Nutritional Aspects of Milk*

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A group of milk sanitarians is naturally interested in the production of milk of high quality. A group of nutrition workers also would be interested in the production of milk of high quality. The term "high quality," however, would have a slightly different meaning for each group.

The term "quality milk," at least until rather recently, was applied to milk in the production and inspection of which the following points had been given consideration:

1. Health of the cows.
2. Health of the handlers (?)
3. State of the milk (raw or pasteurized).
4. Composition { Fat; Solids not Fat }
5. Keeping power { Acidity; Bacteria { total; harmful } }
6. Cleanness—sediment.
7. Flavor—taste and odor.

It will be noted that all the above points can be included under the general heading of "sanitary aspects". At this point the nutrition group raises the question, "What about the food value of the milk; should not another item 'Food value' be added to those comprising the sanitary aspects?" It is with this question that this paper will be particularly concerned because in the light of our newer knowledge of nutrition it is known that the value of milk as a food depends to a considerable degree on how the cows producing that milk were fed and how the milk was handled subsequent to its production.

All of you are familiar with the percentage chemical composition of average market milk: water 87.3, protein 3.5, fat 3.6, lactose 4.9, ash 0.7. In general it is almost impossible to change permanently the chemical composition of milk through feeding. The one notable exception to this concerns the element iodine. The iodine content of milk can be changed readily by varying the cow's intake of this element.

There is in milk another class of substances whose vital importance has within the last ten years been brought to the attention of all, namely the vitamins. All of the six generally recognized vitamins, A, B, C, D, E, and G, are found in milk. Fresh milk is a rather constant source of vitamin B, and E, but varies considerably with respect to its content of the other vitamins.

So little work has been done on the vitamin E content of milk that little can be said other than milk contains it and that 5 percent of butterfat in a diet will allow normal reproduction in an experimental animal.

Milk is but a fair source of vitamin B and all attempts to increase the amount in milk by feeding the cow have been unsuccessful.

Milk is an excellent source of vitamin G but the amount present can be varied by changing the nature of the roughage fed. Young, growing, pasture grass, for example, results in milk somewhat richer in vitamin G than that produced on more mature grasses.

VITAMIN C

Until recently most of the experimental evidence has shown that suitable changes in the cow's feed would result in measurable changes in the concentration of vitamin C in her milk. Workers at the

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Kansas Experiment Station have never agreed with this contention, having failed to find increased antiscorbutic potency in pasture milk over that found in winter milk. Using both the biological assay method and the new titration procedure, Riddell and coworkers at Kansas (1936) compared milk from cows receiving pasture with milk from cows receiving either silage or dry feed alone. The results of these experiments indicated that the rations studied had no significant influence on the vitamin C content of milk. Shortly after this there appeared an article by Rasmussen and coworkers at Penn State (1936) on the effect of breed and stage of lactation on the vitamin C content of cow's milk. This work showed that wide variations existed in the vitamin C content of milk from cows of the same breed and that these differences could be partially accounted for on the basis of stage of lactation. The vitamin C content of milk was found to be relatively high during the early stages of lactation, but decreased to a minimum after about two months, and then increased to a maximum in the later stage of lactation. The milk from Brown Swiss, Holsteins, Ayrshires, Jerseys, and Guernseys was studied. Brown Swiss milk had the highest ascorbic acid value and Holstein milk the lowest. At the American Dairy Science Association meeting last June the Kansas workers again showed that they were unable to increase the vitamin C content of milk when as much as 65 to 85 pounds of green rye were fed. The Vitamin C content of the urine increased fivefold, which is in keeping with a similar observation made at the Ohio Experiment Station when cows were fed large quantities of A. I. V. silage. In view of the most recent work on this question it would seem that milk varies considerably in vitamin C content and that breed and stage of lactation are at least as important as feed in determining the amount of this factor in milk. One important point brought out in this recent work is that fresh milk contains considerably more vitamin C than was credited to it in the early work. Our problem in connection with this vitamin would seem to be with conserving the vitamin in the milk after it is produced rather than with trying to put more into milk only to have it dissipated by subsequent handling. In this connection it might be mentioned that high-temperature, short-time pasteurization has little, if any, effect on vitamin C, whereas long-time, low-temperature pasteurization may be quite destructive.

VITAMIN D

Indirect evidence that cow's milk is a poor source of vitamin D has long been available. This was based on the observation that infantile rickets was relatively prevalent and that it was more common in bottle-fed than in breast-fed babies. Biological tests for vitamin D in milk confirmed this observation. As was the case with all the other vitamins except vitamin E, studies were made soon after the discovery of vitamin D to determine what effect, if any, was exerted by the cow's feed on the amount of this factor in milk. One of the earliest observations made was that milk produced by cows on pasture contained more vitamin D than milk of cows that were barn-fed but it was not clearly demonstrated to what extent sunlight was responsible for this difference. Just a few months ago Bechdel and Hoppert of Michigan published a paper which contributes much to the fragmentary evidence that was previously available regarding the relative importance of ordinary feed and sunshine in determining the vitamin D potency of milk throughout the year. By assaying monthly milk fats from several sources over a period of two years it was found that milk may vary as much as 900 percent in antirachitic potency. Values ranging from 3.1 to 43.8 U.S.P. units per quart were observed. Highest values were obtained during July, August, or September, and lowest values during February. This variation could be closely correlated with the amount of available sunshine and led the authors to conclude that sunlight is the major factor contributing to the vitamin D content of milk.

Unequivocal verification of this contention just recently came from England.

The conclusion just cited applies to ordinary feeding operations when the usual roughages like hay, pasture, and silage are fed, but leaves unanswered the academic question as to whether or not the vitamin D content of milk can be increased by feeding.

As early as 1924 Lesne and Vagliano had succeeded in increasing the vitamin D content of milk by feeding cod-liver oil to cows. This was later confirmed by several groups of investigators who found at the same time that too much cod-liver oil depressed the fat percentage of the milk. Wachdel, in Germany, was the first to show that the vitamin D content of milk could be materially increased by feeding the cows irradiated yeast. Since then, other vitamin D concentrates have been fed, such as irradiated ergosterol and a concentrate (Vitex) prepared from cod-liver oil. Very recently it has been shown that by feeding two pounds daily of cacao shells the vitamin D content of winter milk could be brought up to that of summer milk. Of these methods, the feeding of irradiated yeast has been shown to be most economical. In addition to proving that vitamin D could be fed into milk, such a large amount of D needed to be fed before much change in the milk could be effected, that under ordinary feeding conditions sunshine is seen to be the principal factor in causing seasonal variations in the vitamin D content of milk.

In view of the available evidence, then, we can expect market milk to vary in vitamin D content throughout the season and to be a poor source of vitamin D even during the summer months. Owing to the efforts that have been made within recent years to point out the desirability, from a public health standpoint, of enriching milk with vitamin D to the extent that it becomes an antirachitic agent, it is well to be informed as to the status of this question from time to time. The use of sun-cured legume hay during the winter and turning the cows out-of-doors as much as possible during the effective sunshine season will help to keep up the vitamin D content of milk, but for the production through feeding of what is now classified as "vitamin D" milk, irradiated yeast must be resorted to.

Milk is also being enriched with vitamin D by the direct addition of vitamin D concentrates and by irradiation with ultra-violet light. A discussion of this nutritional aspect of milk might well occupy the full time allotted to this paper. Suffice it to say at this time that in the opinion of nutrition workers, it is desirable to fortify milk with vitamin D and to point out that as far as the Council on Foods of the American Medical Association is concerned, approval of the fortification of foods with vitamin D will be restricted to milk.

This group is interested also in control measures. The newest control measure concerns the checking of commercial vitamin D milks. Our laboratories at the Ohio Experiment Station have for more than two years assayed periodically surprise samples of commercial vitamin D milks produced in the state of Ohio. The results have been gratifying. In very few instances have we found samples to be below standard, and on rechecking these have met the requirements. This new development in the production of milk with enhanced food value is progressing under what seems to be satisfactory control.

VITAMIN A

In speaking of the vitamin A potency of milk we are referring to the response obtained with rats in a properly conducted biological assay. In the case of milk, this response is due to two biologically active substances: (1) the precursor of vitamin A—carotene, or, more popularly, the colored form of vitamin A, and (2) true vitamin A, or the colorless form of vitamin A. This is important because the fat of milk, which is the biologically active fraction of milk, contains both the colored and colorless forms of vitamin A, the amount of each present depending upon the feed and the breed of the cow. Thus, a deeply colored Guernsey butterfat does not necessarily contain more vitamin A activity than a less deeply colored fat from Holsteins if both breeds were fed alike because Guernseys secrete proportionately more of the colored form of vitamin A into their milk, whereas Holsteins secrete more of the colorless form. Both fats may have the same biological activity. Within the same breed, however, color of the fat is a rough index of its vitamin A activity.

It must be explained that in plants vitamin A exists in the colored form as carotene which is a yellow pigment. The depth of yellow color in butterfat depends, therefore, upon the amount of this yellow pigment consumed by the cow and upon the extent to which she transfers carotene into the colorless form. The vitamin A response obtained from plants can be accounted for on the basis of the amount of carotene present. Since carotene can be determined chemically, there is thus afforded a means of determining the vitamin A potency of plants by a chemical method. The significance of this lies in the fact that the effect of any particular feed on the vitamin A and yellow color of milk can be predicted with reasonable accuracy on the basis of a chemical determination.

All research work on the problem has shown that as the vitamin A intake of the cow increases, the vitamin A content of her milk increases up to a certain maximum. So uniformly consistent have been the results in this field that it seems unnecessary to review the early literature. This early work soon showed that milk varied considerably in vitamin A potency, the most striking change being observed to occur when the cows were placed on or removed from pasture. Recent work in this field has been concerned primarily with developing systems of handling crops that will make available for winter feeding material which will at least prevent the large drop in vitamin A potency that occurs after the pasture season ends.

To refer to each of the researches of very recent years would consume considerable time so we will concern ourselves with a summary of the results with natural crops and then spend a little time on special treatments. Green crops, such as grass, alfalfa, clover, and soybeans, have been found to be outstanding sources of carotene, the consumption of which by cows results in milk rich in yellow color and high in vitamin A potency. The great loss of carotene which has been shown to occur in the methods usually used in preparing crops for winter feeding has led to a search for methods of conserving carotene. Grass silage and artificially dried hay have given striking results in this respect. More recently attention has been directed to the ensiling of leafy crops like soybeans, alfalfa, and alfalfa-clover mixtures. By adding molasses or mineral acids to crops such as these when they are put into the silo, carotene is preserved to a high degree and it is possible by feeding these silages during the winter months to maintain the yellow color of milk at a high level.

There are several reasons for being concerned about preserving the carotene normally present in green crops. In the first place it has been shown that cows have a high requirement for vitamin A and that when an excess of the body requirements is not fed this is reflected in a lowering of the vitamin A content of the milk. This occurs during the winter when the vitamin A intake, due to the feeding of dry roughage, is materially reduced. In the second place, young calves have a high requirement for vitamin A and it has been shown that disease and mortality in young calves increase when their dams are fed roughage low in carotene. Thirdly, the vitamin A intake of humans decreases during the winter months due to a decrease in the supply of fresh vegetables and due to the drop in the vitamin A content of milk. A fourth reason involves milk sales. Every milk dealer has complaints during the winter because of lack of color in the milk. Should it be possible to prevent this, milk sales might be maintained and even stimulated.

It is hoped that by this time you have become more familiar with the newer concept of "quality milk" which combines the sanitarian's and the nutritionist's viewpoints. As sanitarians, can you accept this broader concept of quality milk, and if so, can you incorporate it in your guardianship of the nation's most vital food? When it is realized that a cow may be free from contagious disease and still produce, because of poor feeding and management, milk of lower nutritive value, I think you can. By encouraging whenever possible the adoption of feeding programs of proved value, and by keeping abreast of developments in handling and processing milk after it is produced so as to preserve or enhance its nutritive value, you will be having a part in the production of not only a pathologically safe milk but a nutritionally sound milk.

Abstract of Third Annual Report of the Committee on Milk Control of the Canadian Public Health Association.— *Canadian Public Health Journal, September,* 1937.

Milk-borne epidemics in Canada between 1906 and 1935 are listed. Typhoid fever was responsible for 6,612 out of 7,935 cases and for 681 of 688 deaths. The Montreal epidemic of 1927 was responsible for the bulk of these.

A survey of the extent of pasteurization in cities of over 20,000 population is reported. Information concerning the percentage of cows tested for tuberculosis and contagious abortion is included in the table. A further table shows the approximate number of dairy cows in each province and an estimate of the percentage tested for these two diseases.

Licensing of milk distributors under the new regulations in Ontario is dependent upon a favorable report by the Provincial Department as to the type of plant and equipment, method of processing and qualifications of the operator.

Studies of the present standard methods for laboratory examination of milk and of the phosphatase test have been carried on under the direction of the Committee in three laboratories.

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The Accuracy of the Direct Microscopic (Breed) Count of Bacteria and Leucocytes.— *N. J. Strynadka and H. R. Thornton. J. Dairy Science. 20,* 685-692 (1937).

With a view to determining the accuracy of the Breed count for milks containing few bacteria, counts were compared on from 60 to 2,000 fields per smear of aseptically drawn samples of middle-milk. Replicate smears were also prepared from 8 samples. The authors concluded that counts on 60 fields were seldom reasonably representative of the sample even when the bacterial content was rather high for such milks. The examination of even 1,000 fields sometimes gave misleading results. Consequently, as milk improvement is effected the usefulness of this test decreases unless more fields are examined than seems possible in routine work. The number of fields examined should always be indicated in reporting Breed counts unless the bacterial content is high.

When applied to the determination of leucocyte content, the Breed method showed reasonable accuracy. Differences observed between replicate 60 field counts were attributed to uneven distribution of cells in the smear.

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