A STUDY OF METHODS FOR THE DETERMINATION OF MOISTURE AND FAT IN CHEDDAR CHEESE

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MASTER OF SCIENCE

1950

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A STUDY OF METHODS FOR THE DETERMINATION OF MOISTURE AND FAT IN CHEDDAR CHEESE

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1949

Submitted to the Faculty of the Graduate School of the Oklahoma Agricultural and Mechanical College in Partial Fulfillment of the Requirements for the Degree of

MASTER OF SCIENCE

1950

ACKNOWLEDGMENT

The author wishes to take this opportunity to express his sincere appreciation to Dr. H. C. Olson for the many helpful suggestions and the guidance throughout this study and during the preparation of this thesis.

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INTRODUCTION

The composition of cheddar cheese, from the standpoint of moisture and fat content, is very important to the cheese industry for several reasons. It is important to know the composition of cheese, especially that shipped in inter-state commerce because the Federal government has established standards fixing the maximum moisture and minimum fat content allowable for legal cheese. The composition of cheese has an important bearing on the quality of the cheese because if the moisture is too high, defects will likely develop in curing and if the moisture is too low, the body and texture of the cheese will likely be undesirable. Factories making cheese are very much concerned with keeping the composition very close to legal limits because if cheese with high fat content is manufactured, huge losses will result unless the factories are compensated for extra fat in the cheese.

Many tests have been developed for determining the fat and moisture contents of various dairy products, but not many of these are applicable to cheese because of its physical characteristics, specially the solid or semisolid body which makes it difficult to extract the fat or drive off the moisture. Some of the tests which are used to determine the composition of cheddar cheese are rather cumbersome or require skilled technicians for the operations. There is a great need in the cheese industry for a simple, accurate, and rapid test for moisture and fat in order that these factors of composition may be employed as a routine practice in all cheese factories as a means of making cheese of uniform quality.

STATEMENT OF PROBLEM

The objectives of the work herein reported are to develop a simple, accurate, and rapid test for the fat and moisture content of cheese which will be practical for use in ordinary cheese factories.

REVIEW OF LITERATURE

The most widely used method for testing of cheddar cheese for fat is the Babcock method. This test was originally developed by Babcock (3) in 1890 for the testing of milk and has since been modified for the testing of almost all dairy products. Briefly this test for cheese consists of weighing a nine gram sample of cheese into a special test bottle and digesting the curd with sulfuric acid and then centrifuging and measuring the separated fat in the usual manner. Sammis (15) modified the Babcock test as follows: he weighed into a test bottle a portion of cheese, varying from eight to 12 grams, cut into thin strips so as to easily slip down the neck of the test bottle. Then he added 10 ml. of hot water and 17.5 ml. of sulfuric acid to dissolve the curd and completed the test in the usual manner. Wilster, et al (24) recommended the adding of 12 ml. of hot water (160-170° F.) to the ground cheese in a test bottle and then using the usual Babcock procedure. Ross (12) said that cold water was as effective as hot water for softening the cheese and recommended that the water not be over 45° F. He said that this low temperature will aid in preventing "blowing out" of the cheese mixture on adding of the sulfuric acid.

Other modifications of the Babcock test have been developed for the testing of dairy products other than cheese. These modfications can be divided into two classes, those using acid and hose using alkali for digesting the curd.

Swope (20) developed the Pennsylvania method for the testing f ice cream. This test uses ammonium hydroxide, n-butyl alcohol

and sulfuric acid. The sulfuric acid recommended is that of sp.g. of 1.72 to 1.74 instead of a sp.g. of 1.82-1.83 as recommended for the regular Babcock test. Crowe (5) devised the Nebraska method for the testing of ice cream. This method utilizes ammonium hydroxide, n-butyl alcohol, sulfuric acid (sp.g. 1.82-1.83) and ethyl alcohol. Smith, et al (19) devised a test using mixed perchloric and acetic acid for the testing of ice cream. They stated that this test will check with the Mojonnier on the average of ±.07%. Turnbow, et al (23) discuss a glacial acetic sulfuric acid test for ice cream. In this test eight ml. of glacial acetic acid are used then nine ml. of sulfuric acid used to digest the curd and sugar. Peterson and Herreid (12) devised a modification known as the Minnesota test for the testing of buttermilk but this test has since been adapted to the testing of other dairy products. The reagents used in this test have been changed several times since the method was first devised. Basically the reagent contains sodium carbonate, sodium salicylate, sodium hydroxide, and n-butyl alcohol. Bird and Breazeale (4) made a study of the various Minnesota reagents used and found that reagent A caused a 5.17% saponification of fat, reagent B caused a 8.62% saponification of fat and reagent C caused a 16.73% saponification of fat when testing buttermilk by this method. Overman and Garrett (11) devised the so called Illinois test for the testing of ice cream. The reagent contains trisodium phosphate, sodium acetate, ammonium hydroxide, n-butyl alcohol and ethyl alcohol. Kniaseff (8) reported the California modification of the Babcock test developed by the Bureau of Dairy Control, Div-

ision of Animal Industry, California State Department of Agriculture. This test was developed for use on ice cream. He says that duplicates will check within .1% and that this method checks with the Mojonnier test within .2%. Schain (17) devised an entirely different modification of the Babcock method for the testing of milk. This test uses two detergents to digest the curd. Detergent A is nonionic polyoxyethylene sorbitan monolaurate which contains a fat soluble dye to color the fat column. Detergent B is anionic dioctyl sodium phosphate. The procedure for this test is as follows: Seven ml. of detergent A is added to the sample in the test bottle and the bottle is agitated to thoroughly mix the milk and detergent. Then 20 ml. of reagent B is added without agitation and the bottle placed in a water bath at a temperature of 180° F. for five minutes. Then water is added to the bottle to bring the fat column up to the top of the graduated portion of the bottle and it is set aside at room temperature for 10 minutes and the fat measured. He reported that (18) this test has proven accurate only within the range of 3.6 to 3.8% fat.

Several ether extraction methods have been used for the determination of fat in cheese. Of these methods probably the most accurate is the continuous extraction method as described by Triebold (21). This method is the continuous refluxing of ethyl ether over a sample of cheese until all of the fat has been extracted. Then the ether is evaporated off and the fat dried and weighed. The main disadvantage of this method is that it takes 48 hours or longer to complete and requires extensive labor-

atory equipment as well as a skilled operator.

The method recommended by the A.O.A.C. (2) is equally as accurate but it also requires a long period of time, although not as long as the continuous extraction method, and requires skilled operators. This method consists of boiling the sample in ammonium hydroxide and then digesting the curd with hydrochloric acid and following this the fat is extracted by washing with petroleum benzene. The method devised by Mojonnier and Troy (9) is very accurate, with duplicates checking within .1%. The test is quite similar to the A.O.A.C. method except that the ammonium hydroxide is added directly into the extraction flask and the extraction is affected by petroleum and ethyl ethers.

The determination of moisture content of cheese is very important to the cheese maker both from the standpoint of controlling the composition of the cheese to meet the legal standards and in the production of a uniform quality cheese.

According to Gould (6) the main disadvantages to the majority of methods which have been developed for determining the moisture in cheddar cheese is the time required for the operation of the tests. The A.O.A.C. (2) method requires from four and one-half to five hours. This method consists of heating the cheese at 212° F. in a vacuum oven to a constant weight. Sammis (14) discusses the steam pressure oven where the cheese is heated under a pressure of 50 to 60 pounds of steam for five hours. Duplicates by this method check within .2%. Troy (22) proposed a test in which the cheese is heated in a double walled cup. The inner cup containing the cheese and the outer cup containing

an oil such as lard or tallow. The oil is heated at a temperature of 245° F. for 50 minutes. Mojonnier and Troy (9) suggested the following method. The cheese is weighed into a pan and a small amount of water is added. The pan is then heated on a hot plate at 356° F. until the residue begins to turn brown. Then the pan is transferred to a vacuum oven at 212° F. under 15 inches of vacuum for 20 minutes, cooled and weighed. Duplicates will agree within .5%. Wilster (25) discusses the 212° F. oven at atmospheric pressure for 24 hours. This method should give checks within .2% moisture on duplicates. Gould (6 and 7) compared the modified Mojonnier and the steam oven methods with his olive oil method. The olive oil method consists of adding a cheese sample to a measured amount of olive oil, to which sodium chloride has been added to prevent spattering, and then heating over a low flame to drive off the moisture. According to Gould this method is accurate within .5% of the results by the steam oven method and within .3% of the modified Mojonnier method. Sanders (16) discussed the volatile-solvent method in which the moisture is boiled off the sample with a volatile solvent, such as toluene, condensed and measured. Sanders says this method will give higher results than the vacuum oven method.

METHODS

A. Sampling

The sampling was done as recommended by Wilster, et al (24). The ground cheese was placed in air tight containers and stored at -10° F. until tested.

B. The Standard Babcock Method

The Babcock as recommended by Wilster, et al (24) consists briefly of weighing a nine gram sample of ground cheddar cheese into a cream test bottle, then adding 10 ml. of hot water and 17.5 ml. of sulfuric acid. After the curd has digested the bottle is centrifuged for five minutes. Hot water is added to bring the level of the acid-cheese mixture to the bottom of the graduated portion, and the bottle is centrifuged again for two minutes. Following this water is added to the bottle, up to the top of the graduated portion and the bottle is again centrifuged for one minute. After centrifuging the bottle is placed in a water bath at 130-140° F. for five minutes, glymol is added and the percent of fat measured.

C. The Mojonnier Method

Briefly this test consists of weighing a one gram of sample into an extraction flask, adding to this eight ml. of hot water to soften the cheese, and then adding three ml. of ammonium hydroxide with thorough shaking after the addition of the hydroxide. After this 10 ml. of ethyl alcohol, 25 ml. of ethyl ether and 25 ml. of petroleum ether are added and the flask shaken one-half minute after the addition of the alcohol and 20 seconds after the addition of each of the two ethers. The flask is then centrifuged 30 turns,

taking one-half minute. The etherfat layer is then poured into a tared fat dish. For the second extraction five ml. of alcohol, 25 ml. each of ethyl and petroleum ether are added and shaken for 20 seconds after the addition of each reagent. The flask is again centrifuged for 30 turns, taking one-half minute and the ether-fat layer poured off into the dish. The ether is evaporated off from the dish and the dish placed in a vacuum oven at 275° F. for five minutes to dry the fat. The dish is then cooled in a dessicator, reweighed and the percent fat calculated.

D. The Minnesota Methods

The work herein reported on fat determinations by the Minnesota method involves two procedures, hereafter referred to as Minnesota method I and Minnesota method II, the only difference between the two methods being the use of different reagents.

Minnesota method I involved the use of the original reagent which consisted of 110 grams of sodium carbonate and 200 grams of sodium salicylate dissolved in 1000 ml. of water; to this solution was added 30 ml. of 50 percent sodium hydroxide and 100 ml. of n-butyl alcohol.

Minnesota method II involved the use of commercial reagent No. 735. obtained from Kimble Glass Company, Vineland, New Jersey. This reagent is patented and the exact composition is not known.

The procedures used for both of these Minnesota methods is essentially the same as recommended in the Kimble Manual on Dairy Testing (1). The procedure used in the work herein reported was as follows: Nine grams of ground cheddar cheese or 18 grams of cheese-emulsifier mixture were weighed into a 50 percent nine

gram cream test bottle, on a Torsion balance and a 20 ml. portion of the reagent added and mixed thoroughly. Then the bottle was placed in a water bath (gently boiling) for 15 minutes, centrifuged for one-half minute, filled to the top of the graduated portion with hot water and centrifuged again for one-half minute. The test was completed as in the Standard Babcock procedure.

EXPERIMENTAL

A. FAT TESTS

Since in the usual fat test for Cheddar cheese involves a rather cumbersome method of forcing ground cheese or strips of cheese down the neck of the bottle, it was thought that it would be more convenient if cheese could be emulsified with some chemical compound or reagent to a smooth, creamy consistency so that the cheese could then be pipetted into the test bottle.

1. Effectiveness of Various Chemical Compounds and Reagents as Emulsifiers for Cheddar Cheese

In this work the object was to find a reagent or combination of reagents which would emulsify the ground cheddar cheese into a smooth creamy mixture so that it could be pipetted into the test bottles. As a matter of convenience in performing the test an equal weight of cheese and of various compounds were used so that when an 18 gram portion of a mixture was weighed into the test bottle it would contain nine grams of cheese.

In determining the effectiveness of a chemical compound or reagent as an emulsifier for cheddar cheese, from 10 to 40 grams of ground cheddar cheese were weighed into a 150 ml. beaker and an equal amount of an aqueous solution of one of the compounds or reagents was also weighed into the beaker. Usually two or three concentrations of each chemical compound was employed. In unpublished work at the Oklahoma Agricultural Experiment Station 10) some results were recorded which indicated the approximate concentrations of various chemical compounds required for satisfactory emulsification of cheddar cheese. These results were used as a guide in making up some of the solutions. The cheese and

solution were immediately mixed with a glass stirring rod and then stirred at frequent intervals for about four minutes or until the cheese and solution were well mixed. The mixture was then observed for texture, consistency, degree of emulsification (amount of fat separation) and amount of foam. After these observations were made at room temperature (about 80° F.) the samples were heated in a water bath, with intermittent stirring, to 150° F. and the observations again made to note the effect of the higher temperature on the mixtures. The effectiveness of various chemical compounds and reagents as emulsifiers for cheddar cheese are shown on Table I.

Sodium hydroxide in concentrations of one, and two percent was not satisfactory because at room temperature the mixtures were curdy, too viscous to pipette and some fat separation was observed. At 150° F. the mixtures were less curdy, less viscous but fat separation occurred. An additional trial was run in which one and two percent solutions of sodium hydroxide were mixed with another lot of cheese and the mixtures heated to 180° F. to note the effect of the higher temperature. At this temperature partial precipitation of the curd and fat separation occurred.

Sodium citrate in concentrations of one and two percent was not satisfactory because at room temperature the mixtures were slightly curdy and too viscous to pipette. However the cheese was apparently emulsified because there was no fat separation. At 150° F. the mixtures were of curdy texture, too viscous to pipette and fat separation occurred.

Citric acid in concentrations of one, three, and five percent

TABLE 1

EFFECTIVENESS OF VARIOUS CHEMICAL COMPOUNDS AND REAGENTS AS EMULSIFIERS FOR CHEDDAR CHEESE

CHEMICAL COMPOUND OR REAGENT USED	%	ROOM TEMPERATURE				150° F.			
		TEXTURE	CONSISTENCY	EMULSIFICATION	FOAM	TEXTURE	CONSISTENCY	EMULSIFICATION	FOAM
Sodium hydroxide	1	curdy	too viscous	fat separation	none	sl. curdy	satisfactory	fat separation	slight
	2	curdy	too viscous	fat separation	none	sl. curdy	satisfactory	fat separation	slight
Sodium citrate	1	sl. curdy	too viscous	apparently complete	none	curdy	too viscous	apparently complete	none
	2	sl. curdy	too viscous	apparently complete	none	curdy	too viscous	apparently complete	none
Citric acid	1	smooth	too viscous	apparently complete	none	smooth	satisfactory	apparently complete	none
	3	smooth	too viscous	apparently complete	none	sl. curdy	too viscous	fat separation	none
	5	smooth	too viscous	apparently complete	none	sl. curdy	too viscous	fat separation	none
Sulfuric acid	15	curdy	too viscous	fat separation	none				
Boric acid	1	smooth	too viscous	apparently complete	none	sl. curdy	too viscous	fat separation	slight
	3	smooth	too viscous	apparently complete	none	sl. curdy	too viscous	fat separation	slight
	5	smooth	too viscous	apparently complete	none	sl. curdy	too viscous	fat separation	slight
Tri-sodium phosphate	8	sl. curdy	too viscous	apparently complete	none	curdy	too viscous	apparently complete	none
Di-potassium phosphate	4	sl. curdy	too viscous	apparently complete	none	curdy	too viscous	apparently complete	none
	8	sl. curdy	too viscous	apparently complete	none	curdy	too viscous	apparently complete	none
Sodium salicylate	1	smooth	too viscous	apparently complete	none	smooth	satisfactory	fat separation	none
	2	smooth	too viscous	apparently complete	none	smooth	satisfactory	fat separation	none
	5	smooth	too viscous	apparently complete	none	smooth	satisfactory	fat separation	none
Minnesota reagent I single strength		curdy	too viscous	fat separation	none	smooth	too viscous	fat separation	none
Minnesota reagent I double strength		curdy	too viscous	fat separation	none	smooth	too viscous	fat separation	none
California reagent #1 (one-half strength)		smooth	satisfactory	apparently complete	slight	smooth	satisfactory	apparently complete	slight
Perchloric acid (60%)	10	curdy	precipitation of curd	fat separation	none				
Glacial acetic acid	10	curdy	precipitation of curd	fat separation	none				
Orthophosphoric acid (85%)	10	curdy	precipitation of curd	fat separation	none				
Ammonium hydroxide (28%)	10	curdy	precipitation of curd	fat separation	none				
	20	curdy	precipitation of curd	fat separation	none				
	40	curdy	precipitation of curd	fat separation	none				
	60	curdy	precipitation of curd	fat separation	none				
	80	curdy	precipitation of curd	fat separation	none				

were satisfactory because at room temperature the mixtures were of smooth uniform texture and no fat separation occurred. However the mixtures were too viscous to pipette. At 150° F. citric acid in a concentration of one percent was found to be satisfactory. The mixtures were smooth textured, the viscosity was such that it could be easily pipetted, and there was no fat separation. Citric acid in concentrations of three and five percent at 150° F. was unsatisfactory because the mixtures were of curdy texture, too viscous to pipette and fat separation occurred.

Sulfuric acid in concentration of 15% at room temperature was unsatisfactory because the mixture was very curdy, too viscous to pipette, and fat separation occurred. No trial was run at 150° F.

Boric acid in concentrations of one, three and five percent at room temperature resulted in mixtures that were of smooth texture, and there was no fat separation. However the mixtures were too viscous to pipette and so were unsatisfactory. At 150° F. the mixtures were slightly curdy, too viscous to pipette and considerable fat separation occurred, and also there was slight foaming.

Tri-sodium phosphate in a concentration of eight percent at room temperature resulted in a mixture which was slightly curdy, and too viscous to pipette. However the emulsion was apparently complete as no fat separation occurred. At 150° F. the mixture was curdy, too viscous to pipette, but there was no fat separation.

Di-potassium phosphate in concentrations of four percent and eight percent at room temperature resulted in mixtures which were

unsatisfactory because they were slightly curdy and too viscous to pipette. However there was no fat separation. At 150° F. the mixtures were curdy and too viscous to pipette.

Sodium salicylate in concentrations of one, two, and five percent at room temperature resulted in mixtures which were of smooth texture and apparently complete emulsification because no fat separation occurred. However the mixtures were too viscous to pipette. However at 150° F. the mixtures were of smooth texture and satisfactory for pipetting, but some fat separation occurred.

Minnesota method I reagent used in the regular strength and double strength were of curdy texture, too viscous to pipette and considerable fat separation occurred at room temperature. At 150° F. the mixtures were smooth textured, less viscous but still too viscous to pipette and fat separation occurred.

California reagent #1 (one-half strength) when mixed with the ground cheddar cheese resulted in a mixture at room temperature which was of smooth texture, about the right viscosity for pipetting and the emulsion was apparently complete, but some foam was produced. At 150° F. the mixture had the same characteristics which were observed at room temperature except that the viscosity was somewhat less. It was observed that the California reagent #1 (one-half strength) produced the most desirable results of all the emulsifiers tried.

Perchloric (60%), glacial acetic, and orthophosphoric (85%) acids in a concentration of 10% were used individually and found to be unsatisfactory because at room temperature the mixtures

were of curdy texture, considerable precipitation of curd and fat separation occurred. No trials were run at 150° F.

Ammonium hydroxide (28%) in concentrations of 10, 20, 40, 60, and 80 percent were unsatisfactory because at room temperature the mixtures were very curdy and considerable precipitation of curd and fat separation occurred. No trials were run at 150° F.

From the above results it is evident that citric acid in the concentration of one percent at 150° F. or California reagent #1 (one-half strength) when mixed with the ground cheddar cheese, in equal portions by weight, resulted in mixtures which was of smooth texture, the right viscosity for easy pipetting, only slight foam and no fat separation occurred.

2. Fat Determinations on Cheese Emulsified with Citric Acid and California Reagent #1

Since the results in section one indicated that a one percent solution of citric acid at 150° F. or California reagent #1 (one-half strength) at room temperature when mixed with ground cheddar cheese resulted in satisfactory mixtures, fat determinations using the Babcock method and the Minnesota method I were made on cheese emulsified with these two reagents.

A lot of cheese was finely ground and then emulsified with one percent citric acid or California reagent #1 (one-half strength). Then 18 grams of the mixture were weighed into a nine gram 50% cream test bottle, using a nine ml. cream pipette to make the transfer and a four bottle Torsion balance for weighing.

Replicate determinations were made on the sample of cheese using the Babcock method and the Minnesota method I. The Mojonnier method was also run on the same lot of cheese.

a. Cheese Emulsified with Citric Acid

The results of 14 replicate fat determinations by the Babcock method and the Minnesota method I on a lot of cheese emulsified with one percent citric acid at 150° F. are shown in Table 2. The lot of cheese tested 36.13% fat by the Mojonnier method.

The fat percent of the cheese ranged from 33.0 to 40.5% and averaged 34.92% when tested by the Babcock method. The Babcock test varied from -3.13 to +4.37% from the Mojonnier test and the average variation was -1.21%. There was considerable variation among the replicate tests of the cheese when tested by this

TABLE 2

FAT DETERMINATIONS ON CHEESE
EMULSIFIED WITH ONE PERCENT CITRIC ACID AT 150° F.

BABCOCK METHOD		MINNESOTA METHOD I	
% FAT	VARIATION FROM THE MOJONNIER TEST (36.13%)	% FAT	VARIATION FROM THE MOJONNIER TEST (36.13%)
34.0	-2.13	32.5	-3.63
35.0	-1.13	32.5	-3.63
33.0	-3.13	32.0	-4.13
34.0	-2.13	32.5	-3.63
34.5	-1.63	33.0	-3.13
33.0	-3.13	32.0	-4.13
33.0	-3.13	31.5	-4.63
34.5	-1.63	32.0	-4.13
33.5	-2.63	34.0	-2.13
36.0	- .13	32.0	-4.13
36.5	∕ .37	32.5	-3.63
33.5	-2.63	31.5	-4.63
40.5	∕5.37	31.0	-5.13
38.0	∕1.87	32.0	-4.13
Av. 34.92	Av. -1.21	Av. 32.21	Av. -3.92
range	range	range	range
33.0-40.5	-3.13-∕4.37	31.0-34.0	-2.13 - -5.13

method and it was observed that the fat columns were all slightly burnt.

The fat percent on this same lot of cheese when tested by the Minnesota method I ranged from 31.0 to 34.0% and averaged 32.21%. The Minnesota test varied from -2.13 to -5.13% (from the Mojonnier test and the average variation was -3.92%. It was noted that the tests varied considerably, they were always lower than the Mojonnier test and that all fat columns had curd at their base ranging from slight to excessive.

From the results presented above it was concluded that citric acid was unsatisfactory as an emulsifier for cheddar cheese.

b. Cheese Emulsified with California Reagent #1 (One-half Strength)

Eight trials were made with the California reagent #1 as the emulsifier on two lots of cheese. The results obtained from these trials are shown in Table 3.

Only one trial was run using the Standard Babcock method because when the acid was added to the emulsified cheese a violent reaction occurred which caused the mixture to boil so that "blowing out" of some of the contents through the neck of the bottle would likely occur in routine testing. In this one trial on a lot of cheese, which tested 27.04% fat by the Mojonnier method, a Babcock test of 27% was obtained. This test varied from the Mojonnier test by -.04 percent.

With the Minnesota method I the fat percent of the cheese ranged from 36.0 to 36.5% and averaged 36.33% on lot I on which the Mojonnier test was 36.13%. The variation from the Mojonnier

TABLE 3

FAT DETERMINATIONS ON CHEESE EMULSIFIED WITH CALIFORNIA REAGENT #1 (ONE-HALF STRENGTH) AT ROOM TEMPERATURE

	MOJONNIER METHOD	MINNESOTA METHOD II	
LOT	% FAT	% FAT	VARIATION FROM THE MOJONNIER TEST
I	36.13	36.0	- .13
		36.5	± .37
		36.5	± .37
		Av. 36.33	± .22
		range	range
		36.0-36.5	-.13 to ±.37
II	33.11	34.0	± .89
		33.5	± .39
		33.5	± .39
		33.5	± .39
		34.5	±1.39
		33.5	± .39
		Av. 33.75	Av. ± .64
		range	range
		33.5-34.5	±.39 to ±1.39

test ranged from -.13 to +.37% and averaged +.20%. The Mojonnier test on lot II was 33.11% fat while the Minnesota method I ranged from 33.5 to 34.5% and averaged 33.75%. The variations from the Mojonnier test ranged from +.89 to +1.39% and averaged +.64%.

The results indicate that by using the Minnesota method on cheese emulsified with California #1 (one-half strength), fat tests which check fairly closely with each other but ran consistently higher than the Mojonnier test was obtained. It was found that the rate of emulsification with California reagent #1 (one-half strength) can be increased by heating the mixture to 150° F.

5. Comparison of Various Fat Tests on Cheese Emulsified with the California Reagent #1

Since the results reported in section 2 indicated that the California reagent #1 (one-half strength) was satisfactory for emulsifying ground cheddar cheese, fat tests were run with various modifications of the Babcock test on a lot of emulsified cheese to determine which method would be the most practical and accurate. The results of these tests were compared with the Mojonnier method and with the Standard Babcock method.

The ground cheddar cheese was emulsified with California reagent #1 (one-half strength) and 18 gram samples of the emulsified cheese were transferred, using a nine ml. cream pipette, to 50% nine gram Babcock test bottles. The weighing was done on a four bottle Torsion balance.

After the emulsified cheese was weighed into the test bottles the tests were completed in the usual manner except for some variations indicated in the discussion of each test.

The results of duplicate determinations with various modifications of the Babcock test on a lot of cheese emulsified with California #1 (one-half strength) are shown in Table 4.

a. The Illinois Method

Two and one half ml. of reagent A was added to the test bottle and mixed well, then 10 ml. of reagent B was added and the bottle shaken again. Following this the test bottle was placed in a water bath at 180°-190° F. for 15-30 minutes to digest the curd. The test bottle was shaken three or four times during the digestion period. After digestion the bottle was centrifuged and the percent of fat measured in the usual manner.

TABLE 4

COMPARISON OF VARIOUS FAT TESTS ON CHEESE EMULSIFIED WITH CALIFORNIA REAGENT #1 (ONE-HALF STRENGTH)

TEST USED	% FAT AV. OF DUPLICATES	REMARKS
STANDARD BABCOCK	26.50	
MOJONNIER	27.04	
ILLINOIS	28.00	clear fat column
NEBRASKA	26.50	clear fat columns
CALIFORNIA	29.00	profuse foaming
GLACIAL ACETIC-SULFURIC	27.00	clear fat columns
PERCHLORIC-GLACIAL ACETIC	-----	fat column too curdy to read
SCHAIN	40.25	very curdy fat column
PENNSYLVANIA	27.00	slightly curdy fat columns
MINNESOTA METHOD I	27.25	clear fat column

The results indicate that this test is unsuitable for testing of emulsified cheddar cheese because the fat percent was one and one-half percent higher than the standard Babcock test and almost one percent higher than the Mojonnier test.

b. The Nebraska Method

Five ml. of reagent A was added to the mixture and the bottle was shaken. Then 30 ml. of reagent B was added and mixed well and the bottle placed in a water bath at 175-180° F. for 15 minutes to digest the curd. The bottle was shaken three or four times during the digestion period. The test was completed as in the Standard Babcock procedure.

The results indicate that this test could be used in the testing of the emulsified cheese, but the large amount of reagents needed makes adequate mixing of the reagents and emulsified cheese difficult and the acid used in the test causes a violent reaction when added to the emulsified cheese in the bottle.

c. The California Method

Eight ml. of reagent #1 was added to the test bottle and mixed well, then five ml. of reagent #2 was added and again mixed well. The bottle was placed in a water bath at 180° F. for 15 minutes and shaken three or four times during digestion. After digestion the test bottle was centrifuged for one-half minute and the bottle filled with hot water up to the top of the graduated portion and the test was centrifuged again for one minute. The test was completed as in the standard Babcock procedure.

The results presented in Table 4 indicate that this method was not satisfactory because of profuse foaming during digestion

nd the diffusion of the glymol throughout the fat column, which auses the test to be very high as compared to those of the ojonnier and Standard Babcock methods.

d. The Glacial Acetic-Sulfuric Acid Method

Five ml. of glacial acetic acid was added to the test bottle nd mixed well, then nine ml. of sulfuric acid was added and the ottle heated for five minutes in a water bath at 170° F. The ottle was agitated three or four times during digestion. The ottle was then filled to the top of the graduated portion and entrifuged for two minutes and the test completed as in the tandard Babcock procedure.

The results shown in Table 4 indicate that, while this test ompares favorably with the results obtained by the Mojonnier and he Standard Babcock methods, the reaction upon addition of the cids creates a tremendous amount of heat with possible "blowing ut" of the acid-cheese mixture.

e. Perchloric-Glacial Acetic Acids Method

A 30 ml. portion of reagent (equal parts of 72 percent per-hloric acid and glacial acetic acid) was added to the test ottle. Then the bottle was immersed in boiling water for five inutes with two or three agitations during the digestion period. he bottle was then filled to the top of the graduated portion nd centrifuged for two minutes. The test was then completed as n the Standard Babcock method. The results in Table 4 indicate hat the test was unsatisfactory because the reagent does not igest all of the curd and the fat columns are too curdy to easure.

f. The Schain Method

Seven ml. of reagent A was added to the sample and mixed thoroughly. Then 20 ml. of reagent B was added to the bottle without shaking so as to form a layer under the mixture. The bottle was placed in a water bath at 180° F. for five minutes, then removed and set aside at room temperature for ten minutes and the percent of fat read by subtracting the lower meniscus reading from the upper meniscus reading.

The results obtained when the curd was omitted from the reading were very low and when the curd was included, as shown by the results in Table 4 in the reading, they were very high when compared to either the Standard Babcock or the Mojonnier tests and therefore the test was considered unsatisfactory.

g. The Pennsylvania Method

Two ml. of ammonium hydroxide (28%) was added to the test bottle and mixed well and then three ml. of n-butyl alcohol was added and mixed. Following this 17.5 ml. of sulfuric acid (sp.g.1.72-1.74) was added and mixed until the curd was digested. The test was then completed as in the Standard Babcock method.

The results of this test indicate that while the fat percent agrees closely with the Mojonnier tests, the fat columns were slightly curdy and the reaction upon adding of the acid is quite violent so this test cannot be safely used.

h. The Minnesota Method I

This test was run as described in D under "Methods".

The results presented in Table 4 show that fat tests by the Minnesota method on cheese emulsified with California reagent #1

(One-half strength) agreed closely with the Standard Babcock and the Mojonnier tests on the same lot of cheese. The fat columns were clear and distinct, free from curdiness, or cloudiness and there was no foaming.

4. The Influence of Some Variations in the California Method on the Fat Test Obtained on Cheddar Cheese

The results in section 3 indicated that the California method was not satisfactory for testing cheddar cheese but since the California reagent #1 was being used for the emulsifier it was thought that perhaps some variation in either the reagents or the procedure used would make the test more suitable and therefore more convenient since no other method would have to be used in testing of the cheese for fat. Normally, the test involves the use of 8 ml. of reagent #1 and 5 ml. of reagent #2 with a digestion time of 15 minutes. Several variations, the results of which are presented in Table 5, were made as follows:

1. The amount of reagent #1 was decreased to five ml., while the amount of reagent #2 was increased to 10, 12, and 14 ml. The rest of the test was not varied.

2. Reagent #2 was increased to 14 ml. and the rest of the test was not varied.

3. Reagent #1 was increased to 10 ml., while reagent #2 increased to 16 ml. and the rest of the test was not varied.

4. The above variations were also heated in the digestion bath for an additional 10 minutes.

5. Reagent #1 was decreased to three, four and five ml., while reagent #2 increased to eight ml.

6. Reagent #1 was decreased to two ml. and omitted entirely, while reagent #2 was increased to eight ml. and the rest of the test was not varied.

7. Reagent #1 was omitted, while reagent #2 was decreased

TABLE 5

THE INFLUENCE OF SOME VARIATIONS IN THE CALIFORNIA METHOD ON THE FAT TEST OBTAINED ON CHEDDAR CHEESE

VARIATION NO.	ML. REAGENT #1	ML. REAGENT #2	MINUTES DIGESTION TIME	FAT TEST % (% FAT BY THE MOJONNIER METHOD (27.04))	REMARKS
1	5	10	15	30.00	Profuse foaming; glymol diffused throughout the fat columns
	5	12	15	30.00	
	5	14	15	31.50	
2	8	14	15	30.00	
3	10	16	15	28.00	
4	5	10	25	32.50	
	5	12	25	31.50	
	5	14	25	31.00	
	8	14	25	31.00	
	10	16	25	30.00	
5	3	8	15	28.50	
	4	8	15	29.00	
	5	8	15	29.00	
6	2	8	15	26.00	
	0	8	15	29.00	
7	0	3	15	-----	Incomplete digestion of the curd
8	8	5	15	-----	Ethyl and petroleum ethers omitted; Profuse foaming and curdy fat columns
8	8	5	15	-----	Ethyl ether and ethyl alcohol omitted; Profuse foaming and curdy fat columns
8	8	5	15	-----	Ethyl ether and butyl alcohol omitted; Profuse foaming and curdy fat columns
8	8	5	15	28.50	Ethyl ether and ammonium hydroxide omitted; Profuse foaming and throughout the fat column glymol diffused
8	8	5	15	29.00	Ethyl ether and pet.ether, butyl alc., and am. hydroxide omitted; Profuse foaming.
8	8	5	15	-----	Only ethyl alcohol used; No fat separation

o three ml. and the rest of the test was not varied.

8. In this variation a succession of tests were run with eagent #1 remaining as in the usual test, while reagent #2 was aried by omitting the ethyl ether and one of the other chemicals n each of the trials.

The results presented in Table 5 show that none of the variaions were effective in improving the California test for cheese. n every instance there was profuse foaming except in one and in hat one the foaming was slight. In some instances there was ncomplete digestion of curd. The glymol diffused throughout the at columns in all of the tests.

5. The Influence of Some Variations in the Schain Method on the Fat Test Obtained on Cheddar Cheese

Since the results in section 3 indicate that the Schain test was unsatisfactory but since the time involved is so much less than other tests and because of its simplicity some variations were made in the test in an attempt to eliminate the difficulties and make the test satisfactory for cheese.

The results of these variations are shown in Table 6 and are as follows:

1. Reagent A was decreased to one, two, four, and six ml. in four tests and increased to eight ml. in the fifth test, reagent B was increased to 30 ml. The tests were read in the usual manner and also after one and two minutes of centrifuging.

2. Reagent A was omitted and reagent B increased to 31 and 46 ml. The rest of the test was not varied.

The results of these variations indicate that they were ineffective in correcting the difficulty of high fat tests or curdiness of the fat columns.

TABLE 6

THE INFLUENCE OF SOME VARIATIONS IN THE SCHAIN METHOD ON THE FAT TEST OBTAINED ON CHEDDAR CHEESE

ML. REAGENT A.	ML. REAGENT B.	FAT % NOT CENTRIFUGED	FAT % CENTRIFUGED ONE MINUTE	FAT % CENTRIFUGED TWO MINUTES	REMARKS
1	30	8.0	30.0	30.0	All fat column
2	30	24.0	33.0	32.5	were curdy
4	30	14.0	29.5	31.0	
6	30	15.0	31.5	32.0	
8	30	18.0	31.5	32.0	
0	30	33.0			
0	46	33.0			

5. Comparison of Minnesota Method II with the Standard Babcock and Mojonnier Methods

Since the results of the work reported in section 3 indicate that the Minnesota method was perhaps the most practical and accurate of all of the modified Babcock tests used, further work was done to check its accuracy. Four replicate samples were run on each of 10 lots of cheese using Minnesota Method II as given in section D under "Methods" and the fat percent was measured both with and without the use of glymol to depress the meniscus. The results of these tests as compared with both the Standard Babcock and Mojonnier methods are shown in Table 7.

The results indicate that the average fat test by the Standard Babcock method on the 10 lots of cheese was 32.47%. This varied from the average Mojonnier test by -.44% and the variation from the Mojonnier ranged from -1.13% to +.31%, while the average test by the Minnesota method II when no glymol was used was 32.99 or an average difference of .52% higher than the Standard Babcock test. The variation ranged from -.75 to +1.62% from the Standard Babcock method. After adding glymol the average fat test by the Minnesota method was 31.74% or an average difference of -.73% from the test obtained by the Standard Babcock method. The variation ranged from -2.00 to +.50% from the Standard Babcock test.

The average fat test with the Mojonnier method for the 10 lots was 32.91% while that for the Minnesota Method II when no glymol was used was 32.99% or an average difference of .08% higher for the Minnesota Method II. The variation from the

TABLE 7

COMPARISON OF MINNESOTA METHOD II WITH THE STANDARD BABCOCK AND MOJONNIER METHODS

LOT NO.	MOJONNIER TEST (AV. OF DUPLICATES)	STANDARD BABCOCK TEST (AV. OF DUPLICATES)		MINNESOTA METHOD II (AVERAGE OF FOUR REPLICATES)					
				WITHOUT GLYMOL			WITH GLYMOL		
	% FAT	% FAT	VARIATION FROM THE MOJONNIER	% FAT	VARIATION FROM MOJONNIER	VARIATION FROM STANDARD BABCOCK	% FAT	VARIATION FROM MOJONNIER	VARIATION FROM STANDARD BABCOCK
1.	36.13	35.00	-1.13	36.37	± .24	±1.37	34.75	-1.38	- .25
2.	33.11	32.00	-1.11	33.62	± .51	±1.62	32.50	- .61	± .50
3.	35.86	35.50	- .36	35.25	± .61	- .25	34.50	-1.36	-1.00
4.	34.52	33.50	-1.02	34.12	- .41	± .62	33.00	-1.52	-1.50
5.	35.34	35.00	- .34	36.40	±1.06	±1.40	35.00	- .34	.00
6.	32.98	32.25	- .73	33.25	± .73	± .95	33.00	± .02	± .75
7.	33.20	33.00	- .20	33.50	± .30	± .50	31.50	-1.70	-1.50
8.	33.69	34.00	± .31	34.16	± .47	± .16	32.00	-1.69	-2.00
9.	33.78	33.50	- .46	32.75	-1.03	- .75	31.50	-2.28	-2.00
10.	20.50	20.00	- .50	21.00	± .50	±1.00	19.70	- .80	- .30
AVERAGE	32.91	32.47	- .44	32.99	± .08	± .52	31.74	-1.17	- .73
			range -1.13 to ± .31		range -1.03 to ±1.06			range -2.28 to ± .02	

Mojonnier test ranged from -1.03 to +1.06%, with five of the 10 tests by the Minnesota Method II varying .50% or less from the Mojonnier method. After adding glymol the average fat test by the Minnesota Method II was 31.74% or an average difference of 1.17% lower than the tests by the Mojonnier method. The variation from the Mojonnier test ranged from -2.28% to +.02%.

These results show that the Minnesota Method II, using no glymol, varies on the average less from the Mojonnier than does the Babcock method; however it ranges slightly more from the tests by the Mojonnier method than does the Standard Babcock method. Minnesota Method II on cheese emulsified with California reagent No. 1 (one-half strength) has the following features which make it a desirable test for cheddar cheese:

1. The tedious labor of forcing ground cheese or strips of cheese down the neck of the bottle is eliminated.

2. The Minnesota reagent is relatively harmless to hands and clothing.

3. There is no danger of "blowing out" on adding of the reagent.

4. The Minnesota Method II requires only one minute of centrifuging.

5. There is no danger of burning the samples.

6. Test bottles may be dumped into the sinks, without harm to blumbing.

7. The reagent acts as a cleaning solution when cleaning the bottles.

7. Comparison of Minnesota Methods I and II for Fat Tests on Emulsified Cheddar Cheese

Since the work of Bird and Breazeale (4) indicated that Minnesota method I caused a 5.17% saponification of fat and Minnesota method II caused a 16.73% saponification of fat when testing buttermilk, some work was done to compare the suitability of these two methods for testing ground cheddar cheese emulsified with California reagent #1 (one-half strength).

In this work five lots of cheese were prepared as in section and tested as in "Methods" under D. Duplicate determinations were made on each lot of cheese by Minnesota method I and Minnesota method II.

The results shown in Table 8 indicate that the Minnesota method I results in much higher fat percentages than does Minnesota method II. The average fat percent on the five lots of cheese obtained with Minnesota method I was 35.90% when no glymol was used and 34.70% when glymol was used, while the average obtained with Minnesota method II was 33.60% when no glymol was used and 31.70% when glymol was used. The fat tests obtained with Minnesota method I ranged from 2.5% to 3.5% higher than those obtained with Minnesota method II and averaged .0% higher. It was observed that, after standing for a few hours, the glymol diffused throughout the fat columns in the tests obtained with Minnesota method I but not in those obtained with Minnesota method II.

From these results it was concluded that Minnesota method I was not as satisfactory for the testing of emulsified cheddar

TABLE 8

COMPARISON OF MINNESOTA METHODS I AND II
FOR FAT TESTS ON EMULSIFIED CHEDDAR CHEESE

AVERAGE OF DUPLICATE TESTS

LOT NO.	MINNESOTA METHOD I		MINNESOTA METHOD II	
	WITHOUT GLYMOL % FAT	WITH GLYMOL % FAT	WITHOUT GLYMOL % FAT	WITH GLYMOL % FAT
1	27.75	26.75	26.00	24.00
2	30.00	28.50	28.25	26.00
3	33.00	32.00	30.25	29.25
4	44.75	43.75	42.75	40.25
5	44.00	42.50	40.75	39.00
Average:	35.90	34.70	33.60	31.70

heese as was Minnesota method II because the fat tests were much igher.

3. MOISTURE TESTS

The determination of the moisture content of cheddar cheese is of the great importance to the cheese manufacturer from the standpoint of producing a product of uniform quality and from the standpoint of meeting the Federal standards set up for the maximum moisture content of cheddar cheese.

Several tests for determining the moisture content of cheddar cheese have been devised from time to time and their main disadvantages are the length of time required to run the tests and their lack of accuracy.

Several oils have been used in a test in which the cheese is immersed in the oil and then the two heated to drive off the moisture from the cheese. Gould (6 and 7) modified this test to use olive oil. He said that the olive oil test was accurate within .5% of the results by the steam oven method and within .3% of the modified Mojonnier method. He also found that the duplicate tests would check well with each other. The olive oil test is run as follows:

The 20 ml. of olive oil is placed in a pan and approximately one gram of sodium chloride is added. Then the cup and oil are tared on a Torsion butter balance and five grams of ground cheese are carefully weighed into the cup. The cup and contents are then carefully heated over a low flame until the moisture is driven off. During the heating the cup is gently rotated and moved in and out of the flame to keep the oil from getting too hot and vaporizing. After the moisture is driven off, the cup is wiped clean, cooled and reweighed on the balance. The percent of mois-

ure in then calculated.

The object of the following work was to compare moisture ests obtained by heating weighed samples of ground cheese in an ven at 212° F. at atmospheric pressure for 24 hours with the live oil method and to substitute other oils in the place of the live oil in an attempt to improve the accuracy of the olive il method.

1. Comparison of Olive Oil and Various Other Oils for Use n the Moisture Test

In this work mineral oil, cocoanut oil, soyabean oil, corn il, peanut oil and paraffin were substituted for olive oil in he procedure described above.

The results of duplicate analysis on one lot of cheddar heese as shown in Table 9 and compared with the moisture con- ents obtained by heating at 212° F. in an electric oven for 24 ours indicate that none of the oil tests is accurate and dupli- ate tests on the same lot of cheese do not check closely.

The mineral oil gives much lower results than does the 212° F. ven method and also fumes profusely during the heating period. he average percent of moisture obtained when using mineral oil as 39.01%. The test when using mineral oil averaged 2.60% lower han the 212° F. oven method. When using cocoanut oil the aver- ge percent moisture was 47.98% or 8.97% higher than the 212° F. ven and the oil foamed profusely during heating. When using soya- ean oil or corn oil the average moisture was 39.33% and 39.98% espectively. The two oils averaged .32% and .97% higher respectively han the 212° F. oven method. Whenusing paraffin the average mois- ure percent was 36.21% which was 2.80% lower than the 212°F. oven

TABLE 9

COMPARISON OF OLIVE OIL AND VARIOUS OTHER OILS FOR USE IN THE MOISTURE TEST

Average of Duplicates (39.01%)

OIL USED	% VARIATION FROM THE 212° F. OVEN METHOD	% MOISTURE	REMARKS
Mineral oil	-2.60	36.41	Content fumes profusely during heating
Cocoanut oil	±6.97	47.98	High test, profuse foaming during heating
Soyabean oil	± .32	39.33	O. K.
Corn oil	± .97	39.98	O. K.
Peanut oil	±1.80	40.84	High test, profuse foaming during heating
Paraffin	-2.80	36.21	Low test, profuse foaming during heating
Olive oil	- .14	38.87	O. K.

est. Also there was profuse foaming during the heating period. hen using peanut oil the average moisture content was 41.24% hich was 2.23% higher than the 212° F. oven test. When using live oil the average moisture content was 38.87% which was .14% igher than the 212° F. oven method.

The results above indicate that olive oil, corn oil, and oyabean oil were perhaps the most promising and that further ests should be made with these oils.

2. Comparison of Olive Oil, Corn Oil and Soyabean Oil for the Determination of Moisture in Cheddar Cheese

Since the results in the section 1 above indicated that olive il, corn oil, and soyabean oil were perhaps the best oils to se in the moisture test for cheese, further trials were run on ive lots of cheese to determine the suitability of the oils for he oil immersion method of determining moisture.

The results of this work, as shown in table 10, indicate hat the oil method for determining the moisture in cheddar heese is unsatisfactory because the results of the tests do not heck with the 212° F. oven method nor did they check with each ther.

The average percent of moisture in the five lots of cheese r the 212° F. oven method was 33.94%. The average moisture rcent when using olive oil in the oil test was 32.99% which ried from the 212° F. oven method by -.95% and the variation nged from -1.93% to +.49%. It was also noted that the dupli- te tests on the same sample of cheese varied as much as .9% some cases. When corn oil was substituted for olive oil in e oil test the moisture percent in the cheese averaged 33.47% d varied from the 212° F. oven method by -.47% and the varia- on ranged from -2.39% to +1.71%. It was noted that the dupli- tes varied from each other by as much as 1.1% in some cases. en soyabean oil was used in the oil test the average moisture rcent on the five lots of cheese was 33.45%. This varied from 212° F. oven method by -.39% and the variation ranged from .62% to +2.34%. It was noted that the duplicate tests varied

TABLE 10

COMPARISON OF OLIVE OIL, CORN OIL, AND SOYABEAN OIL FOR THE DETERMINATION OF MOISTURE IN CHEDDAR CHEESE

LOT No.	212° Oven Method	Oil Test					
		Olive Oil		Corn Oil		Soyabean Oil	
	% Moisture Av. of Duplicates	% Moisture Duplicates and Av. of Duplicates	Variation from the 212° F. Oven	% Moisture Duplicates and Av. of Duplicates	Variation from the 212° F. Oven	% Moisture Duplicates and Av. of Duplicates	Variation from the 212° F. Oven
1	33.46	31.09-31.97		31.78-32.02		31.80-31.87	
		31.53	-1.93	31.90	-1.56	31.84	-1.62
2	32.30	32.64-32.95		32.58-32.10		32.19-31.99	
		32.79	± .49	32.34	± .04	32.09	- .21
3	36.20	34.23-34.66		33.28-34.37		32.50-35.41	
		34.44	-1.76	33.81	-2.39	33.95	-2.35
4	35.49	32.25-31.96		35.79-34.90		35.04-34.45	
		32.10	-3.39	35.35	- .14	34.75	- .74
5	32.27	34.11-33.48		33.88-34.09		34.20-33.03	
		33.80	±1.53	33.98	±1.71	34.61	-2.34
Average	33.94	32.99	- .95	33.47	- .47	33.45	- .39

rom each other by 3% in one case and by as much as .6% in the ther cases.

5. A Rapid Method for the Estimation of the Moisture Content in Cheddar Cheese

Since the results presented in the preceding sections indicate that the "oil" methods of testing cheddar cheese for moisture were unsatisfactory, it was thought that perhaps the cheese could be dried directly over a low flame if it could be spread evenly over the bottom of the pan.

In this test five grams of ground cheddar cheese were weighed into a tared cup on a Torsion butter balance and then five ml. of water added to the cup. The cup was then heated over a low flame until the cheese had melted and mixed well with the water. After the cheese and water had mixed the pan was set on an asbestos screen, on a tripod, with the tip of the flame just touching the bottom of the screen. The pan was then heated in this position until the curd was well browned. In some cases where the mixture fumed profusely before the curd was browned the pan was removed from the flame until the fuming ceased before continuing the heating. The slight fuming which occured in nearly all cases in the heating of the curd appeared to have little effect on the results by this method.

The results obtained on eight lots of cheese by the rapid method described above as compared with the 212° F. oven method are shown in Table 11.

The results indicate that the percent of moisture by the 212° F. oven method on the 8 lots of cheese averaged 35.67% while the average percent of moisture on the same lots of cheese by the rapid method was 35.28%. The variation from the 212° F.

TABLE 11

COMPARISON OF THE RAPID MOISTURE TEST AND THE 212° F. OVEN FOR THE DETERMINATION OF MOISTURE IN CHEDDAR CHEESE

AVERAGE OF DUPLICATE TESTS

LOT NO.	212° F. OVEN	RAPID MOISTURE TEST	
	% MOISTURE	% MOISTURE	VARIATION FROM THE 212° F. OVEN
1	35.36	35.20	- .16
2	32.35	31.90	- .45
3	34.51	34.10	- .41
4	34.95	34.90	- .05
5	35.49	35.00*	- .49
6	35.66	34.80	- .86
7	42.92	42.30	- .62
8	34.11	34.00	- .11
Average	35.67	35.28	- .39
			range
			-.05 to -.86

*Sample spattered during drying

ven method was -.39% and the variation ranged from -.86 to -.05%. t was noted that the variation in six of the eight trials was ess than -.5%. In only one case, Lot 5, was there any trouble rom excessive spattering.

While the number of samples run was insufficient to justify conclusion as to the merits of this method it does seem to be ccurate enough for use in a cheese making plant.

It was noted that when a factor of .39% is added to the esults of the tests by the rapid method that the variation rom the 212° F. oven method ranges from -.42% to +.35%. Also he total time needed, including the weighing, for this test is ess than 15 minutes per sample with seven to nine minutes tilized for heating of the sample to drive off the moisture.

CONCLUSIONS

. A satisfactory emulsion of smooth texture, liquid enough to e easily pipetted, yet viscous enough to prevent separation of ne fat of ground cheddar cheese, was obtained using California eagent #1 (one-half strength).

. Satisfactory fat tests were obtained on the ground cheddar heese emulsified with California reagent #1 (one-half strength) sing the Minnesota method II without glymol. The tests compare easonably close with the results by the Mojonnier method on he same lots of cheese and the duplicate tests check well with ach other.

. The oil immersion tests for determining the moisture content f cheddar cheese were found to be unsatisfactory when using araffin, cocoanut, soyabean, corn, peanut, mineral, and olive ils because the results were not accurate as compared to the esults by the 212° F. oven method and trouble was encountered n some cases from fuming or foaming of the oils.

. A rapid method is described for the determination of the oisture content of cheddar cheese. The method gives results nich are accurate enough for use in an ordinary cheese plant. riefly this test consists of weighing five grams of cheese into tared dish, adding of five ml. of water, spreading the mixture ver the bottom of the pan and then heating the pan to drive off ne moisture. Then the dish is cooled and reweighed and the ercent of moisture calculated.

BIBLIOGRAPHY

- Anonymous, Kimble Manual on Dairy Testing. 3rd. ed. Vineland, N. J.: Kimble Glass Co., 1942.

- Association of Official Agricultural Chemists. Official and Tentative Methods of Analysis. 6th. ed. Washington, D. C.: A.O.A.C., 1945.

- Babcock, S. M. A New Method for the Estimation of Fat in Milk Especially Adapted to Creameries and Cheese Factories. Wisc. Agr. Exp. Sta. Bul. 24, 1890.

- Bird, E. W. and Breazeale, D. F. A Study of Several Minnesota Reagents for the Determination of Fat in Butter Milk. J. Dairy Sci., 20: 1-7. 1937.

- Crowe, L. K. Testing Ice Cream for Butterfat. Nebr. Agr. Exp. Sta. Bul. 246. 1930.

- Gould, I. A. A Comparitive Study of Methods of Determining the Moisture Content of Cheddar Cheese. I. Modified Mojonnier and Olive Oil Methods. J. Dairy Sci., 20:625-635. 1937.

- Gould, I. A. A Comparitive Study of Methods of Determining the Moisture Content of Cheddar Cheese. II. The Steam Oven Method at High Pressure and the Olive Oil Method. J. Dairy Sci. 21:379-383. 1938.

- Kniaseff, V. Improved Babcock Method for Determining Fat in Ice Cream. Ice Cream Review. 28:6. January, 1935.

- Mojonnier, T. and Troy, H. C. The Technical Control of Dairy Products. 2nd. ed. Chicago, Ill.: Mojonnier Brothers Co., 1925.

- Olson, H. C. and Bruce, J. Unpublished Data. Oklahoma Agricultural Experiment Station. 1949.

- Overman, O. R. and Garrett, O. F. A Non-acid Babcock Method for Determining Fat in Ice Cream. Ill. Agr. Exp. Sta. Bul. 360. 1930.

- Petersen, W. E. and Herreid, E. O. A New Method for Estimating the True Fat Content of Buttermilk. Minn. Agr. Exp. Sta. Tech. Bul. 63. 1929.

- Ross, H. E. Using the Babcock Method for Testing Cheese for Fat. Nat. Butter and Cheese J. 27:18. September, 1936.

- Sammis, J. L. The Moisture Test in the Cheese Factory. Use of the Steam Pressure Oven. Wisc. Agr. Ext. Circ. 81. 1917.

15. Sammis, J. L. Cheese Making. 11th ed. Madison, Wisc.: The Cheese Maker Book Co., 1946.

16. Sanders, G. P. Comparison of the Volatile Solvent Method with the Vacuum Oven Method for Determining the Moisture Content of Cheese. J. Dairy Sci., 11:325-330. 1928.

17. Schain, P. The Use of Detergents for Quantitative Fat Determinations. I. Determination of Fat in Milk. Science. v. 110. July 29, 1949.

18. Schain, P. Personal Communication to Dr. H. C. Olson, Oklahoma A & M College. Feb. 14, 1950.

19. Smith, G. F., Fritz, J. S., and Pyenson, H. The Determination of Butterfat in Ice Cream Employing Mixed Perchloric and Acetic Acids. J. Dairy Sci., 31:905-908. 1948.

20. Swope, W. D. The Pennsylvania Method for the Determination of Fat in Dairy Products. Penn. Agr. Exp. Sta. Bul. 412. 1941.

21. Triebold, H. O. Quantitative Analysis with Applications to Agricultural and Food Products. 3rd. printing. New York: D. Van Norstrand Co., Inc., 1949.

22. Troy, H. C. A Cheese Moisture Test. Cornell Agr. Ext. Bul. 17. 1917.

23. Turnbow, G. D., Tracy, P. H., and Raffetto, L. A. The Ice Cream Industry. 2nd. ed. New York: John Wiley and Sons Inc., 1947.

24. Wilster, G. H., Price, W. V., Morris, A. J., Goss, E. F., and Sanders, G. P. Determination of Fat, Moisture, and Salt in Hard Cheese. J. Dairy Sci., 20:27-30. 1937.

25. Wilster, G. H. Practical Cheddar Cheese Manufacture and Cheese Technology. 6th ed. Corvallis, Ore.: O.S.C. Cooperative Assn., 1949.

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