Factors Affecting B-Complex Vitamin Content of Cottage Cheese[1,2]

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ABSTRACT

Cottage cheese contained on the average 257 μg niacin, 24 μg vitamin B_6, 2.1 μg vitamin B_{12}, and 40.6 μg folic acid per 100 g. In general, the higher the vitamin content of the skim milk, the higher the vitamin content of the resultant cheese curd. The cheese culture synthesized vitamins during the curd setting period. Considerable quantities of vitamins were lost in the whey during the manufacturing process, but 16.0 to 63.7% of niacin, vitamin B_6, and vitamin B_{12} was retained in the cheese. Cottage cheese starter culture synthesized vitamin B_{12} and folic acid actively during the setting period, which resulted in higher concentrations of these vitamins in the cheese curd. The addition of calcium chloride to the skim milk caused an increase in calcium content and a concomitant increase in folic acid content in the cheese. Likewise, the use of rennet in the process of manufacturing cottage cheese increased its calcium and concomitantly its folic acid content. Such a relationship between calcium and niacin was not observed. A manufacturing process capable of increasing the calcium content of cottage cheese also may increase its folic acid content.

INTRODUCTION

Cottage cheese is nutritionally an excellent food, being an economical source of high quality protein and a good source of a number of minerals and vitamins (4, 10, 20). While the B-vitamins are essential for human health, the dietary requirements for only some of them have been established (5). More information concerning the B-vitamin contents of cultured dairy foods would be desirable to help appraise the nutritive value of diets containing these foods.

Gregory (6) has reviewed the content of six water soluble vitamins in milk of several species of animals and in various milk products. While the literature records several studies concerning the B-vitamin content of many varieties of cheese, information is limited concerning the B-vitamin content of cottage cheese. Asenjo et al. (1) reported that cottage cheese contained 70 μg of niacin per 100 g whereas Shahani et al. (17) reported it ranged from 22 to 233 with an average of 120 μg/100 g. The vitamin B_6 content of cottage cheese has ranged from 44 to 53 (9, 14, 17), folic acid from 21.0 to 46.5 (17, 19), and vitamin B_{12} from .7 to 1.2 μg/100 g (8, 14). As far as could be ascertained, no study has been made of the factors affecting the content of these vitamins in cottage cheese.

As an extension of continuing work in this laboratory on the vitamin content of several varieties of cheese (13, 17), this study was to investigate possible factors, such as the effect of the starter and manufacturing procedure, which may influence the niacin, B_6, B_{12}, and folic acid content of cottage cheese.

EXPERIMENTAL PROCEDURE

Manufacture of Cheese

From lots of skim milk obtained from the University of Nebraska dairy plant, separate batches of cottage cheese were manufactured by the long-set method. Milk was pasteurized, cooled to 21.1 to 23.3 C, transferred to a cheese vat and inoculated with about .5% commercial (Hansen) cottage cheese starter maintained at the plant. No rennet or coagula-

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tor was used in the process. After about 14 h when the curd had set and had a pH of 4.5 to 4.7, the curd was cut with 1.26-cm wire cheese knives and cooked slowly to 50 to 51.6 C to achieve proper firmness. Finally, the whey was strained off, and the curd was washed once with tap water and twice with cold water. Dry curd was mixed with an appropriate amount of 18% fat cream to obtain creamed cottage cheese containing 4.7% fat. The vitamin content of milk, whey, and curd or cheese samples was determined immediately after the cheese was made, or the samples were held frozen until the assays could be made. All figures are the average of about six trials.

Vitamin Assay Methods

Vitamin assays consisted of slight modifications of those described by Shahani et al. (17), Gregory et al. (7), and Lichtenstein et al. (11). Vitamin extracts for milk, whey, and cheese were prepared separately for each vitamin and assayed with *Lactobacillus plantarum* 8014 as the test organism for niacin, *Saccharomyces carlsbergensis* 9080 for vitamin B_6, *Lactobacillus leichmannii* 7830 for vitamin B_{12}, and *Streptococcus faecalis* 8043 for folic acid.

Synthesis of Vitamins by the Starter Culture

To determine whether vitamins in curd were synthesized partly by the starter, the rate of biosynthesis of the four vitamins was determined during the 16 h setting period, simulating the conditions in the manufacture of cottage cheese. Vitamin assays were run at 4-h intervals during the 16-h coagulation period.

Effect of Creaming and Storage upon the Vitamin Content of Cheese

To determine the effect of creaming on vitamin content of cottage cheese, dry cottage cheese curd was mixed with an appropriate amount of 18% fat cream to prepare creamed cottage cheese containing 4.7% fat. Vitamin assays were on dry curd as well as on the creamed curd. Thereafter, the creamed cottage cheese was stored in a refrigerator at 4 to 6 C and assayed 1 and 2 wk after storage.

Effect of Rennet and Calcium Chloride Addition on Calcium and Vitamin Content of Cheese

Cheese made by rennet coagulation has contained more calcium than cheese made by acid coagulation (3, 12). Nicotinic acid and folic acid, being acid in nature, may exist as salts of calcium or other cations in cheese. Therefore, studies were to determine the effect of adding rennet and calcium chloride to skim milk upon the calcium, niacin, and folic acid content of cottage cheese.

Separate batches of experimental cottage cheese curd were made by the short-set method, employing 30, 60, and 90 ml of rennet per 453.6 kg of milk. Commonly, in the manufacture of cottage cheese by the short-set method, 1.0 ml of rennet is added per 453.6 kg of milk. Therefore, the control batches of cottage cheese in this study involved the use of 1.0 ml rennet per 453 kg of milk. Batches of milk containing 60 or 90 ml of rennet per 453.6 kg coagulated a bit faster than those containing the lesser rennet. The cheese curd then was assayed for calcium, niacin, and folic acid.

Federal food law permits the addition of calcium chloride up to .02% to the skim milk used in the manufacture of cottage cheese. Since this also may increase the calcium content of the cheese, separate batches of cottage cheese were made by the short-set method from milk to which .02 and .05% anhydrous calcium chloride was added. No calcium was added to the control batch. The resultant curd was assayed for calcium, niacin, and folic acid.

Calcium was determined chemically by the standard oxalate precipitation and potassium permanganate titration method outlined by the Association of Official Analytical Chemists (2).

RESULTS AND DISCUSSION

Vitamin Content of Skim Milk, Whey and Curd

Data for concentrations of niacin, vitamin B_6, vitamin B_{12}, and folic acid in skim milk, whey, and cottage cheese curd are in Table 1. Skim milk contained on the average 71 μg of niacin, 26 μg of vitamin B_6, .57 μg of vitamin B_{12}, and .69 μg of folic acid per 100 g. These values are within the range of those in the literature, except for vitamin B_6 which is lower than 26 to 56 μg/100 g (8, 18).

Niacin, vitamin B_6, vitamin B_{12}, and folic acid in whey were 39.5, 21.0, .53, and 1.09 μg per 100 g. A significant portion of the water-soluble B-vitamins, particularly niacin, vitamin B_6, and folic acid, remained in the whey.

TABLE 1. B-vitamin content of skim milk, whey, and cottage cheese curd, and percent retention of vitamins in the curd.

Vitamin	Skim milk		Whey		Cottage cheese curd		% Vitamin content of skim milk retained in cheese curd
	Range	Ave.	Range	Ave.	Range	Ave.	
	(μg/100 g)						
Niacin	62.5 to 87.5	71	31.2 to 47.2	39.5	180 to 311	257	62.8
B_6	24.0 to 27.3	26.0	20.0 to 23.8	21.0	23.8 to 24.0	24.0	16.0
B_{12}	.55 to .59	.57	.50 to .55	.53	2.0 to 2.2	2.1	63.7
Folic acid	.50 to .78	.69	.75 to 1.60	1.09	37.5 to 45.0	40.6	1018

*Commercially known as dry cottage cheese curd.

In general, all the experimental dry curd and creamed cottage cheese were of high quality and compared well with commercial samples. They contained 73 to 74% moisture, approximately 26% total solids, and the creamed samples had about 4.7% fat. There were some variations in the vitamin content among the different batches of cottage cheese curd. In general, the higher the vitamin content of skim milk, the higher was the vitamin content of the curd. On the average, the cheese curd contained 257 μg of niacin, 24 μg of vitamin B_6, 2.1 μg of vitamin B_{12}, and 40.6 μg of folic acid per 100 g. Calculated from the vitamin content of the original skim milk, the percent retention of vitamins in the curd was 62.8% for niacin, 16.0% for vitamin B_6, 63.7% for vitamin B_{12}, and 1018% for folic acid.

The large amount of folic acid in the curd and whey indicated that this vitamin was synthesized, possibly by the starter culture. Pakhlevanyan and Erzinkyan (15) also observed the biosynthesis of pantothenic acid, vitamin B_6, and biotin by streptococci isolated from Matsun (a cultured dairy product).

Biosynthesis of Vitamins by Starter Culture

Since the cottage cheese starter possibly synthesized folic acid, trials were made to determine the rate of biosynthesis of the four vitamins during the 16-h setting. To simulate conditions in the cheese vat, pasteurized milk was set up by the normal long-set method, and the vitamin assays were at 4-h intervals. Results in Fig. 1 confirmed that the culture synthesized all four vitamins. The rates of synthesis of niacin and vitamin B_6 were rather slow, but vitamin B_{12} and folic acid were synthesized rapidly. Niacin content increased from 99 to 126 μg/100 g, vitamin B_6 from 30 to 35 μg/100 g, vitamin B_{12} from .4 to 1.7 μg/100 g, and folic acid from 1.1 to 14 μg/100 g.

Effect of Creaming and Storage on the Vitamin Content

The effects of creaming and storage on the vitamin content of cottage cheese are in Table 2. Creamed cottage cheese contained slightly less of each of the vitamins than dry cottage cheese, evidently due to the dilution effect of the added cream. The storage of creamed cottage cheese up to 2 wk did not cause a

TABLE 2. Effect of creaming and storage upon the B-vitamin content of cottage cheese.

Vitamin	Cottage cheese curd fresh	Creamed cottage cheese		
		Fresh	After storage	
			1 wk	2 wk
	(μg/100 g)			
Niacin	257	203	212	220
B_6	24.0	19.0	19.0	20.0
B_{12}	2.1	1.90	1.90	1.8
Folic acid	40.6	37.2	37.0	38.0

significant change in vitamin content of the cheese.

Effect of Rennet and Calcium Chloride on Calcium, Niacin, and Folic Acid in Cottage Cheese and Cheese Curd

Figure 2 presents the average results of four trials showing the effect of rennet concentration on the calcium, niacin, and folic acid content of cheese curd. Rennet increased the calcium, niacin, and folic acid content of the cheese curd, and there was a direct relationship between the calcium and the folic acid content of the curd. On the other hand, there was a two-fold increase in the niacin content (from 311 to 592 μg/100 g) with the initial increase in calcium from .07 to .24% when 30 ml rennet were used per 453.6 kg. Although a further increase in rennet to 60, or 90 ml/453.6 kg milk further increased the calcium content of the curd to .35%, there was a slight decrease in the niacin content from 592 to 513 μg/100 g. The calcium, niacin, and folic acid content of the curd on a dry weight basis gave essentially the same relationships.

Coagulation time of milk in trials with

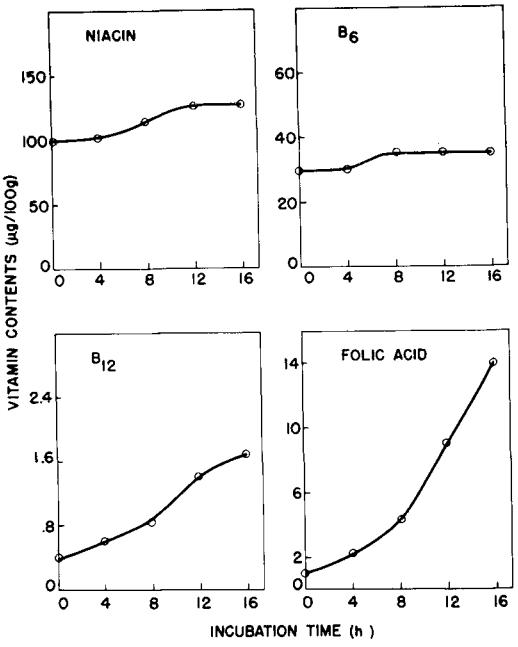

FIG. 1. Biosynthesis of certain B-vitamins by the cottage cheese starter culture.

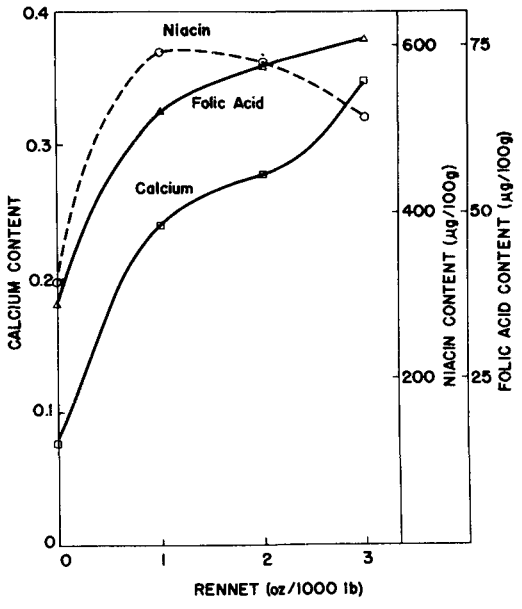

FIG. 2. Effect of the addition of rennet on the calcium, niacin, and folic acid content of cottage cheese curd.

higher rennet was shorter, resulting in the curd setting and cutting at a slightly higher pH than in the batches with the lower rennet. It is probable that the higher pH of the curd with higher rennet may have resulted in greater calcium retention and consequently a higher folic acid content. While the addition of 30 ml of rennet per 453.6 kg of milk yielded good quality curd, higher rennet produced curd which was too hard. Therefore, the use of rennet above certain content is limited by the requirements of the cottage cheese manufacturing process.

Added calcium chloride (Fig. 3) increased calcium content of the cottage cheese curd, and in turn increased folic acid content, again showing a direct relationship between calcium and the folic acid content of cottage cheese. Niacin, on the other hand, decreased slightly with increasing amounts of calcium chloride.

While cottage cheese constitutes an excellent low-caloric food source of high-quality protein and B-vitamins, it is comparatively low in calcium compared to Cheddar cheese and milk (4, 10, 20). McCammon et al. (12) observed that only about 20% of the calcium of milk was retained in cottage cheese. Cottage cheese manufacture involves primarily an "acid coagulation" process, compared to the rennet coagulation characteristic of Cheddar cheese. The addition of rennet to skim milk in the manufacture of cottage cheese has improved coagulation properties of the skim milk (16). As in this and other studies (12, 16), the addition of rennet and calcium chloride to milk also increases the calcium content of cottage cheese. Use of limited amounts of rennet and/or calcium chloride in the manufacture of cottage cheese not only improves the quality of the curd but may also be a means of increasing calcium of cheese.

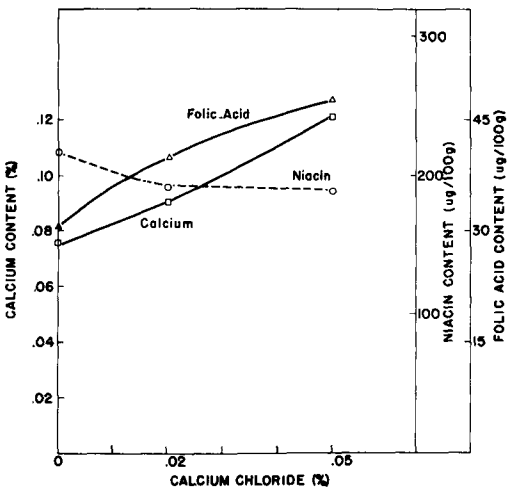

FIG. 3. Effect of the addition of calcium chloride to milk on the calcium, niacin, and folic acid content of cottage cheese curd.

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