10.35
Average for 3 periods	127	933	222.9	5.0	11.10

* Receiving 25 gm. dried yeast per lb. of milk.

** Preliminary period not figured in averages.

TABLE LXXV

WEIGHT AND PRODUCTION PER PERIOD
GROUP Va
COW 301

10-day period	Days in lactation	Weight at end of period	Milk	Per cent butterfat	Butterfat
	days	lbs.	lbs.		lbs.
**1*	98	1420	391.1	2.7	10.56
2*	108	1397	390.0	2.8	10.92
3*	118	1460	400.1	2.9	11.40
4*	128	1450	405.2	2.6	11.75
Average	118	1435	398.4	2.8	11.35
**5	138	1484	409.9	2.6	10.65
6	148	1420	390.7	2.6	10.15
7	158	1450	359.0	2.7	9.87
8	168	1395	384.3	2.8	10.76
Average	158	1421	378.0	2.7	10.26
**9*	178	1435	379.9	2.9	11.01
10*	188	1430	396.8	2.9	11.50
11*	198	1449	387.1	2.9	11.22
12*	208	1484	351.7	2.9	10.19
Average	198	1454	378.5	2.9	10.97
Average for 3 periods	158	1436	384.9	2.8	10.86

* Receiving 25 gm. dried yeast per lb. of milk.

** Preliminary period not figured in averages.

4-22-6M

TABLE LXXVI

WEIGHT AND PRODUCTION PER PERIOD
GROUP Va
COW 317

10-day period	Days in lactation	Weight at end of period	Milk	Per cent butterfat	Butterfat
	days	lbs.	lbs.		lbs.
**1*	195	1681	222.5	3.5	7.78
2*	205	1697	229.5	3.7	8.49
3*	215	1725	225.3	3.8	8.67
4*	225	1725	237.0	3.8	9.00
Average	215	1715	230.6	3.8	8.72
**5	235	1750	224.7	3.4	7.63
6	245	1765	218.5	3.5	7.64
7	255	1740	208.4	3.7	7.81
8	265	1755	192.3	3.7	7.11
Average	255	1753	206.4	3.6	7.52
**9*	275	1765	173.2	4.1	7.18
10*	285	1800	144.3	4.0	5.77
11*	295	1818	112.7	4.3	4.84
12*	305	1823	95.6	4.7	4.49
Average	295	1813	117.5	4.3	5.03
Average for 3 periods	255	1760	184.8	3.9	7.09

* Receiving 25 gm. dried yeast per lb. of milk.

** Preliminary period not figured in averages.

4-22-6M

TABLE LXXVII

WEIGHT AND PRODUCTION PER PERIOD
GROUP Va
COW 320

10-day period	Days in lactation	Weight at end of period	Milk	Per cent butterfat	Butterfat
	days	lbs.	lbs.		lbs.
**1*	307	1680	285.7	3.2	9.14
2*	317	1692	280.9	3.3	9.26
3*	327	1750	266.1	3.4	9.04
4*	337	1740	275.4	3.4	9.36
Average	327	1727	274.1	3.4	9.22
**5	347	1786	269.9	2.8	7.55
6	357	1690	264.0	3.1	8.18
7	367	1740	280.2	3.3	9.24
8	377	1725	269.8	3.3	8.90
Average	367	1718	271.3	3.2	8.77
**9*	387	1720	268.5	3.4	9.12
10*	397	1740	273.2	3.4	9.28
11*	407	1750	264.4	3.4	8.98
12*	417	1728	265.9	3.5	9.30
Average	407	1739	267.8	3.4	9.18
Average for 3 periods	367	1728	271.0	3.3	9.05

* Receiving 25 gm. dried yeast per lb. of milk.

** Preliminary period not figured in averages.

TABLE LXXVIII

WEIGHT AND PRODUCTION PER PERIOD
GROUP Vb
COW 102

10-day period	Days in lactation	Weight at end of period	Milk	Per cent butterfat	Butterfat
	days	lbs.	lbs.		lbs.
**1	43	1110	134.3	4.5	6.04
2	53	1144	114.2	4.6	5.25
3	63	1250	110.7	4.7	5.20
4	73	1175	105.0	4.6	4.83
Average	63	1189	109.9	4.6	5.09
**5*	83	1172	93.0	4.7	4.41
6*	93	1200	86.2	4.7	4.09
7*	103	1175	85.1	5.2	4.46
8*	113	1160	82.5	5.2	4.29
Average	103	1185	84.6	5.0	4.28
**9	123	1178	88.8	5.1	4.57
10	133	1180	86.9	5.0	4.34
11	143	1195	88.0	5.1	4.48
12	153	1201	87.0	5.6	4.87
Average	143	1192	87.3	5.2	4.56
Average for 3 periods	103	1188	93.9	4.9	4.64

* Receiving 25 gm. dried yeast per lb. of milk.

** Preliminary period not figured in averages.

TABLE LXXIX

WEIGHT AND PRODUCTION PER PERIOD
GROUP Vb
COW 306

10-day period	Days in lactation	Weight at end of period	Milk	Per cent butterfat	Butterfat
	days	lbs.	lbs.		lbs.
**1	191	1391	342.4	3.4	11.64
2	201	1401	355.6	3.4	12.26
3	211	1420	340.1	3.5	11.90
4	221	1440	321.1	3.6	11.55
Average	211	1420	338.9	3.5	11.90
**5*	231	1469	330.1	3.0	9.90
6*	241	1425	307.4	3.1	9.52
7*	251	1485	334.5	3.2	10.87
8*	261	1470	323.2	3.2	10.34
Average	251	1460	321.7	3.2	10.24
**9	271	1465	310.3	3.1	9.61
10	281	1492	331.9	3.1	10.28
11	291	1495	327.6	3.1	10.15
12	301	1490	297.8	3.1	9.23
Average	291	1492	319.1	3.1	9.88
Average for 3 periods	251	1457	326.5	3.3	10.67

* Receiving 25 gm. dried yeast per lb. of milk.

** Preliminary period not figured in averages.

TABLE LXXX

WEIGHT AND PRODUCTION PER PERIOD
GROUP Vb
COW 333

10-day period	Days in lactation	Weight at end of period	Milk	Per cent butterfat	Butterfat
	days	lbs.	lbs.		lbs.
**1	184	1380	326.7	3.0	9.80
2	194	1419	343.4	3.1	10.64
3	204	1475	340.5	3.1	10.72
4	214	1450	342.3	3.2	10.95
Average	204	1448	342.0	3.1	10.77
**5*	224	1482	331.4	3.0	9.94
6*	234	1500	317.8	3.0	9.53
7*	244	1490	310.6	3.2	10.94
8*	254	1495	311.2	3.2	10.26
Average	244	1495	313.2	3.1	10.24
**9	264	1490	296.2	3.5	10.51
10	274	1515	279.0	3.3	9.20
11	284	1500	263.6	3.3	8.69
12	294	1494	239.0	3.5	8.36
Average	284	1503	260.5	3.4	8.75
Average for 3 periods	244	1482	305.2	3.2	9.92

* Receiving 25 gm. dried yeast per lb. of milk.

** Preliminary period not figured in averages.

TABLE LXXXI

WEIGHT AND PRODUCTION PER PERIOD
GROUP Vb
COW 500

10-day period	Days in lactation	Weight at end of period	Milk	Per cent butterfat	Butterfat
	days	lbs.	lbs.		lbs.
**1	42	1055	337.5	3.9	13.16
2	52	1070	324.0	3.8	12.31
3	62	1110	331.1	3.7	12.41
4	72	1110	322.2	3.8	12.24
Average	62	1096	325.4	3.7	12.32
**5*	82	1111	317.9	3.7	11.92
6*	92	1115	297.2	3.7	10.99
7*	102	1110	294.8	3.9	11.49
8*	112	1101	281.9	3.9	10.99
Average	102	1108	291.3	3.8	11.15
**9	122	1125	282.1	4.2	11.84
10	132	1125	283.1	3.9	11.04
11	142	1117	265.0	4.0	10.60
12	152	1100	249.2	4.3	10.71
Average	142	1114	265.7	4.0	10.78
Average for 3 periods	102	1106	294.1	3.8	11.41

* Receiving 25 gm. dried yeast per lb. of milk.

** Preliminary period not figured in averages.

TABLE LXXXII

NUTRIENTS* IN RATION
GROUP Va
COW 120

10-day period	Digestible crude protein		Energy		Per cent of required energy consumed
	Consumed	Required	Consumed	Required	
	lbs.	lbs.	therms	therms	
***1**	26.3	24.5	176	144	132
2**	26.4	22.5	174	131	132
3**	26.5	22.9	173	133	130
4**	26.5	22.8	173	133	130
***5	26.1	20.6	167	126	132
6	26.8	21.1	171	126	136
7	28.2	21.9	179	132	135
8	27.3	21.8	171	131	130
***9**	26.9	19.4	173	115	150
10**	26.3	20.0	170	122	140
11**	26.5	19.4	171	117	146
12**	25.9	20.6	165	126	130

* Armsby, H.P.--Nutrition of Farm Animals, The MacMillan Co.,N.Y., 1917, p. 713,715.

** Receiving 25 gm. dried yeast per lb. of milk.

*** Preliminary period not figured in results.

TABLE LXXXIII

NUTRIENTS* IN RATION
GROUP Va
COW 301

10-day period	Digestible crude protein		Energy		Per cent of required energy consumed
	Consumed	Required	Consumed	Required	
	lbs.	lbs.	therms	therms	
***1**	38.8	29.7	251	155	161
2**	40.7	29.4	262	150	174
3**	42.5	30.0	268	154	174
4**	42.1	30.8	253	161	157
***5**	41.4	31.0	249	162	153
6	41.6	29.5	248	152	163
7	41.0	27.8	247	147	167
8	41.2	28.4	247	152	162
***9**	39.0	28.8	248	151	164
10**	38.4	28.9	242	151	160
11**	38.9	29.6	250	155	161
12**	38.4	28.5	244	151	161

*Armsby, H.P.--Nutrition of Farm Animals, The MacMillan Co.,N.Y., 1917, p. 713, 715.

** Receiving 25 gm. dried yeast per lb. of milk .

*** Preliminary period not figured in results.

12-21-6M

TABLE LXXXIV

NUTRIENTS* IN RATION
GROUP Va
COW 317

10-day period	Digestible crude protein		Energy		Per cent of required energy consumed
	Consumed	Required	Consumed	Required	
	lbs.	lbs.	therms	therms	
***1	25.9	23.9	170	139	122
2	27.3	25.6	184	146	125
3	29.4	25.8	188	147	127
4	32.0	25.8	194	147	132
***5**	32.3	23.7	194	137	141
6**	31.9	24.0	194	147	132
7**	32.2	23.6	196	139	144
8**	32.2	23.1	196	136	144
***9	30.6	23.5	198	139	142
10	29.9	20.1	192	121	158
11	28.9	19.3	188	121	154
12	29.1	19.2	186	120	155

* Armsby, H.P.--Nutrition of Farm Animals, The MacMillan Co., N.Y., 1917, p. 713, 715

** Receiving 25 gm. dried yeast per lb. milk.

*** Preliminary period not figured in results.

TABLE LXXXV

NUTRIENTS* IN RATION
GROUP Va
COW 320

10-day period	Digestible crude protein		Energy		Per cent of required energy consumed
	Consumed	Required	Consumed	Required	
	lbs.	lbs.	therms	therms	
***1**	28.5	26.8	187	148	126
2**	31.3	25.6	202	146	138
3**	32.9	26.0	208	148	140
4**	34.8	26.0	216	149	145
***5	33.7	24.6	204	136	149
6	35.3	25.6	213	142	150
7	35.7	26.8	216	149	144
8	35.3	25.5	214	139	154
***9**	31.8	24.9	202	141	142
10**	30.9	25.1	196	143	136
11**	32.2	26.3	208	148	139
12**	32.0	26.5	209	149	140

* Armsby, H.P.--Nutrition of Farm Animals, The MacMillan Co., N.Y., 1917, p. 713, 715

** Receiving 25 gm. dried yeast per lb. milk.

*** Preliminary period not figured in results.

TABLE LXXXVI

NUTRIENTS* IN RATION
GROUP Vb
COW 102

10-day period	Digestible crude protein		Energy		Per cent of required energy consumed
	Consumed	Required	Consumed	Required	
	lbs.	lbs.	therms	therms	
***1	15.2	16.1	111	102	108
2	15.7	15.6	112	100	111
3	18.5	16.3	125	104	120
4	19.1	15.1	128	98	130
***5**	20.3	14.5	137	95	143
6**	19.4	13.9	131	93	140
7**	18.3	14.0	126	94	132
8**	18.9	13.8	129	94	138
***9	18.2	14.3	123	96	128
10	18.2	13.9	123	93	131
11	18.6	14.4	125	94	132
12	18.3	14.7	124	98	125

* Armsby, H.P.-- Nutrition of Farm Animals, The MacMillan Co. N.Y., 1917, p. 713, 715.

** Receiving 25 gm. dried yeast per lb. of milk.

*** Preliminary period not figured in results.

TABLE LXXXVII

NUTRIENTS* IN RATION
GROUP Vb
COW 306

10-day period	Digestible crude protein		Energy		Per cent of required energy consumed
	Consumed	Required	Consumed	Required	
	lbs.	lbs.	therms	therms	
***1	33.9	28.6	211	157	134
2	36.6	29.0	226	158	142
3	38.0	28.7	231	157	147
4	40.4	27.4	241	151	159
***5**	41.1	27.1	255	143	177
6**	40.6	25.7	251	140	179
7**	39.8	27.8	245	153	160
8**	39.5	27.4	244	156	156
***9	39.7	26.1	239	144	166
10	39.2	26.9	235	145	161
11	40.2	27.3	241	147	164
12	38.0	26.2	231	143	161

* Armsby, H.P.--Nutrition of Farm Animals, The MacMillan Co.,N.Y., 1917,p. 713, 715.

** Receiving 25 gm. dried yeast per lb. of milk.

*** Preliminary period not figured in results.

4-22-6M

TABLE LXXXVIII

NUTRIENTS* IN RATION
GROUP Vb
COW 333

10-day period	Digestible crude protein		Energy		Per cent of required energy consumed
	Consumed	Required	Consumed	Required	
	lbs.	lbs.	therms	therms	
***1	34.1	26.6	212	142	148
2	36.7	28.1	227	149	151
3	35.1	28.5	215	151	142
4	37.6	28.5	226	150	150
***5**	38.8	27.3	241	147	163
6**	37.6	26.6	235	144	163
7**	35.2	26.7	229	147	154
8**	35.5	26.7	229	147	155
***9	36.2	25.2	221	135	162
10	36.3	24.2	220	138	158
11	34.6	24.3	211	138	153
12	31.9	24.2	180	138	129

* Armsby, H.P.-- Nutrition of Farm Animals, The Mac Millan Co, N.Y., 1917, p. 713, 715

** Receiving 25 gm. dried yeast per lb.of milk.

*** Preliminary period not figured in results.

TABLE LXXXIX

NUTRIENTS* IN RATION
GROUP Vb
COW 500

10-day period	Digestible crude protein		Energy		Per cent of required energy consumed
	Consumed	Required	Consumed	Required	
	lbs.	lbs.	therms	therms	
***1	34.0	25.5	213	149	142
2	32.7	26.7	206	147	140
3	34.6	26.9	216	147	146
4	35.8	25.9	225	147	152
***5**	34.6	25.4	223	144	154
6**	33.6	23.4	218	134	162
7**	33.6	22.4	215	131	163
8**	32.6	22.3	212	131	162
***9	32.1	25.5	202	145	138
10	32.0	22.6	201	132	151
11	32.2	23.2	203	135	150
12	29.7	24.0	191	134	142

* Armsby, H.P.-- Nutrition of Farm Animals, The MacMillan Co., N.Y. 1917, p. 713, 715.

** Receiving 25 gm. dried yeast per lb. of milk.

*** Preliminary period not figured in results.

PLATE 1

CALF Y-1 GROUP IIIa

At Close of Experiment

Age, 189 days. Average daily gain, 1.68 lbs.

Weight, 402 lbs. (111.3 per cent normal).

Height, 102.8 cm. (100.9 per cent normal).

Ration: Skimmilk "good ration",

alfalfa hay, ad libitum,

grain mixture, (corn 4, bran 1, oilmeal, 1), ad libitum.

PLATE 2

CALF Y-3 GROUP IIIa

At Close of Experiment

Age, 187 days. Average daily gain, 1.73 lbs.

Weight, 408 lbs. (113.0 per cent normal).

Height, 99.7 cm. (98.1 per cent normal).

Ration: Skimmilk "good ration",

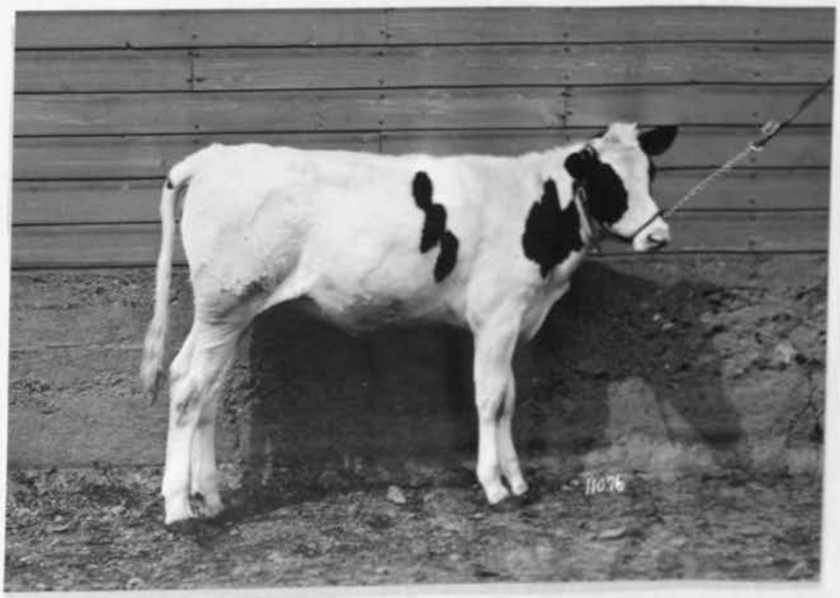
alfalfa hay, ad libitum,

grain mixture (corn 4, bran 1, oilmeal 1), ad libitum.

PLATE 3

CALF Y-4 GROUP IIIb

At Close of Experiment



Age, 186 days. Average daily gain 1.41 lbs.

Weight, 358 lbs. (100.3 per cent normal).

Height, 100.8 cm. (99.3 per cent normal).

Ration: Skimmilk "good ration",

alfalfa hay, ad libitum,

grain mixture (corn 4, bran 1, oilmeal 1), ad libitum.

Dried yeast approximately 10 per cent of dry matter in ration.

4-22-6M

PLATE 4

CALF Y-5 GROUP IIIb

At Close of Experiment

Age, 191 days. Average daily gain 1.72 lbs.

Weight, 425 lbs. (116.8 per cent normal).

Height, 104.6 cm. (102.2 per cent normal).

Ration: Skimmilk "good ration",

alfalfa hay, ad libitum,

grain mixture (corn 4, bran 1, oilmeal 1), ad libitum.

Dried yeast approximately 10 per cent of dry matter in ration.

PLATE 5

CALF Y-6 GROUP IIIb

At Close of Experiment

Age, 188 days. Average daily gain, 1.40 lbs.

Weight, 352 lbs. (97.9 per cent normal).

Height, 101.5 (99.8 per cent normal).

Ration: Skimmilk "good ration",

alfalfa hay, ad libitum,

grain mixture (corn 4, bran 1, oilmeal 1), ad libitum.

Dried yeast approximately 10 per cent of dry matter in ration

PLATE 6

CALF Y-7

GROUP IIIb

At Close of Experiment

Age, 189 days,

Average daily gain, 1.60 lbs.

Weight, 380 lbs. (105.2 per cent normal).

Height, 101.6 cm. (99.8 per cent normal).

Ration: Skimmilk "good ration",

alfalfa hay, ad libitum,

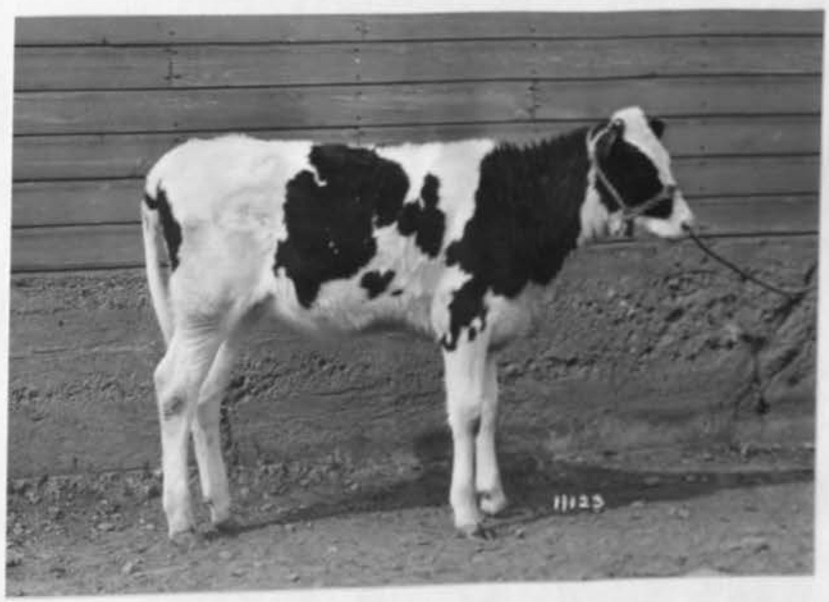
grain mixture (corn 4, bran1, oilmeal 1), ad libitum.

Dried yeast approximately 10 per cent of dry matter in ration.

PLATE 7

CALF Y-8 GROUP IIIb

At Close of Experiment



Age , 138 days Average daily gain, 0.91.

Weight, 270 lbs. (96.1 per cent normal).

Height, 95.9 cm. (101.2 per cent normal).

Ration: Skimmilk "good ration",

alfalfa hay, ad libitum,

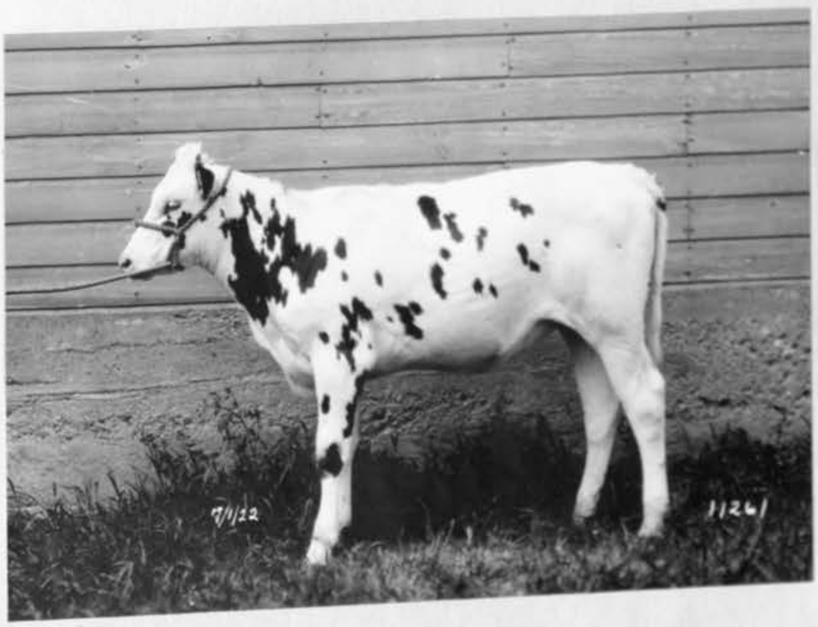
grain mixture (corn 4, bran 1, oilmeal 1), ad libitum.

Dried yeast approximately 10 per cent of dry matter in ration.

PLATE 8

CALF Y-9 GROUP IVa

At Close of Experiment



Age, 193 days. Average daily gain, 1.67 lbs.

Weight, 397 lbs. (108.3)per cent normal).

Height, 104.5 cm. (102.2 per cent normal).

Ration: Skimmilk "poor ration",

prairie hay, ad libitum,

grain mixture(corn 1, oats 1),ad libitum.

PLATE 9

CALF Y-10

GROUP IVa

At Close of Experiment

Average daily gain, 1.45 lbs.

Age, 197 days.

Weight, 373 lbs. (100.3 per cent normal).

Height, 99.5 (96.9 per cent normal).

Ration: Skimmilk "poor ration",

prairie hay, ad libitum,

grain mixture (corn 1, oats 1,), ad libitum.

PLATE 10

CALF Y-11 GROUP IVa

At Close of Experiment

Age, 195 days. Average daily gain, 1.56

Weight, 376 lbs. (101.9 per cent normal).

Height, 104.0 (101.5 per cent normal.

Ration: Skimmilk "poor ration",

Prairie hay, ad libitum,

grain mixture (corn 1. oats 1,), ad libitum.

PLATE 11

CALF Y-12

GROUP IVa

At Close of Experiment

Age, 193 days.

Average daily gain, 1.60 lbs.

Weight, 391 lbs. (106.7 per cent normal).

Height, 103.6 cm. (101.2 per cent normal).

Ration: Skimmilk "poor ration",

prairie hay, ad libitum,

grain mixture (corn 1, oats 1,), ad libitum,

PLATE 12

CALF Y-13 GAOUP IVb

At Close of Experiment

Age, 198 days. Average daily gain, 1.65.

Weight, 408 lbs. (109.4 per cent normal)

Height, 105.6 cm. (102.8 per cent normal).

Ration: Skimmilk "poor ration ",

Prairie hay, ad libitum

grain mixture (corn 1, oats 1), ad libitum.

Dried yeast approximately 10 per cent of dry matter in ration.

PLATE 13

CALF Y-14 GROUP IVb

At Close of Experiment

Age, 198 days. Average daily gain, 1.54 lbs.

Weight, 388 lbs. (104.0 per cent normal).

Height, 103.3 cm. (100.5 per cent normal).

Ration: Skimmilk "poor ration",

prairie hay, ad libitum,

grain mixture (corn 1, oats 1,) ad libitum.

Dried yeast approximately 10 per cent of dry matter in ration.

PLATE 14

CALF Y-15 GROUP IVb

At Close of Experiment

Age, 201 days. Average daily gain, 1.58 lbs.

Weight, 420 lbs. (111.4 per cent normal).

Height, 108.0 cm. (104.8 per cent normal).

Ration: Skimmilk "poor ration",

prairie hay, ad libitum,

grain mixture (corn1, oats 1) ad libitum.

Dried yeast approximately 10 per cent of dry matter in ration.

PLATE 15

CALF Y-16 GROUP IVb

At Close of Experiment

Age, 191 days. Average daily gain, 1.68 lbs.

Weight, 397 lbs. (109.1 per cent normal).

Height, 104.2 cm. (102.1 per cent normal).

Ration: Skimmilk "poor ration",

prairie hay, ad libitum,

grain misture (corn 1, oats 1), ad libitum.

Dried yeast approximately 10 per cent of dry matter in ration.

PLATE 16

COW 120 GROUP Va

At Close of Experiment

Age: 4 years, 4 months.

Weight: at start, 884 lbs.; at finish, 950 lbs.

Experiment included the 67th to 177th days of lactation period (divided into 3 experimental periods).

Dried yeast fed (25 gm. per lb. of milk produced) during 1st and 3rd experimental periods.

Average daily milk production:

yeast feeding periods, 22.2 lbs.,

control period, 22.4 lbs.

PLATE 17

COW 301 GROUP Va

At Close of Experiment

Age: 14 years, 1 month.

Weight: at start, 1420 lbs.; at finish, 1464 lbs.

Experiment included the 98th to 208th days of lactation period (divided into 3 experimental periods).

Dried yeast fed (25 gm. per lb. of milk produced) during the 1st and 3rd experimental periods.

Average daily milk production:

yeast feeding periods, 38.8 lbs.,

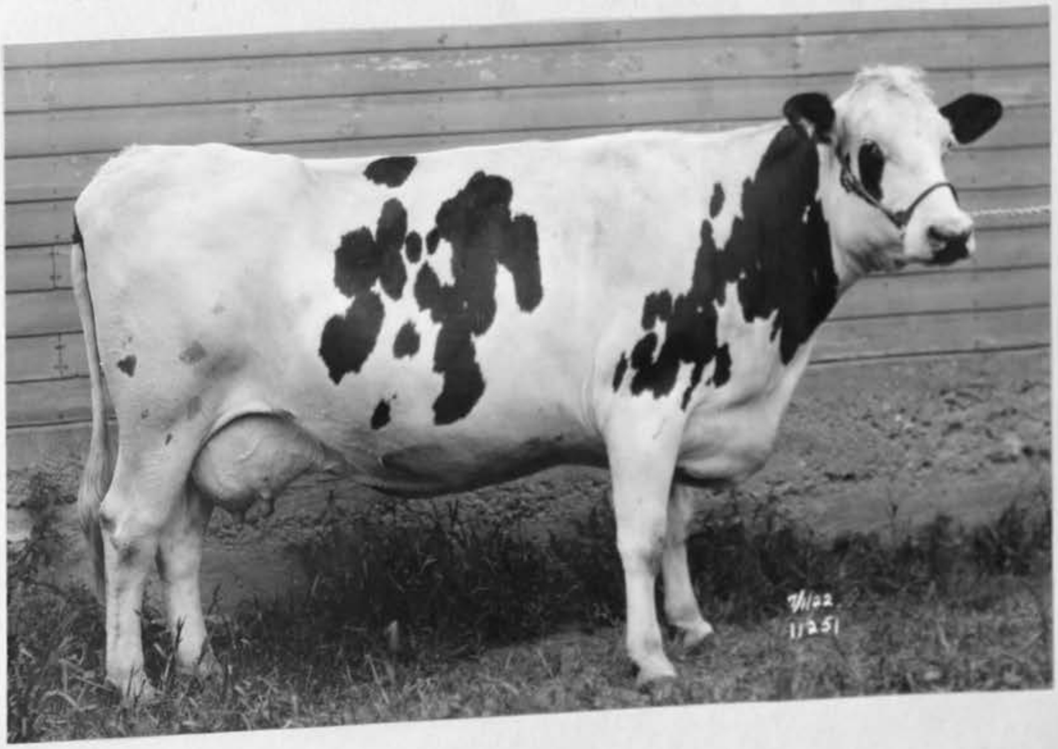
control period, 37.8 lbs.

PLATE 18

COW 317

GROUP Va

At Close of Experiment



Age: 6 years, 1 month.

Weight: at start, 1681 lbs.; at finish, 1823 lbs.

Experiment included the 195th to 305th days of lactation period (divided into 3 experimental periods).

Dried yeast fed (25 gm per lb. of milk produced) during 1st and 3rd experimental periods.

Average daily milk production:

yeast feeding periods, 17.4 lbs.,

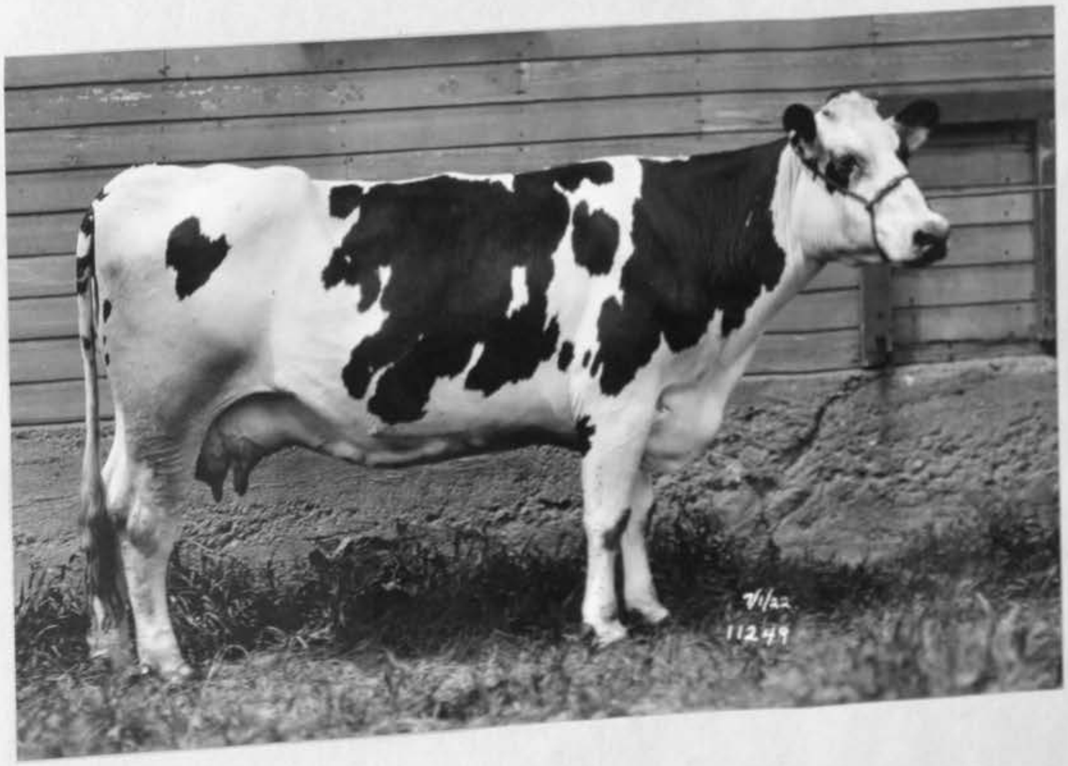
control period, 20.6 lbs.

PLATE 19

GROUP Va

COW 320

At Close of Experiment



Age: 6 years, 5 months.

Weight: at start, 1680 lbs.; at finish, 1728 lbs.

Experiment included the 307th to 417th days of lactation period (divided into 3 experimental periods).

Dried yeast fed (25 gm. per lb. of milk produced) during 1st and 3rd experimental periods.

Average daily milk production:

yeast feeding periods, 27.0 lbs.,

control period, 27.1 lbs.

PLATE 20

COW 102

GROUP Vb

At Close of Experiment

Age: 9 years.

Weight: at start, 1110 lbs.; at finish, 1201 lbs.

Experiment included the 43rd to 153rd days of lactation period (divided into 3 experimental periods).

Dried yeast fed (25 gm. per lb. of milk produced) during second experimental period.

Average daily milk production:

yeast feeding period, 8.4 lbs.,

control periods, 9.8 lbs.

PLATE 21

COW 306

GROUP Vb

At Close of Experiment

Age: 12 years.

Weight: at start, 1391 lbs.; at finish, 1490 lbs.

Experiment included the 191st to 301st days of lactation period (divided into 3 experimental periods).

Dried yeast fed (25 gm. per lb. of milk produced) during second experimental period.

Average daily milk production:

yeast feeding period, 31.1 lbs.,

control periods, 32.9 lbs.

PLATE 22

COW 333

GROUP Vb

At Close of Experiment

Age: 4 years, 3 months.

Weight: at start, 1380 lbs.; at finish, 1494 lbs.

Experiment included the 184th to 294th days of lactation period (divided into 3 experimental periods).

Dried yeast fed (25 gm. per lb. of milk produced) during second experimental period.

Average daily milk production:

yeast feeding period, 31.3 lbs.,

control periods, 30.1 lbs.

PLATE 23

COW 500 GROUP Vb

At Close of Experiment

Age: 12 years 5 months.

Weight: at start, 1055 lbs.; at finish, 1100 lbs.

Experiment included the 42nd to 152nd days of lactation period (divided into 3 experimental periods).

Dried yeast fed (25 gm. per lb. of milk produced) during second experimental period.

Average daily milk production:

yeast feeding period, 29.1 lbs.,

control periods, 29.5 lbs.