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The Relation of Dry Skim Milk to the Physical and Chemical Properties of Cottage Cheese

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The Relation of Dry Skim Milk to the Physical and Chemical Properties of Cottage Cheese

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ABSTRACT.—The physical and chemical properties of cottage cheese manufactured from reconstituted skim milk are very comparable with cottage cheese manufactured from normal skim milk. There is a direct relationship between the acidity of the curd and whey when the curd is cut, the specific gravity, the per cent yield and physical properties of the finished cheese. Differently tempered wash waters do not affect the physical properties of reconstituted skim milk cottage cheese. Atmospheric drum processed dry skim milk is unsuitable for cottage cheese manufacture. Different methods of rconstituting skim milk influences several of the physical and chemical properties of the resultant cottage cheese. The temperature used, periods of setting, cutting, draining, per cent moisture, moisture retaining properties and resultant physical properties of cottage cheese made from reconstituted skim milk are very comparable with those of cottage cheese made from normal skim milk.

INTRODUCTION

Cottage cheese is a valuable food product and it is highly esteemed by the consuming public.

The supply of normal skim milk suitable for cottage cheese manufacture is inadequate during certain seasons of the year. This condition becomes acute in some sections of the country. The steadily growing demand for cottage cheese has led plant managers to search for a substitute for normal skim milk. The possibility of manufacturing cottage cheese from reconstituted skim milk, to overcome these difficulties, at once presents itself.

Skim milk powder can be stored for an indefinite period of time; therefore, its use in the manufacture of cottage cheese can readily be appreciated. The criticism has been offered that the normal chemical composition of milk is disturbed during the dehydration process. resulting in the production of a soft curd when coagulated and an undesirable flavor in the finished product.

The purpose of this investigation was to study the methods and conditions under which dry skim milk might be successfully used in the manufacture of cottage cheese. Three differently processed dry skim milk powders were studied, i.e., spray, vacuum drum and atmospheric drum.

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REVIEW OF LITERATURE

Associates of Rogers[1] state that if milk is boiled subsequent to treatment with rennin, the rate of coagulation is retarded greatly, and there is also a detrimental effect on the character of the clot. Similar, although much less pronounced effects follow the pasteurization of milk. The opinion commonly held as to the cause of these results is that heat precipitates the calcium phosphate. The addition of the soluble calcium salts restores the original properties of the milk.

Goss and Muten[2] were only partially successful in making cottage cheese involving the use of dry skim milk. When using roller processed powder, the curd was weak with a pronounced heat flavor. Spray processed powder produced a curd that did not have a firm smooth texture. A better quality of cottage cheese was made by using half normal skim milk and half of a skim milk powder solution.

PROCEDURE

Studies were made of the influence of the different factors and combination of variable factors on the chemical and physical properties of cottage cheese.

Reconstituted skim milk was made for these studies by stirring dry skim milk into water at 90 degrees Fahrenheit. The ratio of dry skim milk was 1 pound of dry skim milk to 9 pounds of water for spray processed dry skim milk, which gave an average specific gravity of 1.0369, and 1¼ pounds of dry skim milk to 8¾ pounds of water for vacuum drum processed dry skim milk, which gave an average specific gravity of 1.0466. An attempt was made to manufacture cottage cheese from skim milk reconstituted from atmospheric drum processed dry skim milk, but because of the high solubility index of approximately ten cubic centimeters all trials were unsuccessful.

The reconstituted milk was placed in tinned copper vats, unless otherwise designated, three vats being used simultaneously under the same carefully controlled conditions.

The coagulation agencies, commercial starter, rennet, and in some cases calcium chloride solution, were added and the milk incubated at 86 degrees Fahrenheit until the curd was ready to cut, which was determined either by acidity tests on both the curd and whey or by the "clean break" method. The calcium chloride solution was prepared by dissolving 25 grams of dry calcium chloride in 75 c. c. of distilled water. Both the rennet and calcium chloride solution were diluted in 40 parts of water before adding to the milk.

Curd and whey acidities were determined by titrating against tenth-normal sodium hydroxide and calculating the same as lactic acid. The curd showed a clean break when it split above a thermometer without crushing.

When firm enough, the curd was cut with one-half inch curd knives, first into horizontal strips with the horizontal knife the long way of the vat, and then into vertical strips first lengthwise and then crosswise of the vat with the vertical knife.

At the beginning of the experiment the curd was not heated above 90 degrees Fahrenheit but allowed to remain quiet for 20 minutes to permit expulsion of the whey before draining and washing. This method was not entirely satisfactory. In subsequent series heat was gradually applied after the 20-minute quiet period until the curd reached the desired firmness. Heating temperatures ranging from 106 to 133 degrees Fahrenheit were used in an endeavor to establish the relation of the cooking temperature and the physical properties of the finished cottage creese. As little agitation as possible was used to insure even heating. The firmness of the product was determined by placing a small portion of the curd into cold water for one minute. The draining temperature was the same as that of the curd and whey in the vat at the end of the heating period.

Two wash waters were used in washing the curd. After the wash water ceased to run freely from the cheese, samples of the cheese were taken and stored in one-half pint milk bottles to be analyzed for its moisture content and moisture retention properties.

Salt was applied to the curd in the vat at the rate of two ounces for each ten pounds of curd. A definite volume of cream testing 35 per cent butterfat was added to all samples of finished cottage cheese prior to observing it for the physical properties.

The physical properies of each lot were observed after salting and creaming, no numerical score being given as a cottage cheese of high quality was used as a comparison. The flavor was determined by the sense of taste. The body criticisms were determined by the feel of the cheese in the mouth, resistance being the ability of the particles of curd to retain their shape when pressed against the palate. Texture and color were determined by observation and comparison with a cottage cheese possessing very desirable qualities.

EXPERIMENTAL DATA

The Relation of the Curd Acidity at the Time of Cutting the Curd to the Physical Properties of Cottage Cheese Manufactured from Reconstituted Skim Milk.—Four series, of two lots each, were made to determine the effect of the curd acidity at the time of cutting upon the physical properties of cottage cheese manufacured from reconstituted skim milk.

The cottage cheese curd studied was cut at the following acidities:

Lot I ..... .65 per cent acid
Lot II ..... .70 per cent acid
Lot III ..... .73 per cent acid
Lot IV ..... .76 per cent acid

The reconstituted milk was prepared from dry skim milk made by the spray process as indicated in the procedure. Ten per cent starter and 2 cubic centimeters of rennet per 1000 pounds of milk were added as coagulation agencies. No heat was applied to the curd after cutting, the whey being drawn off after 20 minutes and the curd firmed by washing twice in water at 60 degrees Fahrenheit.

Table 1 shows that a cottage cheese possessing a desirable flavor was obtained irrespective of the acidity of the curd. Curd out at the lower acidities has a tendency to form a firm bodied cheese with close texture. There was also a definite tendency for this curd to mat subsequent to draining. The higher the acidity the higher the moisture content, as shown by Table 1, consequently a soft cheese resulted. As evidenced by the most desirable cheese, the optimum acidity for cutting the curd was between .70 and .73 per cent for this type of cheese.

Another relation not shown in Table 1 was that of the problem of drawing off the whey. Curd cut at the lower acidities drained very easily; however, when the acidity exceeded .73 per cent acid, difficulty was encountered because of a soft curd as well as very little whey expulsion before the wash water was added.

TABLE 1.—THE RELATION OF CURD ACIDITY AT TIME OF CUTTING THE CURD TO THE PHYSICAL PROPERTIES OF COTTAGE CHEESE MANUFACTURED FROM RECONSTITUTED MILK

Lot Number	Per Cent Acidity	Flavor	Body	Texture	Color
I	.65	Desirable, mild acid	Somewhat lumpy	Small pop corn	Slight gray
I	.65	Desirable, mild acid	Firm to slightly tough	Small pop corn	Slight gray
II	.70	Milk acid, creamy	Smooth	Close to pasty	Slight gray
II	.70	Desirable, mild acid	Smooth, medium resistant	Desirable pop corn	Slight gray
III	.73	Desirable, mild acid	Smooth, medium resistant	Medium pop corn	Slight gray
III	.73	Desirable mild to high acid	Smooth, medium resistant	Medium pop corn	Slight gray
IV	.76	Desirable, mild acid	Smooth, medium resistant	Medium pop corn	Slight gray
IV	.76	Creamy, mild acid	Smooth, slightly pasty	Desirable to pasty	Slight gray

A Comparison of the Physical Properties of Cottage Cheese Manufactured from Different Proportions of Normal Skim Milk and Reconstituted Skim Milk.—One series, of five lots, of cottage cheese was manufactured to determine the effect of varying the proportions of normal skim milk and reconstituted skim milk upon the physical properties of the finished product.

The different types of skim milk were proportioned as follows:

Lot I	Normal skim milk.
Lot II	Three-fourths normal skim milk and one-fourth reconstituted skim milk.
Lot III	One-half normal skim milk and one-half reconstituted skim milk.
Lot IV	One-fourth normal skim milk and three-fourths reconstituted skim milk.
Lot V	All reconstituted skim milk.

The reconstituted skim milk was prepared from dry skim milk made by the spray process. Ten per cent starter and 2 cubic centimeters of rennet per 1000 pounds of skim milk were added to coagulate the milk. The curd was not heated but drained 20 minutes after cutting.

Table 2 shows that the cottage cheese made from the normal skim milk was considered the most satisfactory, although there was no marked criticisms of any of the lots. A slight powder flavor was noticeable only in Lot V. This would indicate that a high percentage of reconstituted skim milk could be used in cottage cheese manufacture without imparting a dry skim milk flavor.

The normal skim milk furnished a firmer curd at the cutting time, which seems to account for the less resistant body and closer texture when a higher ratio of reconstituted skim milk to normal skim milk was added.

TABLE 2.—A COMPARISON OF THE PHYSICAL PROPERTIES OF COTTAGE CHEESE MANUFACTURED FROM NORMAL SKIM MILK, RECONSTITUTED SKIM MILK, AND DIFFERENT COMBINATIONS OF EACH

Lot Number	Kind of Milk	Flavor	Body	Texture	Color
I	Normal skim	Pleasant, creamy, mild acid	Smooth to slightly lumpy	Close, pop corn	Satisfactory, creamy
II	¾ normal skim ¼ reconstituted	Pleasant, creamy	Smooth, Medium resistant	Medium pop corn	Satisfactory, creamy
III	½ normal skim ½ reconstituted	Pleasant, mild acid, creamy	Smooth, somewhat pasty	Medium close to close	Satisfactory
IV	¼ normal skim ¾ reconstituted	Pleasant, creamy	Smooth, but pasty	Close, pop corn	Satisfactory
V	Reconstituted	Creamy, slight powder	Velvety, very pasty	Close, pop corn	Slightly gray

The Effect of Different Temperatures of Wash Water Upon the Yield and Physical Properties of Cottage Cheese Manufactured from Reconstituted Skim Milk.—Three lots, of two series each, were made to determine the effect of different temperatures of wash water upon the physical properties of cottage cheese manufactured from reconstituted skim milk.

The different wash water temperatures used were as follows:

Lot I ..... 50 degrees Fahrenheit.
Lot II ..... 62 degrees Fahrenheit
Lot III ..... 80 degrees Fahrenheit

Skim milk reconstituted from vacuum drum processed dry skim milk was used to make the cottage cheese for this study.

Five per cent starter and 2 cubic centimeters each of rennet and calcium chloride solution per 1000 pounds of skim milk were added as coagulation agencies.

Heat was applied until the desired firmness of the curd was obtained, and the whey was then drained from the curd. Wash water at 50 degrees Fahrenheit was added to Lot I, at 62 degrees Fahrenheit to Lot II and 80 degrees Fahrenheit to Lot III. When the curd had cooled sufficiently, the water was removed and the cheese again washed with water at the same temperatures. The second wash water was drained and the curd retained in the vats for 16 hours at 40 degrees Fahrenheit, when the physical properties of the cottage cheese were observed.

Table 3 shows that all lots gave the same yield of cottage cheese irrespective of the temperature of the wash water, and were considered to have the same physical properties, indicating that the different temperatures of wash water used had no apparent effect upon the resulting cottage cheese. Although there was a slight powder flavor present in most of the samples, it was not considered objectionable.

TABLE 3.—THE EFFECT OF DIFFERENT TEMPERATURES OF WASH WATER UPON THE YIELD AND PHYSICAL PROPERTIES OF COTTAGE CHEESE MANUFACTURED FROM RECONSTITUTED SKIM MILK

Lot No.	Wash Water Temperature (Degrees F.)	Yield Per 100 Pounds of Milk (pounds)	Flavor	Body	Texture	Color
I	50	20	Mild acid, creamy, slight powder	Smooth, medium resistant	Medium pop corn	Satisfactory, cream
I	50	20	Mild acid, creamy, slight powder	Smooth, medium resistant	Medium pop corn	Satisfactory, cream
II	62	20	Mild acid, creamy, slight powder	Smooth, medium resistant	Medium pop corn	Satisfactory cream
II	62	20	Mild acid, creamy, slight powder	Smooth, medium resistant	Medium pop corn	Satisfactory, cream
III	80	20	Mild acid, creamy, slight powder	Smooth, medium resistant	Medium pop corn	Satisfactory, cream
III	80	20	Mild acid, creamy, slight powder	Smooth, medium resistant	Medium pop corn	Satisfactory, cream

Using the two extreme temperatures as the minimum and maximum, these data would indicate that tap water could be satisfactorily used as wash water for cottage cheese manufactured from reconstituted skim milk, irrespective of the season of the year or the location of the manufacturing plant.

The Manufacture of Cottage Cheese Involving the Use of Skim Milk Reconstituted from Atmospheric Drum Processed Powder.—Five lots of skim milk were reconstituted from atmospheric drum processed dry skim milk and used to determine the possible use of this type of powder for the manufacture of cottage cheese.

Two of the lots were reconstituted by adding 8¾ pounds of water to 1¼ pounds of dry skim milk, and three lots were reconstituted by adding 9 pounds of water to 1 pound of dry skim milk. The method of procedure as outlined was employed for all the lots.

It was found that a curd suitable for cutting was not formed even after an extended setting period. Instead of a smooth curd there was a mass of insoluble dry skim milk present on the bottom of the vat. The dry skim milk was considered inferior for cottage cheese manufacture because of the insoluble residue which also confirmed the solubility index of 10 cubic centimeters in this instance. When the method of procedure outlined in this study is used, it is concluded that dry skim milk manufactured by the atmospheric drum process is unsuitable for the manufacture of cottage cheese. A modification of the present procedure may result in the manufacture of a cottage cheese of a satisfactory quality.

A Comparison of the Factors Involved in the Manufacture of Cottage Cheese from Normal Skim Milk and Reconstituted Skim Milk.—Cottage cheese was manufactured from normal skim milk and skim milk reconstituted from both the spray and vacuum drum processed dry skim milk using the same method as outlined in the procedure.

After the setting temperature of 86 degrees Fahrenheit was attained 5 per cent starter and 2 cubic centimeters each of rennet and calcium chloride solution were added at the rate of each 1000 pounds of skim milk. The curd was cut when the desired acidity was obtained or as soon as it showed a clean break. There was no whey on the surface of any of the lots at this time.

Five lots each of normal skim milk, skim milk reconstituted from spray processed dry skim milk and skim milk reconstituted from vacuum drum processed dry skim milk, furnished the data for a comparison of the factors involved in the manufacture of cottage cheese from normal skim milk and reconstituted skim milk. Tables 4 to 7 inclusive, give the average data for the five lots with their maximum and minimum values.

Table 4 gives a comparison of the acidities of the lots of cheese made from normal skim milk and the reconstituted skim milk. The data show that the average curd acidity, as well as the maximum and minimum acidities of the curd made from the vacuum drum processed reconstituted skim milk were well above that of the other two types of milk at time of cutting, as well as throughout the entire process of manufacture. The acidity was expressed in per cent of lactic acid. Normal skim milk and reconstituted milk made from the spray processed dry skim milk powder gave practically the same acidities before setting and at time of cutting. This can probably be explained by the difference in the volume of powder used in reconstituting the milk which gives a higher specific gravity. The use of a larger volume of dry skim milk, as in the instance of the reconstituted skim milk from the vacuum drum processed dry skim milk, would obviously give a higher acidity caused by a greater concentration of the normal milk salts.

TABLE 4.—A COMPARISON OF ACIDITIES USED IN THE MANUFACTURE OF COTTAGE CHEESE FROM NORMAL SKIM MILK AND RECONSTITUTED SKIM MILK

Type of Milk	Range of Acidity	Per Cent Acidity			
		Acidity of milk when set	Time of Cutting		Whey When Drained
			Curd	Whey	
Normal Skim Milk	Average	.179	.589	.410	.552
	Maximum	.180	.650	.440	.600
	Minimum	.175	.535	.400	.500
Spray Process	Average	.180	.569	.333	.552
	Maximum	.185	.640	.390	.590
	Minimum	.175	.510	.300	.535
Vacuum Drum Process	Average	.241	.745	.431	.645
	Maximum	.245	.765	.510	.680
	Minimum	.240	.690	.355	.615

Table 5 shows a comparison of temperatures used in the manufacture of cottage cheese from the different types of skim milk. The setting and cutting temperatures indicate that the same temperatures can be used for all three types of milk. The draining temperatures are practically the same for the normal skim milk and the milk reconstituted from the spray processed dry skim milk, but the average and the minimum temperatures are somewhat higher for milk reconstituted from the vacuum drum processed dry skim milk. The difference in draining temperatures is probably due to the fact that there is a relationship between the curd acidity at time of cutting and the amount of heat necessary to firm the curd; that is, the higher curd acidity at time of cutting necessitates a higher temperature for cooking the curd to the desired firmness.

TABLE 5.—A COMPARISON OF TEMPERATURES USED IN THE MANUFACTURE OF COTTAGE CHEESE FROM NORMAL SKIM MILK AND RECONSTITUTED SKIM MILK

Type of Milk	Range of Temperature	Temperature Degrees F.		
		Curd set	Curd cut	Curd Drained
Normal Skim Milk	Average	86.8	85.0	121.6
	Maximum	88.0	86.0	133.0
	Minimum	87.0	84.0	106.0
Spray Process	Average	87.0	85.0	122.4
	Maximum	88.0	86.0	133.0
	Minimum	86.0	84.0	110.0
Vacuum Drum Process	Average	85.6	86.8	130.2
	Maximum	86.0	88.0	133.0
	Minimum	85.0	86.0	126.0

The time factors of setting, cutting and draining, as shown in Table 6, indicate there is no significant difference in the total time required for the manufacture of cheese from the different types of milk, although there is a tendency for the milk made from the vacuum drum processed powder to require a greater total time. Practically any variation in total time can be accounted for by the difference in the curd acidity at time of cutting or the rapidity of applying heat subsequent to cutting. As has been previously indicated, cutting the curd at a lower acidity caused the whey to be expelled more rapidly and resulting in a shorter heating period than when the acidity exceeded the desired acid concentration.

TABLE 6.—A COMPARISON OF THE TIME REQUIRED FOR THE SETTING, CUTTING, AND DRAINING PERIODS USED IN THE MANUFACTURE OF COTTAGE CHEESE FROM NORMAL SKIM MILK AND RECONSTITUTED SKIM MILK

Type of Milk	Range of Setting, Cutting, Draining Periods	Time Required for Each Period					
		Setting to Cutting		Cutting to Draining		Setting to Draining	
		Hrs.	Min.	Hrs.	Min.	Hrs.	Min.
Normal Skim Milk	Average	4	27	1	51	6	18
	Maximum	4	35	3	10	7	35
	Minimum	4	15	1	00	4	35
Spray Process	Average	4	27	2	1	6	22
	Maximum	4	35	3	10	7	35
	Minimum	4	15	1	15	5	20
Vacuum Drum Process	Average	5	0	1	43	6	43
	Maximum	5	0	1	45	6	45
	Minimum	5	0	1	35	6	35

There is practically no difference in the per cent of moisture of the cottage cheese obtained from the three different types of skim milk as indicated in Table 7; however, there is a difference in the yield per 100 pounds of milk. It is obvious that the skim milk reconstituted by using a ratio of 1¼ pounds of powder to 8¾ pounds of water would give a higher yield because of a higher specific gravity.

The comparison of per cent drainage of free whey, shown in Table 7, indicates that there is a tendency for cottage cheese made from reconstituted skim milk to have greater moisture-retaining properties than that of cheese made from normal skim milk.

TABLE 7.—A COMPARISON OF THE MOISTURE, YIELD, AND FREE WHEY DRAINAGE OBTAINED IN THE MANUFACTURE OF COTTAGE CHEESE FROM NORMAL SKIM MILK AND RECONSTITUTED SKIM MILK

Type of Milk	Range of Moisture, Yield, Free Whey	Moisture	Yield per 100 Pounds Skim milk	Whey Drainage	
				After 12 Hours	After 48 Hours
		Per Cent	Pounds	Per Cent*	
Normal Skim Milk	Average	80.60	17.80	17.29	24.80
	Maximum	81.60	20.00	20.64	26.46
	Minimum	80.10	16.00	13.76	23.10
Spray Process	Average	80.10	20.00	16.54	23.98
	Maximum	81.00	20.00	21.87	29.63
	Minimum	78.30	20.00	11.46	20.10
Vacuum Drum Process	Average	79.44	20.00	11.25	17.14
	Maximum	80.80	21.00	11.46	22.05
	Minimum	78.30	19.00	10.23	14.99

*Based upon total weights of cheese.

The Manufacture of Cottage Cheese Using Different Increments of Spray Processed Dry Skim Milk.—Five lots, of five series each, of cottage cheese were made in fifty-pound batches for this part of the investigation. Lot I was normal skim milk and was used as a control. Lot II was made up of 3 per cent of spray processed dry skim milk added directly to the normal skim milk. Lots III, IV, and V contained 6, 8 and 10 per cent of spray processed dry skim milk respectively.

The coagulants, commercial starter, rennet and calcium chloride solution, were added and the setting temperature of 86 degrees Fahrenheit maintained until the curd was ready to cut, which was determined by the per cent acidity of the whey and curd combined with the "clean break" method. Both the rennet and calcium chloride solution were diluted in 40 parts of cold water before adding to the milk.

When the correct firmness and acidity had been attained, the curd was cut, and after which, the curd was undisturbed for 20 minutes to permit a partial firming of the cubes due to the expulsion of the whey. At the end of the 20-minute period about 2 inches of water at temperatures varying between 130 and 140 degrees Fahrenheit was slowly run onto the top of the curd. After another undisturbed period of 10 minutes, water with temperatures varying from 150 to 170 degrees Fahrenheit was run more rapidly into the curd, an attempt being made to agitate the curd as much as possible with the force of the water since this agitation was more gentle than that of the hands or a cheese fork. At this time heat was slowly applied through the steam jacket until the curd reached

the desired firmness or temperatures ranging usually between 120 degrees and 130 degrees Fahrenheit. The firmness of the curd was determined by placing it into a small quantity of cold water. This showed the final physical properties of the curd when cooled.

The whey was drained and two wash waters were used in washing the curd, the first being added when the whey had been removed until the curd was beginning to be visible. After the second wash water had drained and the water ceased to run freely the curd was removed from the vat. In the case of the small vats the curd was placed on draining racks and drained for twelve hours. The curd from the larger batches was placed in ice water and held in milk cans. Samples for physical examination and moisture determinations were later placed on drying racks and drained for a period of one hour.

Salt was applied at the rate of 1.8 pounds for each 100 pounds of curd. Cream testing 20 per cent butterfat was added at the rate of 33⅓ pounds for each 100 pounds of curd.

The physical properties of each lot were observed after salting and creaming, no numerical score being given as a cottage cheese of high quality was used as a comparison.

In each case Lot I gave a curd which wheyed off slightly and was usually firm enough for cutting before the desired acidity was developed. Wheying off in this case probably can be attributed to the use of an excessive amount of rennet for normal milk.

The curd of all lots to which powder had been added was very firm and free of whey on the surface. The firmness of the curd and setting time was directly proportional to the amount of dry skim milk used, the higher increments requiring the longer time for setting.

Table 8 shows an average comparison, together with the maximum and minimum values of procedure variations of the different lots of cottage cheese during the process of manufacture. A slightly lower cooking temperature is necessary when the dry skim milk is added to normal milk but these data do not indicate that the temperature is proportional to the amount of dry skim milk added.

The time factor from setting to end of the cooking period shows no significant difference between the different lots although there is a tendency for the reconstituted milk to require a longer time.

The acidity of the milk at time of setting and the curd and whey acidities at time of cutting the curd are proportionately higher as the percentage of dry skim milk is increased because of the higher concentration of milk solids.

Another significant difference is the per cent moisture and per cent total yield. The normal skim milk resulted in cottage cheese of higher moisture content than did the cottage cheese

TABLE 8.—A COMPARISON OF PROCEDURE VARIATIONS IN THE MANUFACTURE OF COTTAGE CHEESE FROM NORMAL SKIM MILK REINFORCED WITH DRY SKIM MILK

Lot No.	Powder Added Per Cent	Range	Temperature (Degrees F.)			Time Required						Acidity Per Cent			Moisture Per Cent	Yield Per Cent
						Set to Cut		Cut to Drain		Set to Drain						
			Set	Cut	Drained	Hrs.	Min.	Hrs.	Min.	Hrs.	Min.	Set	Curd	Whey		
I	None	Average	86.0	85.2	135.8	4	54	1	18	6	40	0.174	0.688	0.416	80.02	14.60
		Maximum	88.0	86.0	145.0	5	45	1	45	7	15	0.180	0.720	0.440	81.20	16.00
		Minimum	84.0	84.0	126.0	4	35	1	25	6	10	0.170	0.670	0.380	78.30	14.00
II	3	Average	85.8	85.2	128.4	5	06	5	21	6	14	0.236	0.810	0.522	79.68	19.20
		Maximum	88.0	86.0	130.0	5	45	1	35	6	45	0.280	0.850	0.550	80.60	20.00
		Minimum	85.0	84.0	126.0	4	35	1	05	5	45	0.210	0.780	0.500	78.90	18.00
III	6	Average	87.8	85.2	126.4	5	06	1	09	6	18	0.294	0.852	0.599	77.62	21.60
		Maximum	92.0	86.0	130.0	5	45	1	30	6	45	0.310	0.940	0.615	79.00	23.00
		Minimum	86.0	84.0	120.0	4	35	0	50	5	40	0.280	0.880	0.560	75.60	20.00
IV	8	Average	84.6	88.4	129.0	5	55	1	06	7	06	0.324	1.070	0.631	78.06	26.60
		Maximum	86.0	90.0	130.0	6	20	1	20	7	40	0.330	1.110	0.740	90.90	30.00
		Minimum	84.0	86.0	120.0	5	25	1	00	6	35	0.310	1.000	0.575	76.10	24.00
V	10	Average	84.6	88.4	129.0	5	55	1	06	7	06	0.369	1.164	0.722	75.92	27.60
		Maximum	86.0	90.0	136.0	5	20	1	20	7	40	0.395	1.210	0.760	77.40	29.00
		Minimum	84.0	86.0	120.0	5	25	1	00	6	35	0.340	1.100	0.610	74.30	25.00

TABLE 9.—A COMPARISON OF THE PHYSICAL PROPERTIES OF COTTAGE CHEESE MANUFACTURED FROM NORMAL SKIM MILK REINFORCED WITH SKIM MILK POWDER

Series	Physical Properties	Lot I	Lot II	Lot III	Lot IV	Lot V
		Normal Skim Milk	Three Per Cent Powder	Six Per Cent Powder	Eight Per Cent Powder	Ten Per Cent Powder
1	Flavor	Pleasant, mild acid	Pleasant, acid	Pleasant, but slightly flat	Creamy, mild acid	Creamy, mild acid
2		Creamy, mild acid	Creamy, acid	Creamy, acid	Slight powder, mild acid	Slight powder, mild acid
3		Pleasant, creamy, mild acid	Pleasant, creamy, acid	Pleasant, creamy, acid	Creamy, mild acid	Medium high acid
4		Creamy, acid	Creamy, acid	Creamy, pronounced acid	Creamy, mild acid	Creamy, slight pronounced acid
5		Creamy, acid	Creamy, mild acid	Creamy, pronounced acid	Creamy, mild acid	Creamy to pronounced acid
1	Body	Smooth, medium resistant	Smooth, resistant	Smooth, very resistant	Very smooth, medium resistant	Very smooth, medium resistant
2		Smooth, medium resistant	Smooth, medium resistant	Smooth, resistant	Smooth, medium resistant	Smooth, medium resistant
3		Smooth, medium resistant	Smooth, medium resistant	Smooth, medium resistant	Smooth, medium resistant	Medium to resistant
4		Smooth, medium resistant	Smooth, medium resistant	Smooth, medium resistant	Smooth, medium resistant	Very smooth, medium resistant
5		Smooth, medium resistant	Smooth, medium resistant	Smooth, medium resistant	Smooth, medium to resistant	Medium to resistant
1	Texture	Pop corn	Pop corn	Pop corn	Pop corn	Pop corn
2		Pop corn	Pop corn	Pop corn	Pop corn	Pop corn
3		Pop corn	Pop corn	Pop corn	Small pop corn	Small pop corn
4		Medium pop corn	Medium pop corn	Medium pop corn	Pop corn	Pop corn, small particles
5		Pop corn	Pop corn	Pop corn	Pop corn	Pop corn
1	Color	Delicate cream	Delicate cream	Delicate cream	Cream	Cream
2		Delicate cream	Delicate cream	Delicate cream	Cream	Cream
3		Delicate cream	Delicate cream	Delicate cream	Cream	Cream
4		Delicate cream	Delicate cream	Delicate cream	Cream	Cream
5		Delicate cream	Delicate cream	Delicate cream	Cream	Cream

made from skim milk to which different increments of dry skim milk had been added. This same relationship was expressed again in the scoring of the cheese as it was observed that the reinforced milk with the higher total solids furnished a cheese with a firmer body. There was an increase in the total yield of cheese as the percentage of dry skim milk was increased, however, this increase in yield was not directly proportional to the increase in dry skim milk due to the fact that the higher percentages of powder resulted in a cheese with a lower moisture content.

Table 9 gives a comparison of the physical properties of samples of the different lots of cheese immediately after salting and creaming. In respect to the different increments of dry skim milk used, the flavor, body, texture and color of the resultant cheese compared very favorably. The lower percentages of dry skim milk were considered more satisfactory from the standpoint of flavor since the larger amounts were more distinctly acid and tended to impart a slight dry skim milk aroma and flavor in the finished cheese. This slight dry skim milk flavor, however, was not considered objectionable.

The body and texture of the cottage cheese of each lot were practically the same with the exception that the higher percentages of dry skim milk gave a firm, brittle, although smooth body that tended to break down during the cooking process into uniform pop corn particles.

A Comparison of the Factors Involved When Using Different Increments of Spray and Vacuum Drum Processed Dry Skim Milk.—Five lots, of 500 pounds each, of normal skim milk reinforced respectively with 3 per cent and 5 per cent spray processed dry skim milk and 3 per cent and 5 per cent vacuum drum processed dry skim milk furnished the data for comparative purposes. Tables 10 and 13, inclusive, give the comparative history, together with averages, of the procedure variations of all the batches. Table 14 shows a comparison of the physical properties of the cottage cheese of each of the batches.

A comparison of the cooking temperatures in this investigation shows that the average temperature required to firm the curd in the batches involving the use of 3 per cent spray processed dry skim milk was considerably higher than the average for any of the other lots. This is apparently a somewhat significant characteristic of milk reinforced with this type of dry skim milk since the curd is more brittle and the whey has a more milky appearance than milk reinforced with vacuum drum dry skim milk.

There is a considerable variation in the acid tests between the 3 per cent and 5 per cent dry skim milk due to the increase in milk solids, but the difference between the two types of dry skim milk is not

TABLE 10.—A COMPARISON OF PROCEDURE VARIATIONS IN THE MANUFACTURE OF COTTAGE CHEESE FROM NORMAL SKIM MILK REINFORCED WITH THREE PER CENT OF SPRAY DRY SKIM MILK

Lot No.	Temperature (Degrees F.)			Time Required						Acidity Per Cent			Moisture Per Cent	Yield Per Cent
				Set to Cut		Cut to Drain		Set to Drain						
	Set	Cut	Drained	Hrs.	Min.	Hrs.	Min.	Hrs.	Min.	Set	Curd	Whey		
I	86	86	131	5	00	1	15	6	15	0.20	0.88	0.49	81.80	20.00
II	86	90	130	5	00	1	00	6	00	0.21	0.70	0.36	81.80	20.00
III	86	85	146	4	50	1	40	6	30	0.23	0.88	0.50	79.70	20.00
IV	86	85	132	5	30	1	30	7	00	0.24	0.88	0.595	83.10	20.00
V	86	85	131	5	00	1	35	6	35	0.24	0.89	0.48	82.50	20.00
Average	86	86.2	134	5	04	1	24	6	28	0.224	0.846	0.485	81.80	20.00

TABLE 11.—A COMPARISON OF PROCEDURE VARIATIONS IN THE MANUFACTURE OF COTTAGE CHEESE FROM NORMAL SKIM MILK REINFORCED WITH THREE PER CENT OF VACUUM DRUM DRY SKIM MILK

Lot No.	Temperature (Degrees F.)			Time Required						Acidity Per Cent			Moisture Per Cent	Yield Per Cent
				Set to Cut		Cut to Drain		Set to Drain						
	Set	Cut	Drained	Hrs.	Min.	Hrs.	Min.	Hrs.	Min.	Set	Curd	Whey		
I	86	85	122	4	50	1	25	6	15	0.24	0.81	0.49	83.20	21.20
II	86	87	127	4	53	1	35	6	30	0.25	0.88	0.51	83.50	21.00
III	86	85	126	5	50	1	40	7	30	0.24	0.88	0.50	82.60	21.40
IV	86	84	130	5	15	1	45	7	00	0.23	0.84	0.47	82.90	21.00
V	86	87	126	4	55	1	35	6	50	0.23	0.86	0.47	81.20	21.40
Average	86	85.2	126.2	5	09	1	36	6	49	0.234	0.845	0.488	82.68	21.20

TABLE 12.—A COMPARISON OF PROCEDURE VARIATIONS IN THE MANUFACTURE OF COTTAGE CHEESE FROM NORMAL SKIM MILK REINFORCED WITH FIVE PER CENT OF SPRAY DRY SKIM MILK

Lot No.	Temperature (Degrees F.)			Time Required						Acidity Per Cent			Moisture Per Cent	Yield Per Cent
				Set to Cut		Cut to Drain		Set to Drain						
	Set	Cut	Drained	Hrs.	Min.	Hrs.	Min.	Hrs.	Min.	Set	Curd	Whey		
I	86	86	130	5	45	1	10	6	55	0.26	0.990	0.60	82.10	22.40
II	87	85	128	4	55	1	25	6	20	0.29	0.945	0.56	82.30	23.50
III	85	84	124	5	00	1	15	6	15	0.28	0.920	0.44	82.20	24.00
IV	85	86	128	5	00	1	25	6	25	0.28	0.855	0.55	81.10	24.00
V	85	86	124	6	00	1	35	7	35	0.28	0.900	0.53	82.80	23.50
Average	85.6	85.4	126.8	5	18	1	22	6	42	0.278	0.922	0.536	82.10	23.50

TABLE 13.—A COMPARISON OF PROCEDURE VARIATIONS IN THE MANUFACTURE OF COTTAGE CHEESE FROM NORMAL SKIM MILK REINFORCED WITH FIVE PER CENT OF VACUUM DRUM DRY SKIM MILK

Lot No.	Temperature (Degrees F.)			Time Required						Acidity Per Cent			Moisture Per Cent	Yield Per Cent
				Set to Cut		Cut to Drain		Set to Drain						
	Set	Cut	Drained	Hrs.	Min.	Hrs.	Min.	Hrs.	Min.	Set	Curd	Whey		
I	86	85	130	5	00	1	30	6	30	0.29	0.95	0.585	82.30	22.40
II	85	84	124	5	15	1	15	6	30	0.26	0.98	0.56	82.90	25.40
III	85	85	130	5	15	1	40	6	35	0.26	0.99	0.63	82.00	24.80
IV	86	86	128	5	00	1	35	5	35	0.28	0.95	0.625	81.30	23.80
V	86	86	125	5	00	1	45	6	45	0.29	0.90	0.59	82.60	23.60
Average	85.6	85.2	127.4	5	06	1	33	6	39	0.276	0.954	0.598	82.22	24.00

significant. There is little variation in the per cent moisture of any of the batches.

A noticeable difference in the percentage yield between the 3 per cent and 5 per cent dry skim milk is apparent and is attributed to the higher serum solids in the latter. These data indicate there is no important difference between the yield of milk reinforced with spray processed dry skim milk and milk reinforced with vacuum drum processed dry skim milk.

Table 14 indicates that the cottage cheese made from each of the batches was satisfactory. Although there was a very slight powder flavor in all the batches it was not considered objectionable. This powder flavor is more pronounced in the cheese made from milk reinforced with 3 and 5 per cent of vacuum drum dry skim milk than with milk reinforced with the same amount of spray processed dry skim milk.

There is no important difference in the body, texture and color of the finished cheese, made by using variable increments of the two different types of dry skim milk.

TABLE 14.—A COMPARISON OF THE PHYSICAL PROPERTIES OF COTTAGE CHEESE MANUFACTURED FROM NORMAL SKIM MILK REINFORCED WITH SKIM MILK POWDER

Lot No.	Physical Properties	Three Per Cent Spray Powder	Three Per Cent Vacuum Drum Powder	Five Per Cent Spray Powder	Five Per Cent Vacuum Drum Powder
I	Flavor	Creamy, mild acid	Mild acid, creamy, slight powder	Mild acid, slight powder	Mild acid, clean, slight powder
II		Creamy, mild acid	Mild acid, creamy slight powder	Mild acid, powder objectionable	Mild acid, clean, slight powder
III		Creamy, mild acid	Mild acid, creamy, slight powder	Mild acid, slight powder	Mild acid, clean, slight powder
IV		Creamy, mild acid, clean	Mild acid, creamy, slight powder	Mild acid, creamy, slight powder	Mild acid, clean, slight powder
V		Mild acid, clean, very favorable	Mild acid, creamy, slight powder	Mild acid, slight powder	Mild acid, clean, slight powder
I	Body	Very smooth, medium resistant	Smooth, medium resistant	Smooth, medium resistant	Smooth, medium resistant
II		Weak, lacks resistance	Smooth, medium resistant	Medium resistant	Smooth, medium resistant
III		Smooth, medium resistant	Smooth, medium resistant	Medium resistant	Smooth, medium resistant
IV		Very smooth, medium resistant	Smooth, medium resistant	Smooth, medium resistant	Smooth, medium resistant
V		Smooth, medium resistant	Smooth, medium resistant	Smooth, medium resistant	Smooth, medium resistant
I	Texture	Medium pop corn	Uniform pop corn	Uneven pop corn	Uneven pop corn
II		Medium pop corn	Uniform pop corn	Distinct, uniform pop corn	Small, broken pop corn
III		Medium pop corn	Uniform pop corn	Uneven pop corn	Small, broken pop corn
IV		Medium pop corn	Uniform pop corn	Uneven pop corn	Small, broken pop corn
V		Even pop corn	Uniform pop corn	Uniform pop corn	Small, broken pop corn
I	Color	Delicate cream	Delicate cream	Delicate cream	Delicate cream
II		Delicate cream	Delicate cream	Delicate cream	Delicate cream
III		Delicate cream	Delicate cream	Delicate cream	Delicate cream
IV		Delicate cream	Delicate cream	Delicate cream	Delicate cream
V		Delicate cream	Delicate cream	Delicate cream	Delicate cream

The cottage cheese made in this part of the investigation, as well as in all subsequent batches, was sold to the consuming public through the wholesale and retail channels of a local commercial milk plant. Accordingly, all the cheese was very satisfactorily received by both the manager of the plant and its patrons.

The Manufacture of Cottage Cheese on a Commercial Scale Using Skim Milk Reinforced with Spray and Vacuum Drum Types of Dry Skim Milk.—Cottage cheese was manufactured on a commercial scale from normal skim milk reinforced with different amounts of dry skim milk powder made by the spray and vacuum drum processes, and the physical properties compared with cheese manufactured from normal skim milk. The laboratory procedure, as outlined, was applied.

Five lots, of 1200 pounds each, furnished the data for this study. Lot I was normal skim milk. Lots II and III were normal skim milk reinforced with 5 per cent of spray processed dry skim milk and Lots IV and V were normal skim milk reinforced with 5 per cent of dry skim milk made by the vacuum drum process.

Table 15 presents a comparison of procedure variations involved in the manufacture of the cottage cheese. That the laboratory method for manufacturing cottage cheese from normal skim milk reinforced with dry skim milk can be used in commercial practice is proven by the results presented in Tables 15 and 16. The values shown in Table 15 compare very favorably with these shown in Tables 10 to 13 inclusive, the most noticeable difference being in the yield of Lot V. The high percentage of yield in Lot V can probably be attributed to the high acidity of the curd at the time of cutting which resulted in the curd being difficult to cook and gave a cheese with a high per cent of moisture.

Table 16 shows a comparison of the physical properties of the cottage cheese from each of the five lots including a description of the dry curd, the salted curd and the cheese after salting and creaming. The flavor, body, texture and color of the salted and creamed cheese are shown to be comparable with that of the cottage cheese described in previous batches made on a laboratory scale. A rather distinct powder aroma and flavor was present in the dry curd but these somewhat objectionable characteristics were entirely submerged by the addition of a normal amount of salt and cream to the extent that the aroma and flavor of the creamed cheese were considered very satisfactory.

TABLE 15.—A COMPARISON OF PROCEDURE VARIATION IN THE MANUFACTURE OF COTTAGE CHEESE, ON A COMMERCIAL SCALE, FROM NORMAL SKIM MILK REINFORCED WITH SKIM MILK POWDER

Lot No.	Type Powder Added	Pounds Milk Plus Powder	Pounds Added	Temperature (Degrees F.)			Time Required						Acidity Per Cent			Moisture Per Cent	Yield Per Cent
							Set to Cut		Cut to Drain		Set to Drain						
			Per Cent	Set	Cut	Drained	Hrs.	Min.	Hrs.	Min.	Hrs.	Min.	Set	Curd	Whey		
I	None	1200	None	87	86	125	5	00	1	30	6	30	0.17	0.70	0.40	84.50	16.75
II	Vacuum Drum	1200	5	86	87	118	5	00	1	00	6	00	0.29	0.91	0.62	82.50	23.33
III	Vacuum Drum	1200	5	85	85	120	5	30	1	00	6	30	0.29	0.93	0.63	82.70	24.50
IV	Spray	1200	5	87	88	126	6	00	1	30	7	30	0.27	0.95	0.60	82.40	23.00
V	Spray	1200	5	87	85	120	5	30	1	20	6	50	0.28	1.00	0.57	83.30	27.00

TABLE 16.—A COMPARISON OF THE PHYSICAL PROPERTIES OF COTTAGE CHEESE MANUFACTURED ON A COMMERCIAL SCALE, FROM NORMAL SKIM MILK REINFORCED WITH SKIM MILK POWDER

Lot No.	Type Powder Added	FLAVOR			BODY			TEXTURE			COLOR		
		Dry Curd	Salted Curd	Salted and Creamed	Dry Curd	Salted Curd	Salted and Creamed	Dry Curd	Salted Curd	Salted and Creamed	Dry Curd	Salted Curd	Salted and Creamed
I	None	Typical raw curd	Mild acid, flat	Mild acid, creamy, desirable	Medium resistant, slightly granular	Smooth, medium resistant	Smooth, medium resistant	Uniform pop corn	Uniform pop corn	Uniform pop corn	Satis-factory	Satis-factory	Delicate cream
II	Vacuum Drum	Flat, pro-nounced powder	Mild acid, pro-nounced powder	Mild acid, slight powder	Smooth, medium resistant	Smooth, medium resistant	Smooth, medium resistant	Medium pop corn	Medium pop corn	Medium pop corn	Satis-factory	Satis-factory	Delicate cream
III	Vacuum Drum	Flat, pro-nounced powder	Mild acid, pro-nounced powder	Mild acid, slight powder	Smooth, medium resistant	Smooth, medium resistant	Smooth, medium resistant	Medium pop corn	Medium pop corn	Medium pop corn	Satis-factory	Satis-factory	Delicate cream
IV	Spray	Flat, slight powder	Mild acid, slight powder	Mild acid, very slight powder	Smooth, pasty	Smooth, pasty	Smooth, pasty	Small broken pop corn	Small broken pop corn	Small broken pop corn	Satis-factory	Satis-factory	Delicate cream
V	Spray	Flat, slight powder	Mild acid, slight powder	Mild acid, very slight powder	Smooth, pasty	Smooth, pasty	Smooth, pasty	Small broken pop corn	Small broken pop corn	Small broken pop corn	Satis-factory	Satis-factory	Delicate cream

CONCLUSIONS

1. There is a direct relationship between the acidity of the curd and whey at the time of cutting the curd, the percentage yield and the physical properties of the finished cheese.

2. When the curd is not heated the curd acidity at the time of cutting should test between .70 and .73 per cent for cottage cheese involving the use of reconstituted skim milk.

3. There is a direct relation between the specific gravity, acidity, and yield of cottage cheese made from normal and reconstituted skim milk.

4. Different temperatures of wash water, within the range of 50 and 80 degrees Fahrenheit, do not have any apparent effect upon the physical properties of cottage cheese manufactured from reconstituted skim milk.

5. Dry skim milk manufactured by the atmospheric drum process is unsuitable for cottage cheese manufacture when using the procedure developed in this investigation.

6. A difference in the method of reconstituting the skim milk causes a variation in the yield of cheese and in the percentage acidity at time of setting, cuting, and draining.

7. The same temperatures and periods of setting, cutting, and draining used during the entire process of manufacture of cottage cheese from either normal or reconstituted skim milk are very comparable.

8. The percentage moisture and moisture-retaining properties are practically the same for cottage cheese manufactured from either normal or reconstituted skim milk.

9. The same method of procedure can successfully be used when different amounts of either spray processed dry skim milk or vacuum drum dry skim milk are used.

10. The physical properties of cottage cheese manufactured from reinforced skim milk are very comparable with cottage cheese manufactured from normal skim milk. This is evidenced by the fact that several thousand pounds of this cottage cheese received a favorable reception from the consuming public.

11. The per cent yield of cottage cheese manufactured from reinforced skim milk is proportional to the amount of the dry skim milk added.

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