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MILK

THE INDISPENSABLE FOOD FOR CHILDREN

By

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INTRODUCTION

The American people are gradually learning that milk is essential not only for the normal healthy development of infants but also for children of all ages and for pregnant women and nursing mothers. Milk has no substitute in the diet of the child. Children are nourished better and more cheaply if an abundance of good whole milk is included in their daily food; also there is less danger of serious dietary deficiencies, which are occasionally the cause of grave nutritional diseases. Besides, plenty of milk in the diet of children has the more important effect of preventing a vague ill health that results from a diet partly lacking in the substances essential to growth and that is followed by failure to grow normally, lack of appetite and of vitality, and weakened resistance to infectious disease. The use of milk is the greatest factor of safety in our diet (1).[1]

About one-fifth of the food budget of the average American family is normally used for milk and milk products. Milk surveys and campaigns urging people to drink more milk (2) have resulted in increasing its use, especially in cities but also in many towns and even in rural districts throughout the United States. Milk has been firmly placed among the health essentials for children.

In view of the established importance of milk and the recent gains in scientific knowledge concerning it, a revision of the Children's Bureau bulletin on milk published in 1918[2] was felt to be needed. The present bulletin is a revision of the material in that publication in the light of later research by many authorities. As a result of studies of the food requirements of infants, of older children, and of expectant and nursing mothers the value of milk is now much better understood. For example considerable advance has been made in the study of vitamins in the last seven years. In the present bulletin the vitamins of milk have been stressed; and a table has been compiled from several sources, both in the United States and in Great Britain, showing the vitamin content of different forms of milk. The relative merits of the various forms of canned milk and of the processes used are discussed with special attention to the retention of vitamins and minerals. Improvements in methods of canning are noted.

[1] The figures in parenthesis used throughout refer to corresponding figures in the list of references on pp. 35–43.

[2] Publication No. 35, superseded by the present bulletin.

The manuscript has been submitted to authorities in the various fields of study touched on in the bulletin, and they have given many valuable criticisms and suggestions.

It is expected that this bulletin will be of use to teachers of home economics and to all persons concerned in the feeding of infants and older children and of expectant and nursing mothers.

THE NATURE OF MILK AS A FOOD

Milk is said to be a perfect food. By this is meant that it contains all the essential elements, which if taken in sufficiently large amounts allow normal growth and symmetrical development. Health and even the maintenance of life itself may depend on the presence of certain indispensable constituents of diet.

CHARACTERISTICS OF AN ADEQUATE DIET

The adequacy of a food or of a diet (3) depends on its containing:

1. Enough of the right sort of material to build up and repair the tissues of the body. The chief body-building substance is called protein. Milk, cheese, meat, fish, and eggs furnish the most valuable forms of protein, because they are constituted most like the proteins that form the principal basis of the structure of the muscles and organs.

2. A variety of mineral substances which are needed in the growth, maintenance, and functioning of the parts of the body, such as the skeleton, lungs, brain, thyroid gland, and muscles, and the blood and other body fluids.

3. An adequate amount of certain substances whose nature is not fully known but whose presence in the diet has been demonstrated to be necessary for health and growth in the lower animals and in man. These substances, known as vitamins or accessory diet factors, are indispensable elements in food, although sometimes they are present only in minute amounts.

4. Enough material to furnish the energy required by the body. Fat, starch, and sugar are the chief energy foods, and these are transformed in the body into energy for its activities and into body heat. A large part of the protein in food is used, even during the growth period, for energy processes.

5. Only substances that are not poisonous to the average individual and that will allow normal digestive processes.

In addition, to be properly digested and of the utmost nutritive value food should be of pleasing taste and of a consistency and appearance similar to other foods in customary use.

Clean milk fulfills all these requirements better than any other single article of food.

Milk is in a sense a complete food; if used as the sole food it will sustain life and allow growth. It may be so used in early infancy, but after that time additional foods must be eaten to supplement the deficiencies of milk in certain substances, especially iron. Milk is so completely digested that it is one of the most efficient foods (4); however, a certain amount of bulk and of nondigestible residue in the diet—so-called roughage—is necessary to regulate the discharge of waste from the digestive tract and so prevent constipation. For

these reasons by the end of the first year of life—and some authorities say after the first six months—a mixed diet including cereals, fruit, and vegetables is better than an exclusive milk diet.

COMPONENTS OF MILK

PROTEINS

Milk contains four proteins, of which two are present in considerable amounts. The curd of milk, which contains all its casein and part of its lactalbumin, has been found to be most valuable for building or renewing body tissues (5). There is no other animal protein of known value procurable at so low a price as the proteins in milk. Grains, legumes, and nuts do afford efficient proteins, more so than those of tubers and other vegetables; but in general plant proteins are not so valuable as animal proteins for tissue building and should not be relied on solely as a source of body-building protein.

MINERALS

Of all the minerals necessary for the growth of the child from conception to adult development, none is of greater importance to all parts of the body than the calcium and phosphorus salts, because these are the essential building materials for bone, which is largely calcium phosphate. Since growth is measured by the development of the skeleton and since the child must have a steady, abundant supply of calcium, as well as of certain vitamins, to build bones and teeth, body organs and fluids, milk should be included in every child's diet during the entire period of growth. "There are but two classes of calcium-rich foods—milk of animals and the leaves of plants."(6) Of all food sources of calcium, milk and cottage cheese are the cheapest, most easily available, and most abundant. Milk also provides other important minerals such as phosphorus and potassium.

When it is realized that 1 quart of milk will furnish as much calcium as 10 large oranges, 10 large helpings of spinach, 24 large helpings of carrots, 32 eggs, or 20 pounds of beef the value of milk for growing children can be appreciated.

The relative amounts of calcium in the foods richest in it are:[3] (7)

	Gram
1 cup milk	0.26
½ cup spinach, cooked (8)	.1
1 orange	.1
1 egg	.03
½ cup carrots, cooked	.04
2 ounces average beef	.006

Unfortunately, cow's milk is low in iron content (9), probably even as compared with human milk (8) (10), and this important mineral must be supplied by other foods. In spite of the fact that the form of iron in milk seems especially favorable for assimilation, the prolonged exclusive use of milk after early infancy tends to produce anemia due to lack of iron in the food. It is generally stated that the infant has considerable iron stored in the liver at birth, which enables it during the period of breast feeding to thrive on a food as low in iron

[3] Calculated from Table III, Appendix B, Chemistry of Food and Nutrition, by H. C. Sherman, second edition (The Macmillan Co., New York, 1918).

as human milk (10). Iron can best be introduced in the diet through the use in early infancy of fruit juices, green leafy vegetables, and egg yolk, and later of whole cereals, beef, and potatoes.

VITAMINS

The character and digestibility of its proteins and the abundance of its calcium make milk a most desirable food; but another property of milk produced under correct conditions lies in its containing ordinarily some of all the known accessory diet factors which control growth and health—the vitamins. Because of the fact that the vitamin content of cow's milk depends largely on the way the cows are fed and on the amount of sunshine they receive it is not always true that "milk is rich in all of the known vitamins" (11), but at least milk from pasture-fed cows is an unusual food in containing some of all the known vitamins. Many authorities believe that the antirachitic factor (see p. 5) should be supplied to all children in the temperate zones, whether breast fed or bottle fed, in winter by cod-liver oil and in summer by direct sunshine. After the first month orange juice should be given as an antiscorbutic to all bottle-fed babies and may be given to breast-fed babies.

The following table shows the relative vitamin content of different forms of milk:

TABLE 1.—*The vitamin content of different forms of milk*[1]

Form of milk	Vitamin A	Vitamin B	Vitamin C	Vitamin D[2]
Cow's milk:				
Fresh, whole, summer, from pasture-fed cows[3]	Rich	Good to fair	Good to fair	Probably poor.
Fresh, whole, winter, from stall-fed cows.[3]	Good	do	Fair to poor	Probably very poor.
Pasteurized	Rich to good.	do	do	Probably poor.
Scalded	do	do	do	Do.
Boiled	do	do	Poor	Do.
Skimmed, raw	Poor	do	Good to poor	Probably very poor.
Buttermilk	do	do	do	Do.
Condensed (sweetened)	Rich to good.	do	do	Do.
Evaporated (unsweetened condensed)	do	do	Poor	Probably poor.
Dried, whole	do	do	Fair to poor	Do.
Dried, skim	Poor	do	do	Probably very poor.
Colostrum	Rich to good.			
Human milk[3]	do	Good to fair	Good to poor	Probably poor.

[1] Adapted from Vitamins in Food (Poster No. 39 of the American Medical Association, 1922); Food Products, by H. C. Sherman, pp. 654–656 (The Macmillan Co., New York, 1924); and Report on the Present State of Knowledge of Accessory Food Factors, p. 116 (Medical Research Council, Special Report Series No. 38, London, 1924).

[2] Laboratory evidence so far seems to show that milk is a poor source of vitamin D. Further studies are needed to determine whether or not the antirachitic factor varies greatly in different forms of milk.

[3] The vitamin content of milk depends in general on the character of the diet.

When a food is lacking wholly or partly in any one of the known vitamins a special form of disease may develop; but long before this happens the person may lose appetite, may fail to grow (if young), and may be ailing and weakened in resistance to infectious disease (12).

At least two vitamins (known as vitamin A and vitamin D) are found in connection with the fat of foods (13) and are relatively stable—not easily injured by heat.

Milk fat, whether in whole milk, cream, or butter, furnishes the most important and most economical source of one of these vitamins,

vitamin A. Egg yolk, leafy vegetables, cod-liver oil, and certain animal organs, such as liver, are also good sources of this substance. Some vegetable oils, such as coconut oil, do not contain it, nor does pork fat. The skim milk left after the cream has been removed by a separator is almost entirely deficient in vitamin A. However, skim milk from which the cream has been dipped may contain as much as 50 per cent of the amount of vitamin A in whole milk. Xerophthalmia, an eye disease caused in young children by a lack of vitamin A in their food, has been found to be especially prevalent when machine-separated skim milk has been used in place of whole milk in their diet (14) (15).

The other vitamin found in connection with fats, which has been discovered recently (14) (15) (16) (17) (18), affects tooth and bone formation, promoting calcium deposition; it has been called the antirachitic factor, or vitamin D. Unfortunately its effect has been confused with the growth-promoting properties of vitamin A, and in some instances the result of the presence of vitamin D in food has been attributed to vitamin A. Egg yolk and, to a less extent, milk fat and coconut oil furnish some of this vitamin, but such fish fats as cod-liver oil are its most abundant source. When vitamin D is excluded from the diet of the young the disease called rickets may occur (19). The antirachitic factor, like vitamin A, may be stored to some extent in the human body (20); but so far as is known the human body is not capable of synthesis of this or any other vitamin, so that rickets in a breast-fed child is not only possible but unfortunately common. The percentage of vitamins in cow's milk has been proved to be dependent on the amount of vitamins in the cow's food (21), and possibly in the case of vitamin D it is dependent on the amount of sunshine afforded (22) (23) (24). Cow's milk, therefore, should not be depended upon solely to supply the antirachitic factor in the food of infants or young children. (Table 1.)

Two vitamins are soluble in water and are not associated with the fat content of foods. Because these water-soluble vitamins, B and C, unlike vitamin A and (probably) vitamin D, are not stored to any extent in the body, the necessity for a continuous supply from the food is most urgent (25) (26).

In foods consumed in their natural state vitamin B is so widely distributed (27) that it is ordinarily present in sufficient abundance to maintain health. In the manufacturing of purified foodstuffs such as polished rice and milled flour vitamin B may be lost, and a diet made up entirely of such denatured foods may cause a particular disease of the nervous system (beriberi) or even death, owing to a deficiency in this essential substance. An infant or a child whose food contains too little of this factor may show the deficiency first in lack of appetite, pallor, apathy, and failure to make normal gains in weight. There is practically none of this substance in fats or oils of any kind, pure sugar, starch, polished rice, or white flour. Milk is a good source of vitamin B.

The other water-soluble vitamin (vitamin C) is found especially in acid fruits, such as the lemon, the orange, and the grapefruit, and in the tomato. Fruits and vegetables, especially uncooked, are good sources of both water-soluble vitamins (28) (29). Vitamin C may

be lacking in cow's milk if it is stale, if it has been exposed to a prolonged high temperature, if it has been reheated, or if an alkali has been added to it. Cows stall fed and not supplied with green foods rich in vitamins, such as alfalfa, may produce milk very low in this factor. Summer milk produced by cows on fresh pasturage may be three to five times as rich in this vitamin as winter milk produced by cows which have been for months on dry feed. Human milk may be deficient in vitamin C, and scurvy of the breast-fed child has been recorded for many years. As an antiscorbutic, after the first month, orange juice should be given to all infants artificially fed and may be given to breast-fed infants. Many children kept on a diet low in vitamin C do not have symptoms of scurvy, but they are listless and are retarded in growth and development; this may be due to a prescurvy state, induced by lack of vitamin C.

Milk which, when produced under the right conditions and given in sufficient amounts, may contain enough of all these vitamins (except possibly vitamin D) to allow normal growth and development has a value in the human dietary greater than that of any other single food.

FUEL

As a source of energy or fuel for the body, milk compares favorably with other foods. The energy value of a quart of milk is about equivalent to that of a pound of lean meat or of eight eggs (32).

As a source of energy, grains (in the form of cereal or flour) are far cheaper than most other foods. Both the minerals and the proteins of cereals (which are largely inadequate for growth) are supplemented efficiently by milk (33). Therefore bread and milk or cereal and milk is an ideal combination of foods to furnish protein and body energy in childhood.

MILK AS A "PROTECTIVE FOOD"

It is true that in the period of growth the dietary should be built around grain products and milk, but it is even more important that the surrounding material should be green leafy vegetables and fruit. Milk has been designated (34) as one of the "protective foods," the greater consumption of which will tend to correct the deficiencies of the present American diet. This diet is largely made up of white bread, meat, potatoes, and sugar. Milk, green vegetables, and fruit are needed to supplement a diet of this type, which is lacking especially in vitamins and minerals (35) (36). "Both city and country dietaries in the United States are more often deficient in calcium than in any other chemical element so far investigated" (37).

THE VALUE OF MILK AS A FOOD

IN PREGNANCY AND LACTATION

MILK A PROTECTION FOR MOTHER AND CHILD

People are just beginning to realize not only that the human mother is intended to furnish nutriment for her baby for an average of at least 18 months (if the prenatal period of 9 months is included), but that the amount and adequacy of her food during this period and the store of food substances in her body determine

whether or not her baby is well nourished before birth as well as during the period of breast feeding. It is absurd to expect a mother living on a limited or deficient diet to build a baby or nourish it after birth successfully when experience in animal husbandry proves this to be impossible. "The nursing mother can not, except in very limited degree, put into her milk from her bodily reserves that which she does not receive in her food supply" (38).

The prevailing view that the pregnant woman's food can be left safely to chance or to the whims of her appetite might hold if people were not removed from their natural environment and were not living largely on devitalized foods and behind glass windows that filter out the essential light rays (39).

This is not the place to consider the details of the daily food in pregnancy (40), but the value of milk in the building of babies makes it essential in the pregnant woman's diet (41). The calcium content of milk is of special value in this country, where, as has been said, the diet is more likely to be deficient in calcium than in any other one substance (37) (42) (10).

The demands of the child's body for tissue-building substances are relatively greatest during the time of most active growth, which is undoubtedly the fetal period. The requirement for protein as shown by the drain on the nitrogenous substances in the mother's blood seems to be greatest during the midperiod of pregnancy, corresponding with the greatest increase in length of the fetus and the early development of the body organs and muscles. The greatest increase in weight, except the increase in the last month, is apparently in the seventh month of intrauterine life (43).

The retention of calcium and phosphorus by the fetus is increasingly great through pregnancy, corresponding to the development of body organs and fluids and the calcification of the skeleton and teeth. The daily absorption by the fetus of calcium oxide during the last third of pregnancy (44) (45) is estimated to be as great as the daily average absorption by breast-fed infants (46). The apparent tendency of the mother's blood to show a definite fall in the inorganic contents during the later months of pregnancy corresponds with this relatively enormous demand for minerals by the fetus and the developing maternal tissues (47) (48).

There is every reason then to believe that during the later months of pregnancy at least the need of the pregnant woman for calcium is one and one-half times as much, if not twice as much, as that of the nonpregnant woman. If there is an insufficiency of calcium in the food during pregnancy the growing fetus will take what it needs at the expense of the mother's organism, and the bones and teeth of the mother may suffer (49). If an abundance of the green leafy vegetables is included in the daily food, a quart of milk a day will insure a calcium intake sufficient for the fetal needs without calling on the mother's bones or teeth. It seems practically impossible for the pregnant woman to obtain enough calcium in her diet unless she takes daily at least a pint of milk or the equivalent in cottage cheese.

The complete nature of the combined proteins of milk, its richness in vitamin A, and the variety of its mineral salts, besides the abundance of calcium it affords, make milk a more important con-

stituent of the diet during pregnancy than perhaps in any other period of life.

Millions are spent for tooth-repair work, to say nothing of the more important preventive dentistry, during both childhood and maturity, but little thought is given to the period when the foundation of the teeth is laid down—the prenatal period (50). It is well to remember that teeth are started in the first months (about the fiftieth day) after conception, that calcification of the first or temporary set is begun in the fifth month, that all the teeth of the first set are in the jaw at birth, and that by the sixth month after birth practically all the teeth, temporary and permanent, have been started, and the entire temporary set are enameled. The nutrition and metabolism of pregnancy seem even more important when it is realized that the temporary teeth are intended to function from the seventh month to the twelfth year, and that the first permanent molars are in some ways the most important teeth (51).

With these facts known, who could question the necessity of milk for the expectant mother, as well as the nursing mother?

Milk can be disguised in the diet. Although the use of milk as a drink is largely a matter of training, adults who have not acquired the milk habit in childhood or those who dislike its taste or are fanciful in regard to food can be given any desired amount of milk in the daily food by a little study (52). A pint of milk can be used easily in cooking the day's food; and in drinks made with milk, such as cocoa and milk shake (with or without egg), its presence need not be noticeable. Milk products, such as cottage cheese, other cheese, skim milk, buttermilk, and cream or butter can be used instead of whole milk. Milk powder or evaporated milk can be used wherever a good grade of fluid milk is not obtainable. Milk powder, being a solid, is particularly useful in those conditions in pregnancy where it is desirable to take small amounts of highly nourishing foods or where liquids are not easily retained.

BREAST MILK THE BEST FOOD FOR BABIES

Among the lower animals, as a rule, the young are not born until near the period when they can dispense with nourishment by the mother and can forage for themselves. It is important to keep in mind the fact that the human infant was evidently intended to be dependent on the mother's nourishment for at least the first year of life as well as the prenatal period, since the infant does not develop teeth nor acquire the power of taking other than soft food for several months after birth.

Any infant that has to be artificially fed during the first months of life is in a sense a premature child, as he has been deprived of maternal feeding long before the normal period of separation from his mother. Giving any other food than human milk to an infant soon after birth, therefore, is introducing a foreign substance into his partly developed digestive system, and the dangers of such feeding vary with the individual as well as with the composition of the artificial food selected. These dangers are still little understood.

For these reasons breast milk—the natural food for human young—is under the right circumstances the best food for the infant. There is nothing just as good as mother's milk. The fact that the

milk of a particular woman may not agree with her child or that it may be inadequate does not alter the truth of the general proposition: Breast milk is the best food for babies. Breast feeding is the one means of giving every infant that survives birth the best chance for life and health.

Besides having great nutritive value breast milk is a protection. Breast-fed infants have been found to have a lower morbidity rate as well as a lower mortality rate than bottle-fed infants. Breast-fed infants are apparently less susceptible to most diseases, are better able to resist infection, and can stand diseases with less injury (53).

Whatever the percentage of artificial feeding among infants—and it has been calculated [4] that about one-fifth of all infants under 1 year of age are weaned before the fourth month of life—two things may be positively stated. The first is that infants artificially fed in the early months of life show a mortality between three and four times that found to prevail among breast-fed infants (54), and the second is that judging by the fine work done in large cities in the last few years the number of children breast fed and the length of period of breast feeding can be greatly increased by careful medical supervision of the mother before and after the birth of the child (55).

The American mother can be taught to nurse her child for as long a period as it can thrive on her milk. The length of this period depends very largely on the previous state of her nutrition, her prenatal food and hygiene, the way in which breast feeding is established, and the care with which her physician instructs her regarding the technique and hygiene of nursing and the food required to keep up her supply of milk (56).

The amount and kind of food required to maintain an adequate milk supply is far more generally understood than what constitutes a balanced, sufficient diet during pregnancy. The use of milk to produce milk is quite generally accepted. The high protein ratio in food which has been convincingly proved necessary for milk production in dairy husbandry (57) (58) is best obtained for the human mother by an abundance of milk or milk products in her diet rather than by an increased use of meat or eggs (59).

A generous diet is necessary during the nursing period, but there is every evidence that the selection of food is far more important than a simple increase in its amount. The diet should be specially rich in protein, for three to four protein calories must be furnished in the diet for every ounce of milk produced (60). Besides the adequacy of the protein in the diet the abundance of minerals must be carefully safeguarded to insure sufficient calcium and phosphorus for bone growth (61) (62) (63). These findings tend to prove the truth of the statement that "in order that breast milk may actually show the superiority that we are accustomed to expect of it, the attention paid to maternal feeding should take account of the food consumed by the mother as well as of the extent to which the mother nurses the child. In the mother's diet milk should have a prominent

[4] In eight of the cities in which infant-mortality studies have been made by the Children's Bureau, it was found that of the 21,560 infants who lived to be 3 months of age, 4,337 (20.1 per cent) had been weaned. See Causal Factors in Infant Mortality, by Robert Morse Woodbury, General Table 67, p. 212 (U. S. Children's Bureau Publication No. 142, Washington, 1925).

place, since it constitutes such an important supply of the nutrients from which the breast milk is to be formed" (64).

A relationship has been traced between the composition of the milk of a species as determined by gross chemical analysis and the normal rate of growth in the young of that species (65). It is known now that the superiority of milk is not due to any one constituent and that milk can seem adequate both quantitatively and qualitatively in regard to protein, fat, sugar, and the inorganic salts, and still be unable to promote normal growth or to prevent serious nutritional disease in the young. "Animals can not grow without accessory food factors" (66). Probably the rate of growth in the young is also closely related to the amount of vitamins supplied, provided that the diet is otherwise adequate and abundant (66). If a mother's diet is deficient in either fat-soluble or water-soluble vitamins this deficiency sooner or later will affect the value of her milk (67). It seems reasonable to suppose that the breast milk of a mother who is receiving adequate sunlight and who is fed on a diet rich in the accessory food factors should supply all the vitamins necessary for growth and normal nutrition, unweakened by heat, oxidation, or dilution. The common occurrence of rickets among breast-fed infants in this country is probably caused by the inadequate sunlight and diet received by mother and child.

For a mother to produce good breast milk is better for herself, better for the child, and incidentally better for the family pocketbook.

IN INFANCY AND EARLY CHILDHOOD

The only foods intended for the exclusive nourishment of young animals are milk and eggs. Except the germ of seed, all other substances suitable for their nourishment are taken from partly or fully grown animal or plant structures. For this reason it would be expected that milk, eggs, and the germ of seed contain the vital elements for the maintenance of young life, and experiments tend to prove that they do.

Unfortunately, eggs and seeds do not lend themselves to the early, exclusive feeding of the human infant. Infants in Japan are occasionally fed even from birth on a soy-bean mixture; but judging by the high infant death rate in Japan, it seems unnecessary to argue for this substitute for milk as the principal food for infants when milk can be obtained.

The statement can not be challenged that for children under 2 years of age breast milk or other milk is an absolute necessity for proper nutrition, which will enable the coming generation not only to measure up to the past standards of healthy growth but to improve on them steadily. One urgent national problem is to see that every child in the United States gets his full quota of milk that is standard in purity and quality.

The necessity for milk in the diet of the child could well rest on its value as a calcium food alone. A recent study has shown a definite relation between the needs of growth and maintenance and the amount of calcium which must be available. It seems settled that for children between 3 and 14 years of age the best storage of calcium occurs when a quart of milk is included in the daily diet. Not as good

calcium storage is obtained on a pint and a half of milk a day as on a quart, nor is this absorption as good if part of the calcium of the food is obtained from vegetables instead of from milk (68).

Although the study mentioned in the preceding paragraph does not include children under 3 years of age, other studies of the use of calcium by infants (46) and of the amount of milk taken by the average breast-fed infant make it proper to assume that the relative need of calcium is not less in infancy than in later childhood. The younger the child the more rapid is the rate of growth, and probably the greater is the relative calcium requirement (69). Recent experimentation on animals would suggest that the amount of lime in the diet directly affects the size and weight of the bones (70).

Much less is known concerning the phosphorus needs of the body and the availability of the different forms of phosphorus in foods. The need for phosphorus of a child under 6 probably is adequately supplied if a quart of milk is included in his food daily. For older children the extra phosphorus needed should be supplied by whole cereals, meat, fish, and eggs. With some children the addition of vegetables to the diet favorably affects the storage of phosphorus (68). A diet rich in milk and in whole grains (cereal or bread) is never deficient in phosphorus.

The ratio of calcium to phosphorus in the diet seems to be important, as well as an adequate supply of the different forms of these two substances (71). The relative proportion, nearly 3 to 2, of calcium and phosphorus in breast milk has been found to be a favorable feeding ratio for normal calcification of bone in human infants and in certain animals. The effect of direct sunlight, or of the antirachitic substance in cod-liver oil and egg yolk and to a slight extent in butterfat, is probably to permit a normal adjustment between the essential minerals supplied to the developing bone, even when the intake of either mineral is usually low. The waste of these elements is thus greatly reduced, and maximal storage is obtained (72) when the antirachitic factor is supplied.

Animal husbandry teaches that the feeding of animals for profit requires that "they must be born in a state of nutrition, obtained through the mother, such that they may begin their independent existence with a fund of vitality which insures growth and normal functions, provided the conditions of living are reasonably favorable. Success in animal production also depends on making the young animals grow just as fast as they are capable of growing. It is now proved that it is not possible for animals to grow too fast, and that the faster the rate of growth in the young the greater will be the vigor when growth is completed. This statement refers to the symmetrical development of all the tissues. Increase in weight from excessive fattening or edema is not the same as normal growth"[5] (73).

[5] One deplorable effect of the recent splendid drive against malnutrition has been a too exact interpretation of the so-called standards of height and weight, regardless of the type of child and the conditions of race, heredity, etc. Well-meaning adherents to different systems of estimating growth and food needs in childhood would actually curtail the food of healthy children or retard their growth to bring them into conformation with such standards. It is well to remember that children can not normally grow too fast and that tables giving averages of height and weight for age are not necessarily optimum tables but must of necessity be low averages since they include those children who have been more or less stunted in growth on account of infectious disease, malnutrition, and other bad conditions.

Milk may be given to young children, as well as adults, in cooked forms, such as soup, weak cocoa, or flavored milk shake (74). White sauce, milk gravy, creamed dishes, milk puddings, milk sherbets, and ice cream require milk in their composition. Milk is a valuable food in any form. If used as a drink, it should be taken near the end of the meal, for many children will not take sufficient other food if they fill themselves up first with milk. Sometimes, but very rarely, a child has an idiosyncrasy for milk proteins and is made violently ill by milk.

Appetite must be considered in planning a child's diet. An exclusive diet of any single food becomes distasteful and tends to lower digestive processes, so that nutrition is impaired. However, a child should not be allowed to refuse milk as a substantial part of his daily diet. Every normal child is better for taking at least 1½ pints of milk a day. The mother who does not make every effort to furnish sufficient milk for her children and to train them to drink it is not fulfilling her duty. Healthy children can be taught to like a varied diet, to eat what is good for them, and to finish the entire meal. Patience, persistence, and tact are needed to teach proper food habits to the young; and to be effective this discipline must be maintained from birth. Young children are very suggestible, and too often their dislike for milk is started by the distaste the parents show for it or by unwise attempts to force it against the child's opposition (75). Food habits are not learned in a day.

Milk is an indispensable part of the diet of pregnant and nursing mothers and of all young children. So long as a child is growing it is well to include a quart of milk daily in his diet, used either as a drink or in cooking his other food. A pint and a half a day is the minimum amount of milk which will insure proper growth in the average child. Children who have too rich or too abundant a diet may seem to do better with less milk, or even without any; but here the fault is not primarily in the quantity of milk but in the total amount of food. On the other hand, an exclusive milk diet after the first year is ultimately harmful. Milk should not be given to a child to such an extent as to prevent his taking an ordinary amount and variety of other food.

SUBSTITUTES FOR BREAST MILK

The use of the milk of domestic animals for the nourishment of infants who have to be weaned prematurely is as old as legendary history. Indeed, in many places wild animals were domesticated first for their direct value as food and then for the production of milk.

The problem of what milk to feed the infant after weaning has become increasingly important, for in general the period of breast feeding unfortunately has become shortened with advancing civilization.

In this country only two animals, the cow and the goat, are milked. A variety of other animals—sheep, llama, buffalo, camel, mare, ass, and reindeer—are milked in places throughout the world where the dairy cow has not yet been introduced or can not thrive. The cow, where the climate and type of country are suitable for its maintenance, gives, on the whole, a better return of milk for the amount

of food required and the labor expended (76) than does the goat. There is as yet no conclusive evidence that there is any marked superiority in either nutritive value or digestibility of one milk over the other for infant feeding.

The following table shows the average composition of milk of various kinds:

TABLE 2.—*Average composition of milk of various kinds*[1]

Kind of milk	Water	Protein			Fat	Carbohydrates (milk sugar)	Mineral matter	Approximate fuel value per ounce
		Casein	Albumin	Total				
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Calories*
Woman	88.3	0.4	0.7	1.1	3.3	7.0	0.3	18
Cow	87.0	2.8	.5	3.3	4.0	5.0	.7	20
Goat	85.7	3.5	1.0	4.5	4.7	4.4	.8	22
Buffalo (Indian)	82.2	4.3	.5	4.8	7.5	4.8	.8	30
Camel	87.1	3.5	.4	3.9	2.9	5.4	.7	18
Llama	86.6	3.0	.9	3.9	3.2	5.6	.8	19
Reindeer	67.2	8.4	1.5	9.9	17.1	2.8	1.5	58
Mare	90.6	1.3	.8	2.1	1.1	5.9	.4	12
Ass	90.1	.8	1.1	1.9	1.4	6.2	.5	13

[1] Adapted from Milk and Its Uses in the Home (U. S. Department of Agriculture, Farmers' Bulletin No. 1359, Washington, 1923), p. 5; and "A chemical study of woman's milk, especially its inorganic constituents," by L. Emmett Holt, M. D., Angelia M. Courtney, and Helen L. Fales, in American Journal Diseases of Children, Vol. X (October, 1915), pp. 239–245

GOAT'S MILK

The goat can thrive either singly or in a herd, on hilly or rocky land, on vacant city lots, along roadways and fences—where there is not sufficient food for a cow (77). The goat has been called the "poor man's cow." The value of the goat when kept singly is largely for families who desire a small quantity of milk and have not the purse to buy a cow nor the space to keep it.

Although goat keeping as an industry was introduced into this country nearly 40 years ago it was confined almost entirely to the Southwestern States until a renewed interest in goat's milk production was stimulated during the last 20 years by importation of the better Swiss breeds.

Keepers of goat dairies, who pay special attention to development of milk production, agree as to the low cost of goat keeping where the best breeds of goats are used and good pasture is available most of the year. The average cost of feed needed to produce a gallon of milk in only 6.4 cents (78). In the scientifically developed herds at the University of California a gallon of milk was produced 23 per cent cheaper and a pound of butterfat 7 per cent cheaper by the goat herd than by the cow herd. These figures, however, would not hold for the average cost of the production of goat's milk and cow's milk throughout the United States. The yield of the average goat varies from 3 pints to 3 quarts a day during the period of lactation of about eight months, or 800 to 1,000 pounds (78) of milk a year—from eight to fifteen times her weight. The average cow has a much larger yield (4,000 pounds (79) annually) and a lactation period longer by several months.

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The composition of goat's milk varies considerably from that of cow's milk. (See Table 2.) The percentage of fat and that of protein tend to be considerably higher in goat's milk. The fat droplets are smaller, and the emulsification of the fat is more thorough, so that the cream does not separate readily upon standing (80). The iron content is said to be, like that of human milk, higher than that of cow's milk (81).

The taste is agreeable if proper precautions are taken in milking. There is no excuse for allowing milk to have either a "goaty" or a "cowy" taste.

The use of goat's milk for infant feeding has enthusiastic supporters, and there is no doubt that it can be as well adapted as cow's milk to serve as a substitute for human milk. The real acidity is said to be considerably less than that of cow's milk (82), and the curd formed in the stomach is apparently finer (76). It has one preeminent use, which makes it of the greatest value in the early feeding of children. Some infants, a relatively small number, show intolerance to cow's milk, due to idiosyncrasy to any or all of the proteins of milk (83). This makes a most difficult feeding problem if for any reason mother's milk is not available in the early months of life. Such infants may do well on goat's milk, if there is no similar intolerance to its proteins (84). For this reason an available supply of goat's milk powder or evaporated goat's milk is important. Evaporated goat's milk is now manufactured in Monterey, Calif. (78).

The goat's apparent insusceptibility to tuberculosis is offset by its susceptibility to Malta fever, epidemics of which in certain Southern States have been not uncommon. The heating of goat's milk before consumption, as practiced in Europe, would seem to be a wise precaution, although the disease so far has been entirely regional.

COW'S MILK

Whether or not cow's milk as compared with the milk of other domesticated animals is nearest in composition to human milk, the development of the dairy cow has brought about the almost exclusive use of cow's milk as a substitute food for infants when artificial feeding as an emergency measure is unavoidable.

The milk of every animal is specially adapted to its offspring—varying with its average size, its rate of growth, and the length of time after its birth before other food can be taken. The difference in the chemical composition of cow's and human milk (85) (86) therefore is best explained by the fact that the calf doubles its weight in 47 days and the infant in 180 days (87).

Human milk has a little more than one-third the amount of protein in cow's milk and less than one-half the amount of mineral salts. The relative proportions of the different salts differ remarkably little, though the percentage of iron is said to be higher in human milk than in cow's milk.

The following table shows the percentage of mineral salts in human milk and in cow's milk:

TABLE 3.—*Mineral salts of human milk and of cow's milk*[1]

	Average percentage of salts in the ash						
	CaO	MgO	P_2O_5	Na_2O	K_2O	Cl	Fe
Human milk	23.3	3.7	16.6	7.2	28.3	16.5	0.00015
Cow's milk	23.5	2.8	26.5	7.2	24.9	13.6	0.00007

[1] Adapted from "A chemical study of woman's milk, especially its inorganic constituents," by L. Emmett Holt, M. D., Angelia M. Courtney, and Helen L. Fales, in the American Journal of Diseases of Children, Vol. X (October, 1915), pp. 246-247.

The fat content and the size of the fat droplet vary greatly in milk from different breeds of cows, but ordinarily there is not much difference in average amount of fat between cow's milk and human milk. The percentage of sugar (lactose) is about twice as high in human milk as in cow's milk.

The relative average difference in the vitamin content of the two forms of milk is not yet known. There is no reason, however, to doubt that the vitamin content of a woman's milk, as of a cow's, depends primarily on her diet, and probably also on her exposure to the direct rays of the sun. (See p. 4.) The occurrence of deficiency diseases—beriberi (88), scurvy (89), and rickets (90) (91)—in breast-fed infants during the first months after birth, as well as later, gives startling evidence of the effect of inadequate feeding and hygiene of mothers.

Digestive disturbances in infants fed on cow's milk have usually been attributed to its difference from human milk in the percentage of casein (see Table 2) or to the chemical differences in the fat (84). It seems probable now that many of these disturbances are due to the fact that cow's milk has a higher "buffer value" than breast milk; that is, cow's milk is able to neutralize or bind more acid than breast milk. The digestion of cow's milk therefore requires more acid secretion in the stomach than the digestion of breast milk. Individual instances of deficient gastric secretion may occasionally be the result of congenital defect or disease. However, breast milk is intrinsically more acid than cow's milk. Acidification is the method generally employed to reduce the buffer content of cow's milk and render it more digestible by the infant. Dilution also slightly increases the acidity of the milk, and so helps to reduce the buffer content. (92) (93) (94) (95) (96)

Cow's milk to be a safe food for anyone must be clean and free from the germs of disease. This is even more important in regard to milk for infants than for older children or adults. Not only should cow's milk be pure, but the fresher it is and the fewer manipulations it has been subjected to, the less probability there is of its having been altered in any of its essential properties as a complete food. Knowledge of the fundamental nutritive qualities of milk is still incomplete, so that it can not be affirmed absolutely that heat, chemicals, or mechanical manipulations do not alter its nature as a food in some essential way.

The modification of cow's milk to adapt it to the needs and digestive ability of the average child is studied in another bulletin of

the Children's Bureau, "Infant Care" (Publication No. 8), and will not be discussed here.

If cow's milk is to be used the questions next to be taken up are which form of cow's milk is the safest and the best adapted to the nourishment of infants, which is best suited to transportation, and which is available in all localities.

THE PURCHASING AND PREPARATION OF MILK FOR INFANTS

LIQUID MILK

GRADES OF RAW MILK

The United States Department of Agriculture takes as the standard for milk (97) "the whole, clean lacteal secretion obtained by the complete milking of one or more healthy cows, properly fed and kept, excluding that obtained within 15 days before and 5 days after calving, or such longer period as may be necessary to render the milk practically colostrum free."

It is left to the State (98) or the city to set up further standards to protect consumers of milk against fraud and disease and to insure that proper methods are used in the production, handling, and transportation of milk. The regulation of milk and milk supplies, with other public-health protection, is part of the police power of the State, as the United States Supreme Court has decided on several occasions (99).

Many cities, both large and small, have strict regulations in regard to such requirements, employing inspectors to detect insanitary practices in dairies and milk plants and to encourage the best methods of dairying. For proper control and study of a milk supply it is also necessary to maintain laboratories to find out its quality—whether it has been adulterated by skimming or watering—and its richness in fat and other solids, its freedom from dirt, and its bacterial content (100). There is no reason why, if funds are available, small cities can not have at least as good a milk supply as larger cities. It is, however, a fact that because milk control has not been developed smaller cities, villages, and rural communities are in more danger from poor milk than large cities, where increasing effort is being made to safeguard the public in the use of all dairy products. It has been estimated that in cities the annual per capita cost of controlling the quality of the milk offered for sale is only about 5 cents (101).

In city or country the quality of milk, whether raw, Pasteurized, or canned, as it reaches the consumer, depends largely on the quality of the original milk (102). Therefore supervision and control of the source of supply are of the utmost importance. The production of clean, pure cow's milk of good quality and low bacterial content depends on the feeding and the health of the cow; the cleanliness of the cow, the milker, and the utensils; the use of the small-mouthed milk pail; prompt, efficient cooling of the milk and constant refrigeration until the milk is used (102) (103).

Grading of milk, based on dairy scores and bacterial count, which has become universal in cities having the best milk ordinances, is one of the first steps necessary in the protection of the public food supply. The United States Department of Agriculture recommends that in framing a milk ordinance city authorities divide milk into three grades.[6] The requirements for these grades as to both composition and bacterial content are different in different localities. The commission on milk standards appointed by the New York Milk Committee requires Pasteurization for all grade B milk and recommends it for grade A milk (105).

In 1920 information was obtained about the milk supply of 83 cities, including 25 cities having a population of more than 250,000 and 58 cities having a population of less than 250,000 (106). Of these cities only 31 reported a graded milk supply, and 45 reported the sale of certified milk for which the bacterial count must not exceed 10,000 per cubic centimeter. In the cities where grade A raw milk was sold the maximum bacterial count allowed varied from 40,000[7] to 100,000 per cubic centimeter, and this milk when Pasteurized was allowed a bacterial count of 5,000 to 30,000 per cubic centimeter. Only a few of the cities had a grade B milk (with a bacterial count up to 200,000 per cubic centimeter in raw milk and from 50,000 to 100,000 in Pasteurized milk), and practically none allowed milk of a lower grade than this to be offered for sale.

A grading ordinance recommended by the United States Public Health Service (107) has been adopted as standard since 1922 by the State boards of health of Alabama, Texas, Virginia, Kentucky, Tennessee, South Carolina, Missouri, and North Carolina, and by July 1, 1925, had been enacted into law by 53 cities. This number, added to the 31 cities reporting in 1920, makes a total of 84 cities in the United States which had adopted grading ordinances up to July 1, 1925.

All market milk should reach the consumer within 48 hours after it is produced, for changes affecting its nutritive value and its purity are likely to occur as time elapses (108). Surprisingly little emphasis is usually put on the differences between stale milk and fresh milk, though it is obvious that milk dried or canned within a few hours after it is drawn is in a sense fresher than so-called fresh milk which may actually be three or more days old. Certified milk is supposed to reach the consumer before it is 24 hours old (104).

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[6] The U. S. Department of Agriculture has drafted the framework of an ordinance upon which cities and towns may build a law adapted to local conditions. Part of this form is as follows:

"*Certified milk* is milk produced and handled in conformity with the methods and standards for the production and distribution of certified milk adopted by the American Association of Medical Milk Commissions May 1, 1912, and amendments thereto (104) in effect at the time of production, and certified to by a milk commission constituted in compliance therewith. *Grade A milk* is milk produced from healthy cows, as determined by the tuberculin test and physical examination within not exceeding one year previously by a qualified veterinarian, from dairies that score not less than ——— on the dairy-farm score card in current use at the time by the U. S. Department of Agriculture, which milk shall not, at any time, contain more than ——— bacteria per cubic centimeter. All persons coming in contact with the milk or milk utensils must be medically inspected, and such inspection must have the approval of the board of health. *Grade B milk* is milk produced from healthy cows, as determined by physical examination within not exceeding one year previously by a qualified veterinarian, from dairies that score not less than ——— on the dairy-farm score card in current use at the time by the U. S. Department of Agriculture, which milk shall not, at any time, contain more than ——— bacteria per cubic centimeter" (100).

[7] Two cities had special grades of milk with maximum bacterial counts of 15,000 and 25,000 respectively.

In large cities, or wherever else it can be obtained, certified raw milk or milk of grade A quality that has been Pasteurized should be purchased for infants. In small cities, if the milk is not graded, information regarding dairies may be obtained from the local board of health. In towns and small communities a visit to the dairy should be made by the householder personally. Bottled milk should always be used, as "dipped" milk, dispensed from a large container, is an unsafe food for young children. When milk is used on the premises where it is produced it should be kept in sterilized bottles or jars. The essentials of the care of milk both in the dairy and in the home are to keep it clean, cool, and covered (109).

In general only the milk of a tuberculin-tested, healthy, well-cared-for herd or single cow should be used. Herd milk tends to vary less in its character than the milk of a single cow, and is preferable for infants if other conditions are equal. Milk relatively low in butterfat is generally better for infants, and the removal of 1 or 2 ounces of cream from the top of a quart by means of a cream dipper easily adapts milk of high butterfat content for their use.

It is very difficult to obtain a constant supply of raw milk in a state suitable to be fed to an infant (110), for even under the best conditions any milk may become contaminated accidentally. Milk fit to be used raw must be produced under conditions which insure rigid scientific inspection of the dairy, the cow, the milkers, and the utensils and supervision of the care given to the milk (102) (103) and which allow the milk to be used in a relatively short time after it is produced. Certified raw milk can be obtained in large cities, but only at a price prohibitive except to families with incomes far above the average. In large cities—where milk has to be furnished to thousands of infants, where it has to be supplied from a large number of dairies of all sizes so that adequate inspection is difficult, and where it has to be transported long distances and kept for a long time—ordinary raw milk is not a safe food for infants.

PASTEURIZED MILK

Pasteurization of most of the milk for infants and children which is supplied to cities and towns therefore becomes a necessity. Such general Pasteurization of milk does not eliminate the need for great care in the production and handling of milk, but it provides an additional safeguard for milk which must be transported long distances. Pasteurization of milk does not justify the use of filthy milk; neither does it take the place of heating milk again before its use by infants. But in some small cities and towns the conditions of production are so insanitary that Pasteurization is doubly necessary if the milk is to be used for children. Pasteurization should be regarded as an additional factor of safety in caring for clean milk and not as a cloak to cover dirty milk. Pasteurization is the best method at present available for obtaining safe milk on a large commercial scale (108) (111) (112) (113). Most public-health authorities consider Pasteurization necessary in order to prevent milk-borne epidemics of disease (114).

When milk is Pasteurized it is generally heated to 145° F. (about 63° C.) and held at this temperature 30 minutes (111). This process

when done by the best commercial methods (112) destroys a large percentage of the bacteria in milk and considerably delays its souring. Vitamin C and the calcium salts of milk are thought to be affected adversely by Pasteurization. The important result of Pasteurization is that if properly done it kills any disease germs present, such as the germs of tuberculosis, diphtheria, typhoid fever, septic sore throat, or scarlet fever. For this reason to render milk a safe food Pasteurization is carried out to some extent in the majority of United States cities of 10,000 inhabitants or more, and 90 per cent or more of the milk that is used in the 12 largest cities is Pasteurized (113). The average cost of Pasteurizing milk was estimated in 1913–14 to be 0.313 cent a gallon (115). Pasteurized milk is not sterile, and it will not keep unless quickly chilled and kept chilled until used; and for children it should be used within 36 hours after being Pasteurized. More general supervision by State and municipal authorities of Pasteurization of milk would tend further to eliminate defects in the apparatus and methods employed (116) and to give the public a good and uniform milk supply (117).

Even when milk is produced under apparently perfect conditions the possibility of bacterial contamination can not be eliminated. Epidemics are frequently reported in which the infection has been traced to a single dairy, even to a dairy which came up to the highest requirements for milk production, and occasionally to a dairy where the milk was Pasteurized, though "no epidemic of disease has ever been traced to properly Pasteurized milk" (118). Furthermore, transporting and keeping milk increase the danger of bacteria's multiplying to a dangerous extent before it is used.

For these reasons the heating of milk sufficiently to insure the killing of bacteria ordinarily present is now generally considered a wise precaution to be taken in the home before young children are fed milk either raw or Pasteurized, even of grade A quality.

PREPARATION OF MILK

The necessity of heating milk to make it a safe food before giving it to infants presents several problems, as the temperatures and methods used to destroy bacteria have other effects also on the milk. At one time heating milk was held to change its food value in no way (119). Recent work on the effect of high temperatures on the accessory food factors in milk has necessitated some change in this opinion (120). Vitamins A and B seem to suffer little, if any, in the heating of milk. There is considerable evidence now that the antiscorbutic vitamin (vitamin C) is the least stable of the accessory food factors and that it is injured in general by heat, oxidation, and alkalization. The degree of heat and the length of time it is applied both affect the amount of injury. These conditions also cause changes in the physical and chemical properties of milk that may definitely influence its physiological value for an infant.

Sterilization of milk requires more heat than any other process. Milk boiled (heated to 212° F.) is often spoken of as sterilized milk. However, milk is not sterilized—that is, freed from all forms of living organisms—unless it is subjected to this high temperature

for an hour or more on several successive days. Boiling for five minutes does kill all ordinary bacteria and does render milk for all intents and purposes a sterile food. If there is any question whether milk is contaminated, this method should be used.

All methods of heating milk probably influence the destruction of vitamin C, although holding milk at a high temperature while exposed to air seems to be more destructive than bringing it to a degree of heat even higher but not holding it at that temperature. Milk heated to just below the boiling point, and even allowed to cool in the air, a process which submits it to a temperature of 212° F. to 158° F. for 5½ minutes was found by certain English investigators to suffer little reduction in its antiscorbutic value (124). Aging of milk also tends to destroy vitamin C (125). Since the vitamin C content of milk may vary from poor to good (see p. 4) it is universally accepted that the antiscorbutic vitamin should be provided in the form of orange juice or tomato juice for all infants no matter how their milk is prepared.

In addition to heating milk to insure the killing of pathogenic bacteria many authorities recommend cooking it to increase its digestibility. The heating of milk causes definite physical or chemical changes in its protein, fat, mineral, and gas content (126). Slight changes occur in milk heated to temperatures lower than the boiling point, but the most distinct changes result from boiling it. As a result of these changes the milk becomes more digestible but also more constipating. The curd of milk which has been subjected to a high temperature forms a fine, easily broken down clot in the stomach (127). The longer milk is cooked the finer and the more digestible the curd (128). Pasteurized milk is no more digestible than raw milk. Scalded milk may be slightly more so, whereas boiled milk is definitely more digestible than raw milk. Evaporated milk (which has been cooked an hour) and dried milk are the most digestible of all. (See pp. —.) This modification of the casein or curd of cow's milk to render it more like the curd of human milk and therefore more digestible can be brought about in other ways than by heat, such as acidification.

In heating milk in the home for an infant the points to be considered in the selection of a method of preparation are, first, whether the milk is made safe; second, whether it retains as nearly as possible its original character; and, third, whether greater digestibility of the curd is necessary for the infant.

Scalding is an easy and quick way of rendering milk safe. It carries the process of sterilization one step further than Pasteurization but not so far as boiling. It takes only a few minutes, but the milk must be watched in order that the scalding point may be recognized. The scalding or simmering of milk consists in heating it over a fire in an open pan, preferably tin or enamelware, until it purls or bubbles around the edge and steams in the middle. At this stage and before it boils it reaches a temperature of 167° F. to 185° F. At these temperatures the germs of disease ordinarily found in milk are destroyed. (The temperature varies with the size of the pan and the amount of milk being treated and the altitude.) The reduction of bacteria has been found to be some-

what greater by scalding than by Pasteurization (129). Because of the low temperature and the short time of heating, scalding probably brings about less destruction of vitamin C than any other method of heating. There is said to be less loss of soluble protein, fat, and salts in scalding milk than in boiling it (130) (131). There is no change in taste in scalded milk, and it has no constipating effect. The curd of scalded milk is more digestible than that of raw milk.

Cooking in a double boiler brings milk to a temperature just a little below boiling. It takes more time than scalding or boiling, but the milk does not need to be watched during the whole period. The milk is placed in the top of a double boiler over cold water and is tightly covered. The water is heated, and after it begins to boil the milk is allowed to cook from 6 to 10 minutes or longer if greater modification of the curd is desired. The germs of disease are destroyed, and the casein curd becomes more digestible than that of raw milk though less so than that of milk boiled in an open saucepan. Vitamin C is partly destroyed, the amount of destruction varying with the length of the cooking.

Cooking milk at a boiling temperature (212° F. or lower in high altitudes) is a simple and quick method of preparation. The milk is placed in an open saucepan, and it must be watched closely until it boils. At this point it may be taken off the fire, or it may be allowed to boil for 2 to 10 minutes. Care must be taken that it does not burn. By this method the germs of disease ordinarily found in milk are destroyed, and the casein curds when formed in the infant's stomach become soft and fine and much more digestible than those of raw cow's milk, which are often large, thick, or tough. The antiscorbutic vitamin is partly destroyed, the degree of destruction depending on the length of the cooking. To supply this vitamin to the infant orange juice or tomato juice should be given.

CANNED MILK

In large areas of this country there are still no milch cows. In these and other large areas, including some big cities, it is becoming increasingly difficult to obtain a good grade of bottled milk, raw or Pasteurized, at a price that can be paid by the average parent. The dangers and delays in transportation, the difficulties of distributing milk rapidly and keeping it iced, and the expense of rapid transportation, distribution, and refrigeration are such that the question of canned milk for infant feeding is forced on the attention of the public. Milk in a condition allowing safe transportation for long distances is a necessity if the children of even continental United States are to be furnished their needed allowance. Hawaii (132), Porto Rico (133), the Philippines (134), and even Alaska (135) depend very largely on importation of canned milk to nourish their child population. In the food crisis precipitated by the World War the United States was forced to consider the varieties and relative merits of different forms of canned milk in order to meet the emergency of helping to feed a large part of Europe as well as its own people.

For infant feeding four kinds of canned milk are now available: Proprietary or patent foods, condensed milk (sweetened), evaporated milk (unsweetened condensed), dry milk or milk powder. The relative merits of these forms will be discussed briefly.

PROPRIETARY OR PATENT FOODS

Proprietary or patent foods are of two types, which may be called class A and class B. Class A includes foods having milk as one of their ingredients, usually in the form of dry milk, and class B those having no milk in their composition.

Class A foods may or may not afford a completely balanced food for an infant, but they all have the disadvantage of being considerably more expensive than is necessary for an adequate infant food. The foodstuffs in any proprietary food can be purchased more cheaply uncombined. These foodstuffs can be combined to meet individual needs more judiciously than is possible by using proprietary foods offered under trade names for general use in infant feeding. Some infants have been reared successfully on patent foods, but many have been unnecessarily sacrified to the hit-or-miss method of prescribing one arbitrary combination of foodstuffs to meet the needs of all infants.

Class B foods consist largely of combinations of sugar and starch, which are of no greater efficiency in the diet than certain flours, cereals, and sugars purchasable in bulk at a much lower price in any grocery store. Patent foods of this type should be used only in combination with cow's milk; they are not complete foods without it. As modifiers of milk or additional foods to be used with milk, they are unnecessarily expensive.

CONDENSED MILK (SWEETENED) (136)

What is comonly known as "condensed milk" is sweetened condensed milk. Evaporated milk is unsweetened condensed milk. Condensed milk is usually made by heating fresh milk to a temperature of 180° to 200° F., which destroys most of the bacteria, yeast, molds, and other organized and unorganized ferments, and facilitates further processing. Cane sugar is then added in the proportion of about 18 or 20 pounds to every 100 pounds of milk. When the sugar is dissolved the mixture is run into vacuum pans and evaporated at a temperature of 130° to 150° F. until the desired concentration is reached. It is then cooled and run into cans. It is not sterilized, but it is preserved by the high sugar content, about 42 to 46 per cent. The specific gravity of condensed milk is about 1.3. This specific gravity is reached when the ratio of concentration is about 2.33 to 1, or when about 2⅓ pounds of fresh milk are reduced to 1 pound of condensed milk (137). The proportions of milk fat and total milk solids are carefully stipulated for every form of canned milk by Federal standards, and variations in composition are much less common than formerly (138).

Sweetened condensed, sweetened evaporated, or sweetened concentrated milk under Federal food and drug regulations must be "the

product resulting from the evaporation of a considerable portion of the water from the whole, fresh, clean, lacteal secretion obtained by the complete milking of one or more healthy cows, properly fed and kept, excluding that obtained within 15 days before and 10 days after calving, to which sugar (sucrose) has been added. It contains, all tolerances being allowed for, not less than 28 per cent of total milk solids and not less than 8 per cent of milk fat" (139).

Since the heat used in the entire process is below the boiling point and since it is applied for a relatively brief time, the more resistant forms of organisms may persist, though they do not grow or multiply in milk properly selected and properly canned.

There is experimental evidence that the vitamin value of condensed milk has suffered little injury if any during the process of evaporation. Some antiscorbutic value (due to vitamin C) has been found to be retained in condensed milk. Its presence depends (140) (141) partly on the antiscorbutic value of the raw milk used for canning. The antiscorbutic value of the raw milk depends in turn upon the feeding of the cow (Table 1).

Condensed milk is a semifluid substance, very sweet, and it is put on the market in cans of varying sizes and prices. Its high sugar content practically prevents its freezing in transportation. If made properly, it will keep well until opened, but it is best when fresh. Once opened it tends to spoil, and it should be kept iced and used in a very few days after opening.

Sweetened condensed milk was the first form of canned milk put on the market. The early French inventions along this line, more than 100 years ago, are said to have been called forth by Napoleon's efforts to obtain a milk that could be transported for the use of his armies. It is interesting to note here that canning milk first became a successful business in the United States because of the problem of the proper nourishment of the soldiers of the North during the Civil War. Milk was demanded that would be small enough in bulk for transportation and that would keep during transportation. The condensed-milk business received a tremendous impetus at that time.

During the World War the demand for canned milk again became insistent; and its production, especially for export, was greatly stimulated. Enormous exportation of condensed milk took place in 1918 and 1919, and exportation is still far above pre-war figures.

Sweetened condensed milk has been used in the feeding of infants for several generations and has been also of considerable use in the general nourishment of the family. As an infant food it has the drawback of an enormously high sugar content. With a 42 to 46 per cent proportion of sugar (sucrose), condensed milk must be so diluted for the average infant that the percentage of the other ingredients of the original milk is brought below the proportions best adapted to growth and development, if human milk is taken as the standard.

A comparison of the distribution of calories in different forms of milk commonly used for children can best be appreciated when 100-calorie portions are compared, rather than portions of equal volume or weight.

The following table shows the percentage distribution of calories in the protein, the fat, and the carbohydrates of a 100-calorie portion of each of certain forms of milk:

TABLE 4.—*Percentage distribution of calories in 100-calorie portions of certain forms of milk*[1]

Form of milk	100-calorie portion		Percentage distribution of calories		
	Measure	Weight in ounces	Protein	Fat	Carbohydrates
Cow's milk:					
Condensed (sweetened)	1½ tbsp.	1.1	11	23	65
Evaporated (unsweetened condensed)	3¾ tbsp.	2.1	23	51	26
Liquid, skim	1⅛ cup	9.6	37	7	56
Liquid, whole	⅝ cup	5.1	19	52	29
Dry, whole	4½ tbsp.	.7	20	52	28
Dry, skim	3⅛ tbsp.	1.0	39	5	56
Human milk	⅞ cup	5.7	10	48	42

[1] Adapted from Feeding the Family, by Mary Swartz Rose, pp. 368–369 (The Macmillan Co., New York, 1924); A Laboratory Handbook for Dietetics, by Mary Swartz Rose, p. 129 (The Macmillan Co., New York, 1921); and unpublished analyses by the Bureau of Chemistry, U. S. Department of Agriculture (1925).

As usually 2 tablespoonfuls of condensed milk is diluted with two-thirds of a cup of water to give the equivalent of a glass of milk, it is obvious that as far as growth food is concerned there can be no comparison between the value of an equal number of calories in fresh milk and in condensed milk. Cane sugar is not equivalent to either protein or fat, and when it replaces these substances in milk the content of calcium and other minerals is also lowered.

If the sugar content is left high by diluting condensed milk less, bad results from the intake of too much sugar may occur. Children who apparently thrive on condensed milk—that is, who can stand a great deal of sugar—are not found, as a rule, to have good muscular development. Though some of them are fat, owing partly to excessive water retention, they are flabby and pale and do not have the average resistance to disease. For babies, "condensed milk is a safe food for a very short time only" (142). Experiments with animals also tend to prove the relative inadequacy of condensed milk as the sole food for the young (143). Condensed milk is not sterile; it may spoil if left open to the air or if not kept iced, and it should be used soon after being opened. These are additional reasons why condensed milk is not a safe food for infants in the hands of the average mother without medical supervision. Condensed milk may sometimes be given to infants—in certain emergencies, or by direction of a physician, or as an occasional food, if cod-liver oil and orange juice are also given. A physician should be consulted as to its use.

Condensed milk is not the form of canned milk to choose for the adequate nourishment of children or adults where fresh milk can not be obtained and food must be transported from great distances. It has the disadvantage of a high water content even after evaporation and is unnecessarily bulky for shipping.

EVAPORATED MILK (UNSWEETENED CONDENSED) (136)

Evaporated milk is made by taking fresh milk with nothing added to it, heating it to a temperature near the boiling point, and evaporating it in a vacuum until the ratio is reached of about 2 to 2½ parts of fresh milk to 1 part of the finished product. It is then placed in cans and sterilized by subjecting the cans to steam under pressure. The temperature must be high enough and maintained long enough to insure practical sterility and to give the evaporated milk sufficient body to prevent separation of the butterfat in subsequent transportation and storage. Temperatures of 226° to 240° F. for 30 to 50 minutes are said to be commonly used.

Evaporated milk has the consistency and appearance of thin cream. If properly made, it is practically sterile, and it will keep unopened indefinitely, but it is said to be best when fresh.

Under the food-inspection decision of January, 1923, evaporated milk (unsweetened condensed or concentrated) must be "the product resulting from the evaporation of a considerable portion of the water from milk, or from milk with adjustment, if necessary, of the ratio of fat to nonfat solids by the addition or by the abstraction of cream. It contains, all tolerances being allowed for, not less than 7.8 per cent of milk fat, nor less than 25.5 per cent of total milk solids; provided, however, that the sum of the percentages of milk fat and total milk solids be not less than 33.7" (144).

The relative proportions of the original ingredients of milk—the so-called "milk solids"—are about the same in sweetened condensed as in evaporated (unsweetened condensed) milk. Sweetened condensed milk as a rule has each of the milk solids in a slightly higher proportion than evaporated milk, probably on account of a greater degree of condensation in the sweetened (136). Evaporated milk has no solids except those originally in the milk, whereas sweetened condensed milk has had large amounts of cane sugar added.

The following table shows the average composition of different forms of canned cow's milk:

TABLE 5.—*The average composition and calorie value of different forms of canned milk*[1]

ITEMS	Condensed milk (sweetened)	Evaporated milk (unsweetened condensed)	Dry whole milk	Dry skim milk
COMPOSITION				
Total ..... per cent	100.00	100.00	100.00	100.00
Water ..... do	28.00	73.00	4.00	3.00
Milk solids ..... do	30.00	27.00	96.00	97.00
Fat ..... do	9.00	8.00	29.00	2.00
Protein ..... do	7.80	7.00	25.50	35.50
Milk sugar ..... do	11.50	10.50	36.00	51.50
Ash ..... do	1.70	1.5	5.50	8.00
Cane sugar ..... do	42.00			
CALORIE VALUE				
Calories per 100 grams	332	145	512	361
100-calorie portion:				
By weight, ounces	1.1	2.1	0.7	1.0
By measure, tablespoonfuls	1½	3¾	4½	3⅓

[1] Adapted from unpublished analyses by the Bureau of Chemistry, U. S. Department of Agriculture, and from Feeding the Family, by Mary Swartz Rose, pp. 368-369 (The Macmillan Co., New York, 1924),

Evaporated milk, if used when the can is first opened, is practically free of all germ life. In this it resembles boiled milk, and, like it, is superior to Pasteurized and to raw milk in sterility and in digestibility. The digestibility of both the fat and the casein is probably increased by the exposure of the milk to as high a temperature as is used in this process (145).

The butterfat, milk-sugar, and mineral contents are not appreciably altered by condensation, but the minerals are rendered less soluble by the process of sterilization (146). Recent investigation (147) shows that the only calcium salts affected by heat are the colloidal calcium salts, which are rendered much less stable and which pass in part at least into a crystalloid form. The precipitation of the phosphates is in general proportional to the amount of heat used and its duration. The change made in the form of the minerals through heating has not been found to cause any appreciable disadvantage to the child, though some recent experiments in feeding infants suggest that the longer heating of milk may result in a decrease in the availability of the phosphorus and calcium (148).

Feeding experiments on animals tend to show that vitamins A and B (and probably vitamin D) are not appreciably injured by evaporating or heating the milk (10). Vitamin C, however, appears to be injured by the great heat (240° F.) necessary for the sterilization of condensed milk not preserved by the addition of sugar (11). As an antiscorbutic, such as fruit juice, should be given to all infants artificially fed, this lack, if it exists, does not necessarily imply a serious lowering in the nutritive value of evaporated milk.

By diluting it with an equal volume of sterile water, evaporated milk can easily be reconstituted approximately as ordinary milk. It has been of great use in the general nutrition of the household, and it has a more tenable place in the feeding of infants and older children, when fresh milk can not be obtained, than condensed milk. However, it freezes and is therefore not suitable for transportation in the coldest weather even to the northern parts of the United States, because freezing apparently alters the chemical nature of milk as well as its digestibility (151) (152). It must be carefully handled and kept cold after opening if it is to remain sterile and fit to give an infant; and even though it is condensed to less than half its original bulk, its transportation still entails the carrying of a considerable amount of water, more than 70 per cent of the weight of the evaporated milk. (See Table 5.)

Sweetened condensed milk is retailed in 12½-ounce, 14-ounce, and 15-ounce cans; evaporated milk in 6-ounce and 16-ounce cans. The 15-ounce can of condensed milk, in April, 1926, could be bought for 19 cents, and the 16-ounce can of evaporated milk, for 12 cents. Since both forms of condensed milk are reduced half or more in bulk these prices represent about the cost of 1 quart of reconstituted milk. At present evaporated milk is the cheapest canned whole milk on the market, but there is no apparent reason why a good quality of whole-milk powder could not be retailed at as low a price if the demand for the powder should increase so as to equal that of either sweetened or unsweetened condensed milk.

Skimmed milk is condensed in both the sweetened and the unsweetened form. However, it is used mostly for commercial purposes and has no place in the feeding of the normal healthy infant.

Goat's milk is available in condensed form and can be used as a substitute for canned cow's milk. (See p. 14.)

DRY MILK OR MILK POWDER

Drying milk on an extensive scale began as a means of saving skim milk, a by-product in the manufacture of butter and cream. On many farms great quantities of skim milk are still wasted or uneconomically used in the feeding of animals. The movement to utilize this product by making more condensed or powdered skim milk or by making skim-milk cheese is an enterprise that should meet with the cooperation and assistance of all interested in the proper nourishment of the human family.

Apparently the first commercially usable patent for any process of drying milk was taken out by Grimwade from the British Government in 1855. Although certain processes have been patented in the United States for more than 50 years, the dry-milk industry can not be said to have become a large business in this country until after 1900; indeed, it has reached large proportions only in the last 10 years.

Milk powder is now made in this country by numerous methods, most of which are based upon two essentially different processes; namely, the drum, roller, or film-drying process, and the spray-drying process.[8] In both processes the milk may or may not be condensed before drying.

Skim-milk powder is still the principal form of dried milk on the market in this country. There is a wide wholesale demand for it for use in bakeries and in the manufacture of ice cream and milk chocolate. There has never been a great retail sale of milk powder, but it is now rapidly becoming better known, and skim-milk powder for family cooking is beginning to receive the attention it deserves as a valuable form of protein food.

Milk is also dried as cream, as whole milk, as partly skimmed milk, and as buttermilk, and the different constituents of the milk itself—the casein, whey, and milk sugar—are separated by certain dry-milk concerns and put on the market as powders.

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[8] In the drum, roller, or film-drying process the milk is dried by coming into contact with the hot surfaces of one or more metal cylinders or drums, charged with steam under pressure. The milk, with or without condensing, is spread upon the surface of the drum or drums in a thin film, and when dry it is automatically removed by a scraper. The machinery used in the Just-Hatmaker process, a widely used variety of the drum process, has two drums, about one sixty-fourth of an inch apart, revolving in opposite directions. These drums, which are some 60 inches long and 24 inches in diameter, are charged with steam under about five atmospheres of pressure, and their heating surfaces attain a temperature estimated at 240° to 280° F. The dried milk comes off each revolving cylinder as a sheet, which is easily crushed into a fine powder. In a more recently invented variety of the drum process the drum is inclosed in a vacuum, so that the milk dries faster and at a lower temperature than it would in the air. Provision is made for removing the powder without breaking the vacuum.

In the spray-drying process the milk is dried by reducing it to a spray in the presence of hot air. Usually it is first Pasteurized and then condensed in a vacuum. A spray is formed, either centrifugally or by forcing the milk under high pressure into a hot-air chamber through minute openings in metal disks. The atomized liquid, surrounded by a current of hot air, instantly dries and falls to the bottom of the chamber as a snowy powder. In the most approved processes a mechanical carrier removes the powder automatically as fast as it is formed.

Under the Federal food and drug regulations dried milk must be "the product resulting from the removal of water from milk," and must contain "all tolerances being allowed for, not less than 26 per cent of milk fat and not more than 5 per cent of moisture." (153)

The essential point in this, as in every kind of canned milk, is that the original milk should be of high quality. No good canned milk can be produced from milk that is stale or impure or that comes from improperly fed cows.

Next to the quality of the original milk, the most important things apparently in all processes used in preparing milk powder are the degree of heat, the period through which it is applied, and the prevention, as far as possible, of oxidation, which causes changes in the fat and the vitamins (154) (155).

The processes differ materially in these points, and they are constantly being modified, so that it is difficult to tell by which process the properties of the original milk are more likely to be changed. The drum process submits the milk (for a brief time) to a higher temperature than the spray process. Theoretically milk would be expected to suffer greater change if submitted to a higher temperature; but recent investigations seem to show that, at least as far as the antiscorbutic vitamin is concerned (155), the prevention of oxidation (by use of a vacuum for condensing or drying and by immediate removal of the powder from the heat of the drying chamber) is as important in preventing change as keeping the temperature low. A tangible advantage of milk powder made by the spray-drying processes, especially those in which the fluid milk is heated to not more than 150° F., is that it may be reconstituted completely, even in cold water, forming a solution and emulsion similar to the original fluid milk (136). Some forms of dry milk leave an insoluble residue, even when mixed with warm water (156).

In the early days of manufacturing milk powder some form of alkali was commonly added in the process of drying to neutralize the acidity of the milk, as well as to render the casein more soluble. Cane sugar or malt sugar also was frequently added. Through the perfecting of the steps used in the process, and especially by the controlling of the temperature employed and the duration of exposure, a powder which may be reconstituted completely in water can now be made of milk, or any of its constituents other than fat, without the addition of any foreign substance.

In the best preparations of dry whole or dry half-skim milk the constituents are little if any altered from their state in fresh milk. The butterfat retains the globular form and readily emulsifies when mixed with water, the actual size of the fat globules is apparently reduced, the albumin is not coagulated, and the casein is not toughened and is still soluble in water.

There is also no doubt that milk can be dried in such a way as to conserve the vitamins of the original milk (155) (157) (158) (159) (160) (161) (162). (See Table 1; also p. 28.)

From recent experimentation on animals it seems probable that the presence of vitamins in milk powder depends primarily on the quality of the milk that has been dried. The effect of change of seasons on

the vitamin content of fresh milk, largely due to green food eaten by the cows (160) (163) (164) (165) and possibly their exposure to sunshine (166) (167) (168) is undoubtedly greater on vitamin C and vitamin D than on either vitamin A or vitamin B (169). Either age or heat in the presence of oxygen may injure the relatively unstable vitamin C, and the injury is greater when an alkali has been added to the milk (170) (150) (171) (172). The necessity for an additional supply of vitamin D in cod-liver oil or sunlight whenever fresh cow's milk is used in infant feeding is even greater when canned cow's milk is used, whether dried, evaporated, or condensed.

Dry milk, like whole milk, if produced under the right conditions, may be a complete food; and ordinarily when it has been tried as an infant food in France (156), England (156), Germany (173), and the United States (174) (174a), its use has not been followed by scurvy. In fact, it may be effective as the sole antiscorbutic in the cure of this disease (175) (176). There is no doubt, however, that some infants whose food consists of cow's milk—Pasteurized, boiled, condensed, evaporated, or powdered—and sugar and water, without the addition of fruit juice or vegetable water, will finally cease to grow and may also show more or less definite symptoms of scurvy. The same disaster may occur on a diet of human milk.

The danger of bacterial decomposition in milk powder is reduced to a minimum by the low moisture content. Bacteria and other microorganisms require moisture for growth and for decomposition of the substances in which and on which they live. The removal of the water from milk makes the resulting powder a poor culture medium and largely does away with the perishable qualities of the liquid milk (176) (177). There is good evidence that pathogenic organisms in milk are greatly reduced in virulence by drying, if not completely done away with (156) (178). If milk powder made from ordinary milk is protected from recontamination during powdering and packing its bacterial content becomes as low as that of certified milk (176). Even this low bacterial content is gradually reduced, for if dry milk is tightly covered it becomes more nearly sterile the longer it is kept.

All products containing milk fat keep better when placed in the cold and not exposed to light and air. One great drawback to the production of dry whole or dry half-skim milk has been the fact that the powder made by the early methods quickly became rancid or acquired a "tallowy" odor or taste. Milk powders containing fat, even if made by modern processes, tend after prolonged storage to become either rancid or tallowy. These changes, though unpleasant, are not injurious. The heat treatment a milk receives in drying, the quality of the original milk, the moisture content of the milk powder, the kind of container in which it is packed (it should be air-tight and moisture proof), and the temperature during its storage all influence its keeping quality (179) (180). The manufacture of dry milk has been so improved that even dry whole milk is now put up (by the best processes) in a form that will keep for many months without any rancid or tallowy taste, which is the first sign of deterioration. Nevertheless, the production of dry milk should be carefully regulated to meet the demand, and the containers should be dated.

The following table shows the average composition of milk powders—whole-milk powder and skim-milk powder:

TABLE 6.—*The average composition of milk powder*[1]

	Whole-milk powder	Skim-milk powder
	Per cent	*Per cent*
Fat	29.0	2.0
Protein	25.5	35.5
Sugar, lactose	36.0	51.5
Ash	5.5	8.0
Water	4.0	3.0

[1] Unpublished analyses by Bureau of Chemistry, U. S. Department of Agriculture, 1925.

Dry milk is put up in tin receptacles of different sizes, sometimes parchment lined, the price per pound varying with the process of manufacture and the character of the milk dried. At wholesale dry skim milk in bulk sells as low as 10 cents a pound and at retail in small cans as low as 23 cents a pound. Dry whole milk in 2½-pound cans sells at 76 cents a pound, which gives a whole milk, when it is properly reconstituted, at about 19 cents a quart. (These prices are as of March, 1925.) The best preparations of milk powder made specially for infants retail at a price which makes the price of the reconstituted milk about 20 cents a quart.

The composition of whole dried milk has been specially studied by a number of authorities, and all agree that the milk solids are increased to about eight times those of the original milk. Therefore, to reconstitute an average milk with a fat content of between 3 and 4 per cent, one part of milk powder should be diluted with 8 or 8½ parts of water (by weight).

The use of dry milk in the Tropics, in the Canal Zone, and in the islands under United States protection is increasing because dry milk keeps without ice (181) (182). Dry milk was used extensively in the British hospitals and ambulances during the World War, and for military purposes it was found in some ways superior to condensed or evaporated milk (181). In explanation of this it was said that the "advantages of this (dried milk) are, of course, the great saving in weight and the fact that the dried milk is even less subject to contamination or deterioration than evaporated or condensed milk" (183). Its desirability for use in traveling or for transportation to places where fresh milk is not available is self-evident. The French picturesquely characterize dry milk as "la vache en placard," "the cow in the cupboard."

In cooking, the equivalent of a glass of milk or even a pint can be added to a food without greatly increasing its bulk or changing its taste or texture (184).

For dispensaries, hospitals, and day nurseries or nursery schools milk powder is distinctly more economical than any other form of cow's milk; the cost of much equipment, including kitchen outfit, ice or refrigerating plant, and the large number of bottles, is eliminated, as well as much of the service needed to prepare and dispense other milk preparations. The use of dry milk as directed by a physician needs only the equipment and intelligence necessary to boil water and measure in a tablespoon.

There are also certain occasions where for the sake of economy, even when fresh milk is available, dry milk seems to have a legitimate use. Such a situation might occur in a poor family, when perhaps only one bottle feeding or one glass of milk a day is given to an infant.

The first medical reports on the use of dry milk in infant feeding were made for the years 1905 and 1906 in England (185) (186) and in France (187). Of late years dry milk has been widely used by physicians in Belgium, France, Germany, England, India, Japan, and the United States (188a–188n), apparently with great success, as far as can be judged by reported normal gains in weight and other indications of good nutrition in infants fed exclusively on it. There seems every evidence that for infants milk powder as a food is equal, if not superior, to any other form of milk except fresh milk produced under strictly hygienic conditions. It is superior in digestibility to raw milk because the curd of all heat-processed milk is finer and more flocculent than that of raw milk (156).

Apparently, according to experience abroad, dry milk from which approximately half the cream has been removed before drying (so-called half-skim dry milk) has distinct advantages in the feeding of very young infants. Possibly these are due to the fact that in the dilution of this milk a mixture relatively high in protein and sugar and relatively low in fat is obtained without the addition of extra sugar or casein, and such a mixture has a nutritive value sufficiently high to produce normal growth. For older infants—those over 6 months—dry whole-milk mixtures are advocated and would seem theoretically advantageous, since at this age a child needs and can digest more fat, and the relatively small amount of sugar in whole milk can be supplemented by cereals or by granulated sugar, as is usually done with cow's milk for older infants.

Milk powder has the great advantage over other forms of milk, even Pasteurized, of having had most of the bacteria originally present in the milk destroyed and of being practically free of the danger of transmitting the milk-borne infections (189). Milk powder, a good food for well infants, seems to have a "distinct therapeutic value" for sick (174a) or premature infants partly because of the digestibility of its protein and partly because, being a solid, it may be made into strong solutions, doing away with the necessity of taking large amounts of fluid.

A well-known German pediatrist sums up the experience of many hospitals in the following report on the use of milk powder in Berlin:

> Within the last two years we have been able to feed very successfully the sick children admitted for treatment to the Children's Hospital of Berlin, thanks to the powdered milk obtained from the United States. The good results so obtained are a sufficient proof that children may be fed on powdered milk. This has been made possible by the progress in the methods of manufacturing powdered milk.
>
> * * * Thus powdered milk makes available for the children of even the large cities and industrial centers a food containing fewer bacteria than the liquid commercial milk. This is a very important factor in the feeding of infants. I myself am of the opinion that many cases of illness could be prevented if the infants were fed on milk containing few bacteria, and our experience with the use of powdered milk substantiates the correctness of this viewpoint.

Even during hot weather we observed among infants fed on powdered milk none of the disorders which we have seen in the cases of infants fed on cow's milk abounding in bacteria; in cases of diseases it was found easier to obtain recovery when powdered milk was used instead of liquid commercial milk. In saying this I realize that I shall not find universal agreement.

* * * Doubts may also arise whether the danger of scurvy among infants could be prevented by the use of powdered milk. So far it has not been observed that an infant fed on this kind of milk develops scurvy, but theoretically such a thing is possible. In the children's clinic of Berlin the children were always given a little fresh-fruit juice as a matter of precaution, although there was no indication of the need of such measure. On the other hand, in the children's clinics of both Vienna and Berlin attempts were made to feed on powdered milk children sick with scurvy; and it can be proved that, provided the other usual precautions are taken, it is possible to cure the disease with powdered milk.

According to recent investigations it seems more important for the prevention of scurvy to feed the milch cows in such a way as to assure a great amount of vitamins in the milk. If this is accomplished, the drying of the milk brings about no harm (173).

Up to this time in the United States too little attention has been paid by dry-milk manufacturers to preparing a product suitable for the use of infants and at the same time cheap enough to attract general notice. As yet relatively little milk of the best quality produced under the most hygienic circumstances is dried. The price of the best dry milk on the market is considerably higher than the highest price asked for fresh grade A milk or even evaporated milk. Whole-milk powder and half-skim-milk powder made of grade A milk to which no foreign substance has been added, dried while still fresh, under proper inspection, and in the immediate locality where it is produced, should be available on the retail market at a price equal to the cost of production plus a reasonable percentage of profit to the manufacturer and the retailer. At the present wholesale prices of milk a grade A milk powder could probably be sold, if the retailing could be controlled, at a price allowing it to be reconstituted at 12 cents a quart. A good demand for dry milk would help to reduce the retail price.

Dry skim milk, dry casein, and dry whey are forms of dry milk especially adapted for the use of the sick child, and these are well known to the medical profession under special trade names. They are, of course, high priced. The separate constituents of milk dried are cheaper than dry whole milk, and they would be used in hospitals or, in the case of skim milk, for household cooking if their properties and legitimate retail prices were known to the public.

To summarize briefly: Against dry milk it may be said that it has been subjected to high temperatures in the process of manufacture and that there is no absolute guaranty of the freshness and purity of the original milk (189). Like any other milk product, if it is made from inferior milk it may be unfit for human consumption. Also there is some danger that a mother unaccustomed to this concentrated form of food may give too much milk to a child either at one feeding or in the entire day's food. The good points about dry milk are: (a) Increased digestibility, (b) greater freedom from bacteria, (c) decreased danger of contamination, (d) better keeping qualities—no ice needed, (e) convenience—always ready, (f) palatability, (g) cheapness—no waste, (h) ease of transportation—small bulk, small weight, freedom from danger of freezing, (i) retention of vitamin C in approximately the amount present in the original milk.

The development of the use of milk powder seems to be the next logical step in the modern health movement to foster the production of milk under sanitary conditions (190) and at the same time to increase its use as a food.

MILK FOR THE OLDER CHILD

Concerning the nourishment of children over 2 years of age two things can be stated absolutely: First, milk is an essential food for their proper growth and development; and, second, the milk should be clean, fresh whole milk. Every growing child is better and more cheaply nourished if he is given clean, fresh, whole milk either as a drink or in the cooked food in his daily diet. The value of milk for children lies in its richness in calcium and in vitamin A and in the superior quality of its proteins.

A quart of whole milk every day is now considered the "optimal"[9] amount for the best development of bones and teeth in the average normal child (68). A pint and a half of whole milk every day is the least amount thought necessary for adequate nourishment of a child from 18 months to 12 years of age when the rest of the diet is balanced.

"The dietary rule of a quart of milk each day for every child is much more than a precept based on individual opinions or drawn by analogy from the results of feeding experiments with lower animals; it now rests on scientific evidence obtained by extensive and intensive experiments directly on the children themselves" (191).

If good raw milk or Pasteurized milk from a reliable dairy can not be obtained, canned milk—either dried or evaporated (unsweetened condensed)—should be used. If canned milk is used it should be used relatively soon after canning, and the original milk should be fresh, clean, and of good quality. This can best be insured by purchasing it from a reliable firm. There is some danger that mothers unaccustomed to the use of canned milk may not properly apportion the amount of milk to be given to the child and for this reason allow either not enough or more than is necessary or judicious for daily use. (See Table 5.) If skim-milk powder is used instead of whole-milk powder, milk fat, which contains one of the accessory factors necessary to produce normal growth in children (vitamin A), should be added to the diet in the form of butter or cream.

There is a difference between the property of butter due to its vitamin A content (13) and its property, common to all fats, of furnishing energy when consumed in the body. As body fuel any edible animal or vegetable oil is the equivalent of butter. In vitamin A content milk fat or butter is probably superior to all other animal fats except fish fats and possibly the fat of egg yolk (192). Pork fat and vegetable oils have, as far as is now known, little or none of the growth-producing vitamin A (193). Beef fat, however, does contain it; and margarin made from beef fat, especially margarin in the manufacture of which skim milk is used, has apparently considerable of this growth-producing power (194). If sufficient whole milk (1 quart) is included in the well child's daily food, most author-

[9] See "The Newer Knowledge of Nutrition," third edition, by E. V. McCollum and Nina Simmonds, p. 229 (The Macmillan Co., New York, 1925).

ities consider that margarin may safely be given instead of butter to furnish the percentage of fat needed in the diet (195), especially if other sources of vitamin A such as leafy vegetables are included in the diet. For economy this may be a wise procedure.

Lard, vegetable oil, and nut margarin are not nutritively equal to butter or to beef-fat margarin, as they are only fuel fats and not fats plus the substance that stimulates body growth (193). Milk, butter, eggs, beef drippings, and body organs such as liver are the chief animal fats that are sources of vitamin A. Fish fats such as cod-liver oil furnish considerably more vitamin A than an equivalent amount of milk fat, besides some of the antirachitic factor, vitamin D (196) (197). All these foods are high in price; and there is great danger that in families of the poor where formerly butter or beef drippings or suet was the chief fat used vegetable oil and nut margarins—which are not equivalent either to beef fat or to butter—may be substituted as the only fat in the diet of the growing child.

Startling evidence of the result of adding milk fat to the diet was given in a recent experience in Denmark. During the World War the prevalence of eye diseases among Danish children was gradually increasing, from lack of the fat-soluble vitamin A, due to the exporting of butter and the feeding of children on separated skim-milk by-products. When the German blockade went into effect in 1918 butterfat was increased in the diet of the children (14) (15), and the prevalence of eye diseases was suddenly checked. [10]

Failure to gain in weight, lethargy, and even marked susceptibility to infectious diseases, especially those of respiratory origin, may precede the more serious manifestations of deficiency diseases (such as xerophthalmia, beriberi, scurvy, rickets, or even pellagra). Frequently these latent symptoms of lack of vitamins in the food are the only evidence of dietary insufficiency. This vague ill health is much more common than the more noticeable symptoms of disease, and its prevention is therefore more important.

Skim milk has a legitimate use in the nutrition of children if it is looked upon simply as a form of protein; that is, a food similar to lean meat. It does not take the place of whole milk for the child, because it lacks more or less of the essential fat, according to whether it is hand skimmed or mechanically separated. No more valuable or cheaper form of adequate protein—tissue-building food—exists than skim milk, and to a large extent skim milk can be substituted for meat in the child's dietary.

In household cooking skim milk can take the place of whole milk and can safely be substituted for it in preparing certain dishes (199), if the amount of animal fat, other than lard, used in the dietary is carefully watched and not allowed to decrease below the percentage found necessary to help furnish vitamin A, to increase the fuel value of the diet, and to promote mineral metabolism (195).

Ordinary cheese is a whole-milk product containing both fat and protein and is of great value in the dietary of older children and adults. Little children can not be given much whole-milk cheese, as

[10] Experience with wounded men during the World War has pointed out another important attribute of milk. The presence of milk fat in the diet apparently promotes not only body growth but body repair, as seen in the healing of wounds. The necessity of a supply of milk and butter for hospital use and for convalescence from wasting disease is apparent.

it is somewhat difficult to digest. Skim-milk cheese, of course, contains no fat. It has the same food value as skim milk and is not indigestible.

SUMMARY

Milk is the indispensable food for children. Whole milk in some form must be furnished them if nutrition is to be adequately maintained and if normal growth in height and weight and normal bone and tooth formation are to be assured.

The proper nourishment of children is the first duty of the Nation. Every child from 1 year to 16 years of age is better for having a quart of milk in his daily diet. The minimum allowance for any growing child is 1½ pints daily; an adult needs 1 pint daily. Milk can be used in the cooking of food and so disguised for those who do not like it as a drink.

Since milk and milk products are a vital necessity for growing children, for pregnant and nursing mothers, and for the sick, a supply of good-quality clean milk should be available in every locality under strict sanitary supervision.

Clean, fresh cow's milk is the best available form of milk for infants after they are weaned, but it may have to be treated or modified to adapt it to the digestion of some infants. Pasteurized milk has become more and more generally used in this country because safe raw milk is difficult to obtain. Milk powder or evaporated milk (unsweetened condensed) may safely be substituted when good raw or Pasteurized milk can not be had.

Goat's milk is equally digestible and nourishing.

Milk has no adequate substitute in the diet of the child. Milk is the chief calcium (lime) food. Milk is the cheapest source of high-grade protein. Milk is rich in the growth-promoting vitamin—vitamin A. Milk is the chief of the "protective" foods that compensate for the inadequacies of the American diet and keep the people well.

There is a real relation between milk and health and growth. Impaired nutrition means decreased vitality and lowered resistance to disease. The future of the Nation depends upon the stamina of the children. The Nation can not afford to permit any child to be deprived of his daily allowance of milk.

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