

## BIOLOGICAL FOOD TESTS

### IX. VITAMIN A IN THREE VARIETIES OF CHEESE

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It is obvious that cheese made from whole or half-cream milk is apt to retain a large part of the vitamin A content of the milk fat. This assumption has been incorporated in most of the current teaching, although published evidence is lacking. The statement by Sherman and Smith (1922) that ripened cheese has a high vitamin A value is based upon unpublished work by Sherman.

Several factors may govern the completeness of retention of the vitamin A content of the milk from which it is made in the ripened cheese. The vitamin potency of the milk used, the per cent of milk fat in the final product, the destruction of vitamin by the heating and aging involved in cheese making, and the possible effect of bacterial agencies may all play a part in this process. It is plain that all types of cheese cannot be expected to be of equal value as sources of vitamin A since all these factors may vary not only among types but even among samples of the same type. It is to be expected that cheese which contains a high per cent of milk fat, 50 per cent of dry matter or more, will provide more vitamin A than that which contains a smaller amount of fat. Whether the temperature used in curd coagulation and the length of ripening period as well as the strain of bacteria involved have also an effect upon this characteristic of the cheese are questions which can be answered only by experiment.

*Standards of cheese selected.* Three types of cheese, American Cheddar, Limburger and Swiss (Emmenthaler) were chosen for the study here reported. The official definitions of these types of cheese published by the United States Department of Agriculture in 1921 in Food Inspection Decision 181 (U. S. Dept. Agric. 1921) as a guide for officials in enforcing the Federal Food and Drugs Act are as follows:

*Cheddar cheese, American cheese, American Cheddar cheese,* is the cheese made by the Cheddar process, from heated and pressed curd obtained by the action of rennet on whole milk. It contains not more than 39 per cent of water, and, in the water-free substance, not less than 50 per cent of milk fat.

*Limburger cheese* is the cheese made by the Limburger process, from impressed curd obtained by the action of rennet on whole milk. The curd is ripened in a damp

atmosphere by special fermentation. It contains in the water-free substance not less than 50 per cent of milk fat.

*Emmenthaler cheese, Swiss cheese*, is the cheese made by the Emmenthaler process from heated and pressed curd obtained by the action of rennet on whole milk, or on partly skimmed milk, and is ripened by special gas-producing bacteria, causing characteristic "eyes" or holes. The cheese is also known in the United States as "Schweitzer." It contains in the water-free substances, not less than 45 per cent of milk fat.

Analyses of these varieties of cheese as given in the United States Department of Agriculture Bulletin 28 (Atwater and Bryant, 1903) are as follows:

	NUMBER OF ANALYSES	WATER	PROTEIN	FAT	CARBOHYDRATE	ASH	FAT ON WATER-FREE BASIS
Cheese, full cream (cheddar).....	25	34.2	25.9	33.7	2.4	3.8	51.2
Cheese, limburger.....	1	42.1	23.0	29.4	0.4	5.1	50.8
Cheese, Swiss (Emmenthaler).....	2	31.4	27.6	34.9	1.3	4.8	50.0

*Methods of manufacture.* According to Doane and Lawson (1918), considerable differences exist among methods used in the production of these three types of cheese. The *Limburger*, which is a soft cheese, is set with rennet at 91° to 96°F., the curd cut and set away for ripening without pressing, and with no further heating. A good deal of salt is used in curing this cheese during the ripening period of one to two months.

The *Cheddar* and *Emmenthaler* are hard cheeses, both of which are set in much the same way as the *Limburger*. The *Cheddar* cheese is heated slowly with stirring to 96° to 108°F. and kept at about 90°F. for one to three hours, while the curd is being cut, matted and drained. After being pressed, usually over night, the cheese is removed to the curing room for a ripening period of three to twelve days, after which it is placed in cold storage. Formerly the ripening period extended to six months.

In the manufacture of *Emmenthaler* or *Swiss* cheese as practiced in Switzerland, after coagulation of the milk the curd is cut very fine, then heated to 126° to 140°F. for about one hour with stirring until the curd becomes firm. It is then drained, salted and ripened at 55° to 65°F. from six to ten months or longer. This period is reduced about one-half in the United States.

Apparently the process used in the manufacture of Swiss cheese involves exposure of the milk fat to longer periods of heating and stirring at higher temperatures than is the case with *Cheddar* and *Limburger* cheeses.

*Methods of vitamin testing.* All rats used in these tests had been depleted of vitamin A reserves by a fore-period of somewhat varying length. During the whole experiment the animals were fed the usual basal diet previously described (Morgan, 1923). Dry brewery yeast was fed as source of

vitamin B in 0.5 gram daily doses separately from the rest of the diet. All animals were kept in separate cages equipped with wire screen false bottoms.

*Antirachitic check.* Since full growth was obtained in the cheese-fed rats even in that group which continued to show ophthalmias throughout the experiment it was assumed that sufficient antirachitic material was furnished by the cheese and therefore no irradiation was carried out. The need for caution on this point in all vitamin A testing as suggested by Steenbock, Nelson and Black (1924), is recognized however and the practice of irradiation in connection with such work is now established in this laboratory.

The cheese samples used were from the same lot throughout and were kept in the ice chest. No chemical analyses of these samples were attempted.

*Results of Cheddar cheese tests.* Five rats which showed by falling weight and ophthalmias a severe condition of vitamin A deficiency were each given at first for a period of two weeks one gram daily of California full cream cheese, Cheddar type. This was then reduced to one-half gram daily. Unfortunately, just at this time for a period of about four weeks an inferior lot of yeast was received with consequent delay in the growth of these animals. The eye condition, however, which was particularly severe in 1004 and 771 cleared up within a day or two after the first administration of the cheese. By comparison with the growth of rat 1003, which was of the same lot but which was given one-half gram of butter-fat daily instead of the cheese, it is evident that the cheese-fed rats made normal progress.

All of the rats when mature were mated but no young were born of the females. Both males, however, when mated with other females were shown to be fertile by the production of litters. Nearly 50 per cent fertility has been obtained in this laboratory in some fifty matings of females reared from weaning on our basal diet which contains 20 per cent of Crisco. The direct influence of the cheese upon fertility is therefore hardly demonstrable by the few cases here reported.

These results are illustrated in table 1.

*Results of Limburger cheese tests.* Four rats showing unmistakable evidence of vitamin A deficiency were given at first one gram daily of Limburger cheese, then after two weeks, one-half gram daily. The ophthalmias in these animals were almost immediately relieved, and their growth even on the half-gram dosage was entirely normal, as shown in table 1. One of the three females mated produced a litter of nine normal young, only one of which she weaned.

*Results of Swiss cheese tests.* Four rats showing severe vitamin A deficiency were placed at first upon one-half gram daily dosage of Emmenthaler cheese imported from Switzerland. After three to four weeks when growth

and eye condition were found to remain unsatisfactory, the dosage was raised to one gram daily. Upon this amount of Swiss cheese the animals showed normal growth, but in three of the four cases never cleared up the eye trouble entirely. The fourth animal 1001, a female, developed satis-

TABLE 1  
*Effect of three types of cheese upon vitamin A deficiency in rats*

NUMBER OF RAT	SEX	TYPE OF CHEESE	AMOUNTS FED	AVERAGE GAINS IN 12 WEEKS ON CHEESE	CONDITION OF ANIMALS AFTER 20 WEEKS
				<i>grams</i>	
756	♀	American full cream Cheddar type (from California)	1 gram daily for 2 weeks, then 0.5 gram daily	36	Excellent nutritive condition, no eye disease, normal size. No young from 3 females mated, but the 2 males were proved fertile
771	♀			74	
1010	♀			59	
770	♂			94	
1004	♂			101	
981	♀	Limburger, full cream (from New York)	1 gram daily for 2 weeks, then 0.5 gram daily	100	Excellent condition, no eye disease, growth rate normal. One out of 3 females mated produced 9 young, weaned one
983	♀			93	
995	♀			71	
986	♂			122	
1001	♀	Swiss, full cream, Emmenthaler type (from Switzerland)	0.5 gram daily at first, raised to 1 gram after 3 to 4 weeks	79	All 4 animals showed persistent ophthalmias, but growth rate was normal. The one female mated produced 2 young; both died
982	♂			106	
993	♂			87	
998	♂			120	
1000	♀	Butter-fat (controls)	0.5 gram daily	(On butter) 76	All made normal growth and rapid recovery from ophthalmias. The female produced 4 young, all of which died
1003	♂			109	
1009	♂			81	

factorily and produced a litter of two young, both of which died in a day or two.

DISCUSSION. There would seem to be a definitely smaller content of vitamin A in imported Swiss cheese than in American Cheddar and Limburger cheese. Although the Swiss cheese tested was sold as a whole

milk product the legal standard for this type of food allows a somewhat lower per cent of milk fat than that required of the other two kinds. The difference, that between 45 and 50 per cent of the water-free solids, is hardly sufficient, however, to explain the decrease in vitamin A here reported, for even with twice the amount of cheese given the other rats those on Swiss cheese showed the persistence of eye infection characteristic of low vitamin A levels. The slight difference in procedure of testing between the Cheddar and Limburger on the one hand and the Swiss on the other can hardly account for the persistent difference in ophthalmia conditions.

Whether the higher temperatures involved in the Swiss cheese-making process, the particular variety of bacterial action characteristic of this cheese, or the longer period of ripening is most at fault in producing the vitamin destruction cannot be stated. All three of these factors may be involved. At any rate, the full protective action of the approximately one-third gram of butter-fat in the Swiss cheese dosage was not present.

The Cheddar and Limburger cheese compared well with butter-fat in these tests, as good results being obtained with one-half gram of these cheeses as have been obtained in this laboratory upon a minimum of one-fourth gram of butter-fat (Morgan, 1923a). Since less than one-fourth gram, probably about one-sixth gram of butter-fat, was present in the cheese doses fed, an advantageous concentration of the total vitamin A of the milk appears to result from these types of cheese curding. Similar studies upon other types of cheese are under way in this laboratory.

#### SUMMARY

1. Young rats suffering from vitamin A deficiency recovered rapidly from the usual eye disease and made normal growth upon addition to their diet of one-half gram daily portions of California cream cheese (Cheddar type), or of Limburger cheese (from New York). These cheeses appear to retain in an unusually concentrated form the vitamin A of the milk from which they are made.

2. Under similar circumstances one-half gram doses of Swiss cheese (from Switzerland) did not cure ophthalmias nor restore growth. With one gram doses growth was normal but eye disease persisted to some extent. The deficiency of this cheese may be due either to the relatively long heating and curing processes used or to selective bacterial action.

## BIBLIOGRAPHY

- ATWATER, W. O. AND A. P. BRYANT. 1906. U. S. Dept. of Agric. Bull. 28, 54.
- DOANE, C. F. AND H. W. LAWSON. 1918. U. S. Dept. of Agric. Bull. 608.
- MORGAN, A. F. 1923. This Journal, lxiv, 522.
- 1923a. This Journal, lxiv, 544.
- SHERMAN, H. C. AND S. SMITH. 1922. The vitamins. 185.
- STEENBOCK, H., M. T. NELSON AND A. BLACK. 1924. Journ. Biol. Chem., lxii, 275.
- U. S. Dept. of Agric. Bur. of Chem. 1921. Service and Regulatory Announcements, no. 27.