Factors Affecting the Nutritive Value and Quality of Dairy Products *

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IT is interesting to have the INTERNATIONAL ASSOCIATION OF MILK SANITARIANS schedule on its program the topic that has been assigned to me. This could be interpreted as manifestation of interest in a new concept of quality in dairy products that includes, in addition to the sanitary and public health aspects, some consideration of nutritive value. For more than 20 years I have been conducting research on the problem of relationships between dairy cattle feeding and management practices and milk quality in terms of nutritive value, as well as on the effect of various processing procedures on these same qualities. At first one approached a discussion of this nature half apologetically but now some reference to these relationships is expected in almost every meeting concerned with products of the dairy industry.

VITAMINS IN FLUID MILK

It is only natural that this discussion begin with fluid milk. Our newer knowledge of nutrition, stemming particularly from discovery of a new class of food nutrients, namely the vitamins, stimulated interest first in determining the vitamin content of milk and then in variations in vitamin content that occurred as a result of environmental changes surrounding the cows producing the milk. Whereas thousands of chemical analyses made over many years revealed that milk varies but little in chemical composition, it was soon found that certain vitamins varied greatly as to their concentration in milk. Carotene, vitamin A, and vitamin D were the vitamins found to vary most with changes in feeding and management practices, while ascorbic acid and riboflvin were found to change in concentration following production in accordance with subsequent handling and processing.

Milk ordinarily is considered to be a good source of vitamin A, the biological activity of which is the result of a combined effect of colored provitamin A (carotene) and uncolored true vitamin A. However, the vitamin A potency of milk may vary by more than 100 percent depending upon the carotene intake of the cow or upon vitamin A intake when special supplements are fed. No real measure of this variation in vitamin A potency was available until very recently. Because of availability now of rapid chemical methods, it was possible, through extensive cooperation, to determine the vitamin A potency of butter as produced and also after storage. For the country as a whole it was found that average butter contains 15,000 International Units of vitamin A per pound. During the barn feeding season, however, butter may contain as little as 8,000 units of vitamin A per pound, whereas during the pasture season this value may get as high as 25,000 units per pound. The plotted potency curve of the vitamin A potency of butter from month to month is an indirect measure of the quality of the roughages being consumed by dairy cattle, for roughage is practically the only source of carotene for dairy animals. This important study showed that butter (and hence milk) was a

* Presented at the thirty-fourth annual meeting of the INTERNATIONAL ASSOCIATION OF MILK SANITARIANS, Milwaukee, Wis., October 16–18, 1947.

much better source of vitamin A than previously supposed and suggested encouragement of those farm practices, like grass-silage making and mow-curing of hay, that would conserve carotene in roughages for winter feeding. The study showed further that practically no vitamin A potency was lost from butter during storage for as long as one year.

Milk, at best, is not a good source of vitamin D and varies in potency from 10 or less units per quart in winter to 40 to 50 units per quart when solar insolation of the cow is at its highest peak. Early attempts to increase the vitamin D content of milk were confined to feeding irradiated yeast to cows and to direct irradiation of milk with ultra-violet light. These methods were effective in producing milk with automatic rickets-preventing properties, but both have been replaced almost entirely by direct addition of vitamin D concentrates to the point where now a sizeable fraction of the milk supply in large cities is vitamin D milk. Undoubtedly the practice of direct addition of vitamin concentrates to milk did not come about without first creating an issue between the nutritional advantages to be derived on the one hand and the sanitary aspects on the other. This same issue will continue to be before you as attempts are made to extend milk fortification.

As produced, milk contains from 15 to 20 milligrams of ascorbic acid per quart. Were this amount of ascorbic acid present when the milk is consumed it could be said that our milk supply contributed markedly to our ascorbic acid needs. Unfortunately, however, ascorbic acid is lost from milk during the usual handling, pasteurizing, and delivery treatments to which it is subjected, to the extent that 50 percent or less of the original amount is present when the milk is consumed. Many samples of milk coming to our laboratory for vitamin D assay contain practically no ascorbic acid. It can be understood, therefore, why some interest has been manifest in the possibility of fortifying both fluid and evaporated milk with vitamin C. Again, the nutritional benefits to be derived must be weighed against the other aspects of the problem. Also suggested are improved pasteurizing procedures and various protective devices for reducing ascorbic acid loss.

Milk is one of the best food sources of riboflavin and the amount in milk as produced is quite constant (1-2 milligrams per quart). In spite of the fact that the riboflavin in milk withstands pasteurization, condensing, and drying, a problem is presented by the characteristic of riboflavin to be quite easily destroyed by sunlight or strong daylight. Since the rate of destruction is a function of temperature and light intensity, the necessity for properly cooling milk and then protecting it becomes apparent. This is especially important because milk is such an important source of riboflavin that all possible means to preserve this factor in milk should be taken. One of the major research projects in the Department of Dairy Technology at Ohio State University is concerned with trying to determine the wave length range of light that is so destructive of riboflavin. This may lead to the development of new types of containers in which to transport milk from plant to home.

Milk as produced is a fair source of thiamine (vitamin B_1) but unlike riboflavin, thiamine is heat-labile, with the result that thiamine losses occur in all processing operations involving heat, ranging from a loss of 10 percent during holder pasteurization to 33 percent during evaporation.

Several vitamins other than those previously discussed are also found in milk but these are present in such small amounts or so little definite is known about their specific functions that no further reference to them needs to be made in this discussion.

VITAMINS IN CHEESE AND BUTTER

It now becomes of interest to examine the changes that occur when milk is processed into such products as cheese and ice cream. Butter was considered previously in discussing variations in the vitamin A content of milk.

Most of the fat in the original milk is retained in the whole milk cheese-making process. Hence one might predict that most of the vitamin A potency of the original milk would be transferred to cheese. Actually in cheddar cheese about 80 percent is retained, the small loss probably being due to adherence of fat to containers and equipment during processing. During the ripening of Cheddar cheese there is little change in vitamin potency and no loss has been found during storage for one year.

In the case of water-soluble vitamins, however, (riboflavin and thiamine) considerable loss may occur in cheese making depending on the amount of whey retained in the curd, the extent to which heat is used, the method of salting, and the exposure to air and light. From one-fourth to one-third of the original riboflavin is retained in whole milk cheeses. Proportionately more thiamine than riboflavin is lost in cheese making, but some compensation for losses of both occurs during ripening and storage when synthesis of these factors can occur.

Little information is available on losses that occur from ice cream. In one study involving three flavors—coffee, maple, and vanilla—samples were stored for seven months at 10° F. During this period 15.7 percent of the carotene and 5.4 percent of the riboflavin were lost.

FOOD VALUES IN DRIED MILK

I have deliberately reserved until last a group of dairy products that from the standpoint of nutritive value rank high as potential sources of human food. I refer to dried milks. These are of especial importance at the present time because of the world food situation and the need for utilizing more completely our food resources and specifically for utilizing more completely our milk supply. To this end the milk drying industry can make a great contribution.

The matter of losses that occur in the drying process can be discussed by a general statement to the effect that losses in nutritive value in the manufacture of dried whole milk or non-fat dry milk solids are minor and that losses during spray drying are usually less than during roller drying. Even these small losses are compensated for by the concentration that occurs in the drying process. When it is realized that on a per pound basis dried milk contains significant quantities of ascorbic acid, niacin, and thiamine, in addition to being rich in riboflavin, vitamin A potency (in the case of whole dried), calcium, protein, and lactose, and that some 40 billion pounds of skimmilk, buttermilk, and whey annually are not utilized as human food, the need for exploring every possible means of utilizing more fully all the nutrients of milk becomes apparent.

This can be depicted even more vividly in terms of disappearance of nutrients from the total milk supply. The 1944 milk supply of 119 billion pounds contained 14.57 billion pounds of nutrients (protein, minerals, lactose, and fat). Of these, about 80 percent found their way into human consumption channels; but when butterfat is left out of the picture we find that only 67 percent of the non-fat solids of milk went into human food. The balance was fed to livestock, used industrially, or lost somewhere. Since even greater nutritional significance can be attached to the non-fat solids of milk than to the fat, this disparity in utilization of fat and non-fat solids of the milk supply would seem to be neither nutritionally nor economically sound.

PROTEIN AND LACTOSE

Perhaps in the past we have emphasized too strongly the calcium and riboflavin contributions made by milk, or rather that we have failed to emphasize sufficiently the protein and lactose fractions. As our knowledge increases we become more and more aware of the importance of high quality protein in normal nutrition and in nutrition of the diseased and mal-nourished. So little is known about the nutritional significance of lactose that certainly we can hope for values not now known that will attach to milk even greater nutritional significance than previously.

RESEARCH NEEDED IN QUALITY CONTROL

By this time you may be wondering about the real significance of this discussion at a meeting of milk sanitarians. To me the significance is real for by keeping abreast of new developments of the kind that have been reviewed you will better be able to realign your sights as to what it really is that milk sanitarians are supposed to do and how these duties permit, encourage, or inhibit the wheels of progress. Certainly quality is a word that is used promiscously in the dairy industry, but who can define "quality"? Do our present concepts permit interpretation or revision as new processes, new machinery, new milking techniques, new packages, new products, new consumer demands, and new avenues of distribution make their appearance?

Research is the key to progress. Under the new Research and Marketing Act great impetus will be given to research in the economics of milk production, distribution and utilization. Keeping in mind that the primary object of milk production is to produce a basic and indispensable food, what modifications in our present concepts of milk control will need to be made? At the present time a committee of the National Research Council is struggling with the matter of defining "quality" as applied to fluid milk and cream. This was thought to be essential before proceeding with a study of factors ultimately affecting milk consumption and leads directly into consideration of movement of milk from one area to another. Inevitably consideration must be given to standards of quality and milk ordinances and regulations. Your association already is participating in this study through representation on the National Research Council committee. It is to be hoped that this discussion today may have been helpful in pointing out the vast network of procedures involved and in getting from you the courage and encouragement that will be needed as these newer ramifications of the dairy industry develop.

The real function of milk sanitarians is to assure the consuming public of a safe, wholesome, nutritious milk supply that has both esthetic and taste appeal. This can only result in increased consumption and greater utilization of all the solids of milk. The incentive for helping bring this about is the knowledge that more equitable distribution of the vital food materials found in milk can do much toward improving the standard of living of the masses and help conserve the world's greatest natural resource, which is its people.

Question 1. What would be your reaction as to the importance of a research project for devising a meat substitute product that consisted predominantly of milk protein?

Answer: Milk proteins have been demonstrated repeatedly to have high biological value, i.e. they supply essential amino acids and in themselves produce excellent growth in experimental animals when constituting the only source of protein. Milk protein in itself would not be a substitute for meat for meat contains other materials of high nutri-

tional value, as for example, iron, copper, thiamine and niacin.

Question 2. Inasmuch as lactose in nature is found in animals for the specific feeding of the young, would not this fact indicate some unique food value of lactose in the very young?

Answer: That lactose has some unique value in the nutrition of the young is shown by work at Wisconsin in which differences in growth response between vegetable fats and butter were obtained only when lactose was the sole source of carbohydrate. At the same time it should be pointed out that during the war lactose was not given priority as an infant food ingredient when there was competition for lactose for other purposes. Our knowledge regarding the nutritional value of lactose is very meagre and yet, on a dry basis, one half of the non-fat fraction of milk is lactose. Research on this important constituent of milk should be encouraged. The presence of lactose in such large quantities in a food intended for young mammals certainly indicates some special nutritional value.

Question 3. Inasmuch as vitamin C is largely destroyed in pasteurization, but can be retained by adequate pasteurization technology (as shown by Sharp), the milk industry and nutritionists excuse their indifference to this loss by reason of the availability of citrus and other natural sources of vitamin C. Do you think such *laissez faire* should be justified?

Answer: It is fundamentally wrong to adopt the attitude that because some food nutrient can be supplied from other sources losses of this nutrient from milk should be tolerated or ignored. Milk is a universal food; other particularly good sources of vitamin C are not. We have every reason to encourage feeding and management practices and handling and processing procedures that will result in milk with enhanced food value. Aside from the nutritional advantages to be derived from observance of this principle, consumer demand and acceptance can be better developed not only because of the educational value of better nutrition but because of greater taste appeal since ascorbic acid is related to flavor.