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NUTRITION IN RELATION TO THE COMPOSITION OF MILK

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The term "composition of milk" may be interpreted in several ways:

1. The general commercial composition of milk, which comprises:
   (a) Fat content
   (b) Casein and Albumen content
   (c) Lactose content
   (d) Ash content.

2. The total composition, including the above major constituents, and in addition a large number of minor constituents:- vitamins, iron, copper, lead, fluorine, lecithin, the flavouring substances and taints, and the non-protein nitrogen fractions.

3. The quantitative composition as set out in (1) and (2), and in addition the qualitative composition, e.g., the type of butterfat or protein.

This paper gives a brief outline of the subject under the above three heads. The presentation in summary form of the results of the very large amount of experimental work published on the subject is, however, difficult, as the results obtained frequently vary with the conditions of the experiment, and a statement of the results without a definition of the conditions under which they are obtained is misleading.

1. General Composition:

(a) Fat Content: From the commercial viewpoint this is the most important component of milk, and much experimental work has been done in attempts to increase the fat content without decreasing milk yield, or, in other words, to increase the fat yield. While the evidence provided by these experiments is complex and not very consistent, the general result of the work seems to be that no method on a commercial scale has yet been found for increasing the fat content of milk by variation of the system of feeding. The results are complicated by the fact that there is a short-term relationship between fat content and yield of milk - a sudden change in diet may cause a sudden change in milk yield, but the production of fat does not change so suddenly. This gives a change in fat content of the milk, but in most cases the change has been found to be temporary. When the cow settles down to the new diet the fat content of the milk returns to the original average. Many of the so-called positive results on the influence of feeding on fat content of milk have been due also to the failure of the observer to allow for the wide daily fluctuations that occur in the fat content of milk of cows on normal diet, which necessitate a lengthy period of trial for soundly based results.

Positive effects of feed on fat content of milk have been recorded under the following conditions:-

(1) The presence of a large excess of fat in the diet has in some, but not all experiments given an increase in fat content of the milk. Palm kernel cake appears to be more potent than other fat-containing foods.

(2) The ingestion, or the injection of thyroxine causes an increase in the fat content of milk by 0.5 to 1.0 per cent fat. This effect continues only so long as the administration of the thyroxine continues.

(3) Cod liver oil and menhaden fish oil have a definite depressing effect on the fat content of the milk, and this

effect lasts as long as the feeding of the fish oil continues; the reason for this peculiar effect of the two fish oils is not known.

(b) Protein Content: Milk contains two proteins, casein and albumen, but only one of these, casein, is of commercial importance, except in the liquid milk trade where albumen is important in its contribution to the solids - not fat - content of the milk, and also because of its high food value to the consumer. The relation of casein to albumen in milk is fairly constant, and the total protein content is a fairly good index of the casein content. The ratio of casein to fat is of great importance to the cheesemaker as it controls the yield of cheese per pound of fat and therefore the payout per pound of fat in the cheese factory. There is fairly conclusive evidence that continued maintenance of cows on sub-normal rations causes a fall in the protein content of milk. During periods of drought in cheese-producing districts it is a common experience that the yield of cheese per pound of fat falls. Feeding trials at the Institute have provided confirming evidence that the sub-normal feeding can cause a fall in protein content, and the fall during drought periods is attributed to the existence of a low nutritional plane. The dry herbage available during droughts has been shown to be low in protein content and high in fibre content. As the feed is at the same time in short supply a low plane of nutrition is inevitable, as it becomes physically impossible for the animal to collect sufficient pasture in the time available and with the proportion of fibre available she could not digest it if she could gather it.

The effect of low nutritional plane on the solids - not fat-content of milk leads to difficulties in the market milk trade where the legal standard may not be reached. During drought periods therefore the feeding of auxiliary rations to supplement the pasture is of great importance. The use of these supplementary rations has been shown at Reading to be effective in raising the solids - not fat - content.

(c) Lactose Content: There is no evidence that lactose content is appreciably affected by feeding conditions. Its variations are mainly lactational.

(d) Ash Content: The ash content of milk is a very constant value and is not affected by normal nutritional changes. The main constituents of the ash are calcium, phosphorus, magnesium, sodium, potassium, and chlorine. Attempts to alter the values for any of these elements by feeding of excessive or sub-normal amounts of the corresponding mineral in the diet have been without success. The cow draws on her body reserves to supplement a deficiency in the diet, and an excess is not excreted via the milk. With a heavy-yielding cow the existence of a negative calcium balance is normal during the flush period, resulting in a depletion of the body reserves of calcium which is made up during the remainder of the year.

2. Minor Constituents:

(a) Vitamins:

Carotene and Vitamin A. Carotene, the colouring matter of butterfat is obtained by the cow from the green fodder which she consumes. It is also the precursor of Vitamin A. The colour of butter is definitely related to the type of food consumed. (Vitamin A content does not always run parallel with the butter colour, as this is affected by other factors such as breed of cow etc.). It has been definitely demonstrated that the Vitamin A content of milk is dependent on the carotene and Vitamin A content of the feed consumed. Moore has recently recorded a sharp rise in the Vitamin A content of butterfat with transfer of cows from stalls to pasture. with use of new hay as compared with old hay, or with use of good silage.

Vitamin B. Group. The relationship between vitamin content of food and of milk has not been clarified for all the vitamins of this group, but it is probable that the cow can synthesise them. Whitnah has recently shown that there is little relationship between the riboflavin content of the milk, and of the rations used for production of the milk.

Vitamin C. The vitamin C. content of milk appears to be independent of the vitamin content of the diet. Cows have been fed diets low in Vitamin C. for three years without any influence on the vitamin C. content of the milk, and the feeding of a diet rich in Vitamin C. did not increase the Vitamin C. content of the milk. It is evident that the cow can synthesise vitamin C. The addition of 5 grams of potassium iodide to the diet, however, depresses the vitamin C. content of the milk by one third.

Vitamin D. The vitamin D. content of milk is probably dependent to some extent on the Vitamin D. content of the food.

(b) Trace Elements:

Iodine. The iodine content of the milk is affected by the iodine content of the diet, and the feeding of potassium iodide to cows increases the iodine content of the milk. The iodine content of milk has in this way been increased 7 - 26 fold.

Copper. The copper content of milk is of importance on account of the catalytic effect of copper in accelerating the destruction of vitamin C. and the development of oxidized flavour in milk, and of tallowiness in butter. It has been shown that the copper content of milk is not increased by a 5 - 10 fold increase in the copper content of the diet.

Iron: Iron has an effect on milk similar to that of copper, but very much less marked. On the other hand, from the point of view of its use as a human food, milk is deficient in iron, and a means of increasing the natural iron content of milk would be of value. It has been shown, however, that the iron content of milk is not affected by artificial increases; e.g., by the addition of iron ammonium citrate, in the iron content of the diet.

Lead: The lead content of milk is not affected by artificial increases in the lead content of the diet.

Manganese: The manganese content of milk appears to be increased by the feeding of materials high in organically combined manganese; e.g., beet, squash, or tulip bulbs, but increase of manganese content by means of minerals in the diet does not affect the manganese content of the milk.

Fluorine: Fluorine content of milk is important as it has been shown that foods rich in fluorine cause a mottling of the enamel of human teeth. The fluorine content of milk has been shown to be related to the fluorine content of the diet of the cow.

Flavour, Tainting Substances, and Drugs: The flavour of milk and butter is definitely related to the type of feed consumed by the cow. This relationship is partly indirect, and partly direct. The flavour is affected indirectly by the influence of the diet on the health of the cow. The degree of the direct effect of any feed on the flavour of the milk is dependent on a number of factors, such as individuality of the cow, time of consumption before milking, season of the year, stage of growth of the plant. Tainting substances in the feed are not all transferred direct to the milk. Many feeding-stuffs with strong flavour do not affect the flavour of the milk, the flavouring substances in the feed being attacked by the digestive juices and rendered innocuous. On the other hand many tainting substances pass directly and very rapidly into the milk. This applies particularly to weeds like pennyroyal and land cress. The taint in the milk may be exactly the same as that in the plant, e.g. pennyroyal, or it may be a partially transformed odour, such as land cress. The taints appear in the milk within a few minutes of consumption of the tainting feeds by the cow. It is an interesting observation that the tainting substances are gradually eliminated from the milk in the udder, and if the milking takes place at a sufficiently long interval after consumption of the tainting feed by the cow, the milk is yielded free of taint. The substance causing "clover taint" in milk and butter appears to be produced in the cow from the clovers consumed. All attempts to isolate from clovers a substance resembling clover taint have been without result.

Many drugs can be partially excreted via the milk, e.g. the passage of nicotine from tobacco smoke, caffeine and theobromine from tea and coffee, and quinine and aspirin, into human milk. In most cases however the proportion excreted via the milk is small. The passage of the bitter and poisonous principle from yew leaves directly into the milk of a cow has been recorded, the milk having a bitter taste and a toxic effect.

3. Qualitative Effect of Feed Constituents on Milk: The type of feed consumed by the cow has an important influence on the composition of the butterfat, apart from the effect on carotene content mentioned earlier. A portion of the fat in the feed appears to pass rapidly into the milk. This has been clearly demonstrated by the feeding of iodized fats as reference substances. The feeding of a diet rich in hard fats, e.g. cottonseed cake, yields a butterfat with a larger proportion of the saturated fatty acids, and a higher melting point. The feeding of diets rich in soft fats, e.g. linseed meal, gives a soft fat richer in oleic acid, and also some of the more unsaturated fatty acids linoleic and linolenic acids. Coconut meal gives a fat higher in the volatile insoluble fatty acids in conformity with the composition of coconut oil. Cod liver oil ingestion gives a direct reduction by 50% in the content of lower fatty acids (C_4 - C_{10} group) and a 30% reduction in the myristic and stearic acid content of the butterfat, the deficiency being almost wholly made up by oleic acid. Inanition causes a decrease to the extent of about 80% in the original content of lower fatty acids in the butterfat, q.e. up to C_{14}, the deficiency being made good by oleic acid.

The lecithin content of milk is not affected by the lecithin content of the feed, but as the fat content of milk increases, the lecithin content of the butterfat decreases.

There are seasonal changes in the quality and character of butterfat in New Zealand butters. It has not yet been established whether these are lactational or feed effects, or partly both. There are also district differences in the quality of the butterfat. The originating cause of these differences has not yet been traced.

The effect of feed on protein quality in milk has not been extensively examined. It is known that the type of feed does in some way affect the cheesemaking quality of the milk. Thus in periods of drought there is a greater prevalence of trouble due to poor rennetting qualities. Whether this is due only to the reduction in protein content, or is partly influenced by a change in the quality or physical condition of the protein in the milk, has not been established. Attempts to overcome the difficulty by feeding calcium phosphate to cows have not been successful.

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