CHEMICAL DEODORIZATION OF CREAM FOR BUTTERMAKING

by

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INTRODUCTION

In 1928 Kansas produced more than 55 million pounds of creamery butter and placed 11th among all states in the production of this commodity (18). Although the production of cream in this section has increased at a very rapid rate, the improvement in quality has been somewhat slower. Educational work among dairymen has aided materially in raising the average quality of the cream produced, but there are at certain seasons rather large quantities of off-flavored cream placed on the market.

There are several reasons for the production of this poor quality product. The prevalent systems of cream procurement necessitate a considerable lapse of time between the production and actual churning process. Many farmers engage in dairying only as a side line and are not particularly interested or well informed in the production of high quality cream. Climatic conditions in Kansas are not as ideal for dairying as in some of the northern states. The average mean temperature for a 40 year period in Kansas was 54.6°F. while in Minnesota, for instance, it was 41.4°F. (19).

It is not uncommon to find cream containing flavors described as onion, oily, weedy and others which are readily carried into the butter. Creameries have resorted to various practices and processes in an attempt to eliminate or

minimize the effect of these flavors on the finished product. Among the best known of these are the Pfaudlerizer treatment, heating cream under reduced pressure, churning in an atmosphere of carbon dioxide and more recently the use of mineral oils to absorb the off-flavors from butter fat. Some of them are widely used but many have been discarded because of expense, labor and time involved or lack of benefit derived from the treatment.

Treating off-flavored cream with chlorine chemical deodorants is quite common in certain sections of the Middle West. These compounds have a rather high percentage of available chlorine, which is liberated when they come in contact with organic material. Nascent oxygen, produced by the reaction between chlorine and water is thought to unite with or drive off certain compounds in the cream which are responsible for the undesirable flavor.

There has been little data published relative to the value of this practice. Since many inquiries have been made at different dairy departments relative to its merits, there appears to be a real need for accurate information on this subject.

The purpose of this experiment was to determine what benefits, if any, were derived from the chemical deodorization of cream for butter making. Investigations were made

to determine the effect of chlorination on the flavor, odor and microbial content of cream and resultant butter. The effect of this treatment on the body, texture, color, healthfulness and vitamin A content of butter was also studied. Several chlorine compounds were compared in various amounts and dilutions and attempts were made to devise a method for detecting butter made from chlorinated cream.

REVIEW OF LITERATURE

The addition of chemical deodorants to cream prior to churning is a violation of the pure food laws in many states. While it is a quite common procedure, there has been little data published on the methods or value of the practice.

Hunziker (5) dismisses the topic by stating, "there are disinfectants and antiseptics that have the property of eliminating or partly eliminating off-flavors from cream. To this class belong some of the chlorine products and particularly those of the chloramine T type. The use of these chemicals is obviously objectionable and is contrary to the intent and purpose of the Federal Pure Food Laws. Their use is illegal. They are, therefore, not recommended or further discussed."

Reid and Rinehart (11) state that the only real remedy for off-flavored cream is to improve the conditions at the

source of production. The data acquired in their investigation indicate that the intensity of the off-flavor largely determines the success of the use of chemical deodorants in cream in improving the flavor score of the resultant butter. The average improvement from this practice being 1 to 2 points. Five different deodorants were used in their experiment, most of which proved satisfactory in removing the off-flavor of cream, but a chemical flavor resulted in certain cases which was considered objectionable. These investigators further state that only flavors volatilizable by heat responded to the treatment of chemical deodorizers. They recommend from an economical point of view adding the deodorant prior to neutralization, at a temperature of 80 to 90°F. The different deodorants proved equally efficient in reducing the bacteria, yeast and mold counts of the butter.

The bactericidal effect of chlorine compounds on milk and its products has been given considerable attention. Investigations were conducted by Tilley (17) comparing the germicidal value of different chlorine compounds. Chloramine T, sodium hypochlorite, hydrogen hypochlorite and chlorine were used. Compared on a basis of weight, the first is least effective. By available chlorine it may be more or less effective depending on the organism treated.

Chloramine T is very effective against Staphylococcus aurens and ineffective in treating Bacillus pyocyaneus. Bacillus tuberculosis organisms are very slightly affected by chlorine disinfectants. Addition of ammonia greatly increases germicidal activity and prevents depreciation of the solution in presence of organic matter.

Hale and Bleecker (4) state that active chlorine acts as a germicide in milk and ice cream with reduction in the numbers of bacteria in general proportional to the amount of active chlorine present. Chlorine water gave as satisfactory results in 45 minutes as sodium hypochlorite did in 90 minutes, or calcium hypochlorite did in 19 hours. The chlorine water could be used in higher concentrations than the other two without affecting the flavor of the product. It was concluded from this study that the action of the chlorine takes place soon after its addition. In every case the counts made on cream one half hour after treatment were lower than those made after two hours.

Tonney, Greer, and Leibig (16) divide bacteria into two groups from the standpoint of resistance to chlorine; vegetative cells and spore bearing organisms. The former was less resistant to the disinfectant in all types studied and with the exception of tubercle bacillus were killed by exposure to 0.15 to 0.25 p.p.m. available chlorine solution

for 15 to 30 seconds.

The chlorine death point of spore formers ranged from 2.5 to 280 p.p.m., 160 was considered an index of usual amounts necessary. The experiments were conducted to exclude as nearly as possible chlorine absorbing factors other than the organisms.

Davis (1) found that preparations containing sodium hypochlorite will not materially reduce the bacterial counts in milk when used in concentrations as high as 1: 5,000 available chlorine. When used in dilutions of 1: 20,000 the taste and odor of chlorine may be detected and is very noticeable in concentrations of 1: 10,000.

He concludes that the unpleasant taste and odor produced when sodium hypochlorite is added to milk in sufficient quantities to act as a preservative renders its use impracticable.

Grunwold and Bass (3) say that chloramine T is a mixture of sodium salt, amid of phospho-toluene, sulfonic acid and hydrogen hypochlorite, combining 12.4 per cent active oxidizing chlorine. When this material is injected intravenously it is highly toxic, when absorbed slowly through the alimentary tract it is comparatively harmless.

Levine, Toluose, Peterson and Buchanan (8) found that a standard hypochlorite solution in distilled water suffered practically no loss, while with the addition of 1 per cent

corn sugar there was a drop of about 67 per cent in the available chlorine in one hour. The addition of 1 per cent sodium hydroxide, tri-sodium phosphate or calcium hydroxide was found to make sodium hypochlorite much more stable in the presence of metals. The organic chlorine containing sterilizers, as chloramine T, are unusually stable. According to Leach (7), the activity of the chloramine compounds is greatly decreased by a slight increase in alkalinity.

Read and Hale (10) fed liberal quantities of fresh milk chlorinated at the rate of 66 to 330 p.p.m. to different groups of albino rats. This trial was continued for a period of 10 months with no apparent detrimental effects.

Quam and Quam (9) compared the stability of some common sterilizers in the presence of milk. Solutions containing 200 parts per million available chlorine of the following compounds were prepared: chloramine T, sodium hypochlorite, sodium hypochlorite made alkaline with sodium hydroxide and a mixture of sodium hypochlorite and tri-sodium phosphate. Milk was added at the rate of 0.2 per cent by volume and the loss in available chlorine was calculated at different temperatures and after different periods of time. In all cases the rate of increasing deterioration of the four materials was in the order named.

Steinbock, Boutwell and Kent (15) were the first to show partial destruction of vitamin A in butter. This was

effected by treating with stearin, carbonated water and air. Drummond and Coward (2) reported that the destruction of vitamin A took place rapidly at high temperature and when exposed to air extensively considerable destruction was noted at 37°C.

McCollum, Simmons and Bleecker as reported by Jones (6) Stated that xeropthalmia was found in rats on a diet containing butter which had been mixed in the diet 6 to 7 weeks. Oxidation aided by iron sulphate was given as explanation by Jones (6) for the vitamin deficiency.

The technique for quantitative determination of vitamin A in food products was outlined by Sherman and Munsell (14). Their methods, including the basal vitamin A free diet, were used in the rat feeding experiment. The amount of butter necessary to supply the minimum vitamin A requirements of Albino rats is given by Sherman (13).

EXPERIMENTAL

Plan of Experiment

The general plan of the experiment included the following major parts:

1. A study to determine the effect of chlorinating cream on:
   a. Its flavor and odor.
   b. The flavor and odor of the resultant butter,

including a comparison of several deodorants added in various amounts and at different points in the manufacturing process.

c. The body, texture, color and keeping qualities of the resultant butter.

2. A study of the germicidal effect of chemical deodorants on cream and butter.

3. An attempt to devise a method of detecting butter made from chlorinated cream.

4. A study to determine the effect of chlorinating cream on the vitamin A content of the resultant butter.

Materials and Procedure

Deodorants Used. The chlorine compounds used in this experiment were freshly prepared at frequent intervals in water solutions and used throughout the experiment in the following concentrations:

Chloramine-T.....	1.8%	available chlorine
Sodium hypochlorite.....	2.8%	" "
Sodium hypochlorite and alkaline sodium phosphate.....	1.3%	" "
Calcium hypochlorite.....	3.0%	" "

Seledtion of Cream. For preliminary studies and churnings made on laboratory scale, samples of cream with

typical off-flavors were selected from that purchased by the college creamery from a Manhattan cream station. Off-flavors most commonly encountered were: weedy, feed, cowy, yeasty, musty and stale. Onion, oily and silage flavors were artifically produced in several lots of sweet cream.

Cream treated and churned on a commercial scale was the usual run received at the Washington County Cooperative Creamery and the College Creamery.

Method of Treatment. Water solutions of the deodorants were added to the cream at the rate of 2 to 5 pints per 1000 pounds of cream. This rate of treatment will yield 70 to 180 p.p.m. available chlorine. Most samples were chlorinated at the rate of 75 to 95 p.p.m., depending on the degree of off-flavor and concentration of the particular solution. The Monsanto Chemical Company recommend from 1.5 to 3 pints of a solution of chloramine-T, containing 1.9 per cent available chlorine, per 1000 pounds of cream. The degree of acidity in the cream being used as a basis for determining the amount of the deodorant to add.

A few samples of cream were treated excessively (at the rate of 400 to 720 p.p.m.) to study the effect of a high concentration of chlorine on the resulting butter. The scores of these samples were not included in the general averages.

Study of the Effect of Chlorination on the Flavor and Odor of Cream

Several lots of off-flavored cream were split into 7 samples each. Six of these were treated with varying amounts of chemical deodorant and the seventh sample used as a check in all lots. The rate of treatment varied from 18 to 320 p.p.m. available chlorine. Three peoples tasted this cream within 30 minutes after treating and their individual placings were recorded.

A more thorough study was made of this phase of the problem on cream that was chlorinated with different deodorants before neutralization, then processed in the usual manner and scored by three judges just prior to churning. Fifteen lots of cream used in this trial were divided into 4 samples each, one sample being used as a check and the remaining three were each treated with a different deodorant. This cream was chlorinated at the rate of 75 to 95 p.p.m.

Effect of Time of Adding Deodorant on the Flavor and Odor of Butter. Three points in the prodessing of the cream were selected for adding deodorant and the churnings were divided into three corresponding series. In one series of experiments it was added to the cream before standardizing the acid, in another it was added after the acid was reduced and in the third series it was added just prior to churning.

Study of the Effect of Chlorination on the Flavor and Odor of Cream

Several lots of off-flavored cream were split into 7 samples each. Six of these were treated with varying amounts of chemical deodorant and the seventh sample used as a check in all lots. The rate of treatment varied from 18 to 380 p.p.m. available chlorine. Three peoples tasted this cream within 30 minutes after treating and their individual placings were recorded.

A more thorough study was made of this phase of the problem on cream that was chlorinated with different deodorants before neutralization, then processed in the usual manner and scored by three judges just prior to churning. Fifteen lots of cream used in this trial were divided into 4 samples each, one sample being used as a check and the remaining three were each treated with a different deodorant. This cream was chlorinated at the rate of 75 to 95 p.p.m.

Effect of Time of Adding Deodorant on the Flavor and Odor of Butter. Three points in the processing of the cream were selected for adding deodorant and the churnings were divided into three corresponding series. In one series of experiments it was added to the cream before standardizing the acid, in another it was added after the acid was reduced and in the third series it was added just prior to churning.

An untreated sample of each lot of cream was churned and used as a check.

Processing the Cream. The usual plant processes were followed as nearly as possible in pasteurizing, neutralizing and preparing all lots of cream for churning. The cream churned on a commercial scale was all neutralized to about .25 per cent acid with Allwood Lime (calcium oxide and magnesium oxide). The vat system of pasteurization was used in all cases. The cream was held below 110°F. for 30 minutes after the neutralizing material had been added, then heated to 150°F. and held for 30 minutes at that temperature. Cold water circulated through the coils cooled the cream to about 80°F. and brine was used to complete the cooling to at least 40°F.

Time and expense involved in churning large lots of cream made it necessary to carry on a considerable portion of the work on a laboratory scale. One quart samples of cream with suitable checks were processed as nearly similar to the larger lots of cream as possible. Pasteurization was effected in pails immersed in a hot water bath. The temperatures employed were the same as those used for the larger lots of cream. The cream was cooled quite rapidly by the use of a cold water bath and ice and salt.

All samples were held at 40°F. or lower for at least 2 hours prior to churning.

Churning. More than 125 churnings were made, 14 of them on a commercial scale and remainder in a 4 quart Dazey churn. The butter was washed, salted at the rate of approximately 2 per cent and in case of the small samples the working process was carried out in a parchment lined container.

The churning temperatures used varied from 45 to 54°F. The lower limit being more nearly approximated for the large churnings. The average for those made on a laboratory scale being about 50°F.

The average time required for churning the one quart samples was about 12 minutes as compared to 40 minutes for those made on a commercial basis.

Storing the Butter Samples. Duplicate samples of each churning were placed in half pint Sealright containers and stored at 0° and 40°F. The method of treatment, date and sample number was written on each container as well as being recorded in the record book.

Scoring. The butter held at 40°F. was scored fresh and at 15 day intervals until it had deteriorated to a point where no further information could be gained by continued scorings. Samples held at 0°F. were scored at 30, 60 and 90 day intervals. The scores used in interpreting all results and compiling tables are the averages of three judges.

Variations in color, body or texture of all samples of butter were also noted.

Microbiological Analysis of Treated Cream and Butter

The standard plate method was used in making all microbial counts. Platings for bacteria were made on milk powder agar standardized to pH7. This material was used to indicate the relative numbers of proteolitic organisms present. A clear ring is formed, in the cloudy media, around each colony of protein spliting organisms. Whey agar standardized to pH3.5 was used for yeast and mold counts.

As a preliminary study several lots of cream were split into seven 100 cc. samples each and placed in sterile bottles. Six of each lot were treated with varying amounts of chlorine, the seventh sample was used as a check. All samples were plated within 2 hours after treating for bacteria, yeasts and molds. These lots of cream were chlorinated in amounts varying from 18 to 5720 p.p.m. About 200 p.p.m. was used as an upper limit for most samples. The plates for yeast and mold counts were held at room temperature for 2 to 4 days prior to counting. Incubation temperature of 37°C for 2 days was used for badteria plates.

Four additional lots of cream were divided into 2 samples each, one of each pair was treated with a definite amount of chlorine, and the other used as a check. Small

samples of these were placed in sterile bottles and plated for bacteria, yeasts and molds immediately after treating and again after 1, 2, 9 and 16 days. The different lots of cream were churned and the butter plated at the same intervals as in case of the cream. All samples were held at 35 to 40°F during the entire period and were removed only during the time necessary to make the dilutions for plating.

Detection of Butter Made from Treated Cream

Since butter fat contains a rather high percentage of unsaturated fatty acid, principally oleic, it was thought that the iodine number might be materially reduced in chlorinated butter. The theory being that free chlorine would become attached to the carbon chain at the double bonded carbon atom. The iodine numbers were taken on butter made from treated and untreated portions of the same lots of cream.

Further work was conducted on the acetyl values of chlorinated butter. This test measures the number of hydroxyl groups in a fat or oil, and if some of the hydrogen atoms should be displaced by chlorine the resulting acetyl number would be altered.

Rupp's hypochlorite test (12) is essentially a test for the detection of chlorine in chemical union with the proteins of milk. Free chlorine readily unites with the pro-

tein molecule, particularly casein, and since butter contains about 1 per cent protein material, a modification of Rupp's test was devised and applied to the curd contained in butter.

About 5 grams of the sample of butter in question was placed in a test tube and melted by emersing in a warm water bath (125 to 140°F.). The moisture and curd will settle to the bottom and may be pipetted into a clean test tube. The water bath should not be over 150°F. to insure a complete settling of the curd. It may be necessary to add about 1 cc. of distilled water in some cases.

The usual starch iodine test is then applied to the protein material. Add 1-2 cc. of a 10 per cent solution of potassium iodide, shake and add 3-4 cc. hydrochloric acid (diluted 1 : 2). The test tube is then placed in a warm water bath for a few minutes and 1 cc. of a 1 per cent starch solution is added. The appearance of a purple or reddish color indicates the presence of chlorine.

A Study of the Healthfulness and Vitamin A Content of Butter Made from Chlorinated Cream

It has been proven that vitamin A is quite easily destroyed by oxidation, this is particularly true of the vitamin from animal sources. Since chlorine is a strong

oxidizing agent it is thought that a part or all the vitamin A may be destroyed by the deodorization process. Butter is one of our most important sources of this vitamin and it is essential to learn of any process that may cause its destruction.

Feeding trials with albino rats are being made to determine whether or not vitamin A is actually destroyed by chlorination. In this study the curative method of vitamin A assay was used. The procedure was essentially the same as that employed by Sherman and Munsell (14), namely: young albino rats, 4 weeks of age and weighing between 35 and 55 grams, were placed on a basal vitamin A free diet until the vitamin A stored in the animal tissues was depleted. They were then placed on the test feed.

Experiments made by the college Home Economics department have shown better results when the per cent of yeast in the Sherman-Munsell ration was doubled at the expense of the commercial starch. This revised ration is composed of the following:

Casein(triple extracted with 95% ethyl alcohol....20%
Corn Starch.....65%
Dried Yeast.....10%
Osborn and Mendel Salt..... 4%
Sodium Chloride..... 1%

Vitamin D was supplied in this diet by irradiation. Vitamin A was removed from the casein by refluxing in 95 per cent ethyl alcohol.

The purpose of the fore period in the feeding experiment is to deplete the animals store of vitamin A. It was considered to be ended when the rat failed to gain for one week or when xerophthalmia had developed. This usually required 4 to 6 weeks. Rats from the same litters, numbering 6 to 8, were placed together during this period in wire cages with raised wire floors. Records were kept of the amount of the basal diet used weekly and weights of individual animals were recorded at first weekly and then daily toward the end of the period.

The test period for each rat began as soon as the fore period ended and lasted 8 weeks. Weekly records were made of the basal diet and butter eaten and the gain or loss in weight of the rats.

Three samples of butter made from the same lot of cream were used throughout the experiment. Sample 1 was made from an untreated portion of the cream. Samples 2 and 3 were made from portions of the cream treated at the rate of 30 and 210 p.p.m. available chlorine respectively.

The rats were divided into 5 groups of approximately 10 each and placed in individual wire cages. Rats in group 1 received .050 grams of butter daily as their only source

of vitamin A. Those in group 2 and 3 received a similar amount of the butter from treated samples 2 and 3. Rats in group 4 received no butter, while the ration of group 5 was supplemented with 10 per cent untreated butter. The unit of vitamin A used was that established by Sherman (13).

If the animals were still alive at the end of the test period, they were killed with ether and autopsied. Autopsies were also made on animals that died before the end of the test period. The general condition of the rats, including condition of the bladder, kidneys, lungs and the presence or absence of puss under the tongue, together with the loss or gain in weight were used as a measure of the potency of the various samples of butter in vitamin A.

DISCUSSION AND RESULTS

Effect of Chlorination on the Flavor and Odor of Cream

Cream that was chlorinated and tasted prior to pasteurization had in most cases a decided chlorine flavor. When the concentration exceeded 50 p.p.m. this flavor obliterated other undesirable flavors in the cream. The judges disagreed as to which of the two was the more objectionable. Samples that were treated with less than 40 to 45 p.p.m. could not be distinguished from the untreated sample. The

flavor of cream treated in excess of 100 p.p.m. was considered quite objectionable.

Further tests were made on cream that was treated at the rate of 75 to 95 p.p.m. available chlorine, then processed in the usual manner and scored just prior to churning. From a flavor and odor standpoint three judges preferred the untreated samples in 54.4 per cent of the trials.

A chemical flavor was noted in some of the chlorinated samples, particularly those treated with the sodium hypochlorite compounds. Chloramine-T and calcium hypochlorite were considered slightly less objectionable from this standpoint.

Some Effects of Chlorination on the Quality of the Resulting Butter

Time of adding the Deodorant. Series A included 45 churnings, made from cream treated with the deodorizing material prior to standardizing the acid. Butter made from cream treated after the acid was reduced shall be designated as series B and included 25 churnings. Series C included butter from 6 lots of cream treated just prior to churning.

The butter made from chlorinated cream was scored comparatively with butter made from untreated portion of the same lot of cream. The average scores of the butter made from the various methods of treatment are shown in Table I.

These scores represent the averages of three judges and were all made on butter held at 40°F. This temperature was used to allow any flavor defects that might develop to do so in a comparatively short time.

Table I

Showing Comparative Scores of Butter made from Cream Treated at Different Points in the Manufacturing Process and Stored at 40°F.

Sample	fresh	15 days	30 days	45 days	60 days
Series A					
Untreated	88.33	87.50	85.52	85.65	86.15
Treated	88.00	87.30	84.40	85.60	86.15
No. of Churnings	45	43	43	13	7
Series B					
Untreated	86.67	86.52	86.55		
Treated	86.23	86.23	86.50		
No. of Churnings	25	25	25		
Series C					
Untreated	91.00	90.75	89.80	88.17	88.00
Treated	90.86	90.66	89.70	88.07	87.50
No. of Churnings	6	6	6	6	5
All Samples					
Untreated	88.11	87.51	86.21	86.49	86.83
Treated	87.76	87.36	86.11	86.42	86.41
No. of Churnings	76	74	74	19	12

Series A-Butter from cream treated prior to neutralization
" B- " " " " after neutralization
" C- " " " " just prior to churning.

Fewer numbers of butter samples were held at 0°F. for the 90 day period than were held at 40°F. for the necessary period. Table II presents the average scores of all butter held at this lower temperature.

Table II

Showing Comparative Scores of Butter made from treated and Untreated Cream and Stored at 0°F.

Sample	Fresh	30 days	60 days	90 days
Untreated	87.65	88.14	88.13	88.19
Treated	87.19	87.48	87.23	87.77
No. of Churnings:	58	38	30	20

The results of this study disagree with those of Reid and Rinehart (11), who report a 1 to 2 point increase in flavor score of butter made from treated cream. In practically all cases the average scores of the untreated or check samples are slightly higher than those of the butter made from treated cream. The first 4 scoring periods in series A show differences between the treated and check samples of .33, .20, .12 and .05 of a point respectively in favor of the butter made from untreated cream. The average scores at the 5th period was the same for both the treated and untreated butter. Since the poorer lots of butter were discarded before the 4th scoring, a higher average score for the last two periods resulted.

The three scorings available on series B show average differences between treated and untreated butter of .44, .39 and .05 of a point in favor of the check samples.

Series C scores higher than A and B but a similar variation between the average scores of the treated and untreated butter is noted. The check sample averaged .14, .09, .10, .10 and .50 higher at each scoring than the samples

made from treated cream.

From these experiments the time of adding the deodorant seems to be immaterial. However, in plant practices it is generally recommended that the deodorant be added to the cold cream prior to the standardization of the acid. The cream used in these three trials varied considerably in quality. The deodorant did not show up to any better advantage in the poor than it did in the higher quality product.

It may be noted that the average scores of all butter made from untreated cream, including more than 70 churnings, are slightly higher at each scoring than those from treated portion of the same lot of cream. The variations between the average scores at the different periods being .35, .15, .11, .07 and .42 of a point in favor of the check samples.

While the rate of deterioration is less rapid in butter held at 0°F., A similar variation is noted between the average scores of the treated and untreated samples. The slight margin was in favor of check samples in all cases. The average scores of the butter at the second and third scoring periods were higher than they were on the fresh butter, this may be explained by the fact that the percentage of butter made from comparatively high quality cream was greater in the samples scored at the last two periods.

Comparison of different Deodorants. Seventeen churnings were made in which chloramine-T was compared with sodium hypochlorite. In 7 of the trials calcium hypochlorite was used and in 4 churnings a mixture of sodium hypochlorite and alkaline sodium phosphate was included. For the purpose of making comparisons the samples treated with the various deodorants were compared with their respective checks.

These churnings were all made on a laboratory scale. The deodorizing solutions were calculated in cubic centimeters to yield 75 to 95 p.p.m. available chlorine, varying with the degree of off-flavor present. Table III presents the average scores of butter treated with the various deodorants.

Table III

Showing Comparative Scores of Butter Made from Cream Treated with Different Deodorants

Sample	Rate of Treatment*	No. of Churnings	Fresh	After 15 days	After 30 days
Untreated	None	17	87.12	86.38	85.68
Chloramine-T	72-96	17	86.73	86.04	85.35
Sodium Hypochlorite	75-93	16	86.13	85.98	85.12
Untreated	None	7	86.40	86.30	86.40
Calcium Hypochlorite	76-96	7	85.93	86.39	86.21
Untreated	None	4	88.74	85.56	85.00
Sodium Hypochlorite**	70-87	4	87.65	85.45	84.75
Aver. untreated samples			87.33	86.13	85.67
Aver. treated samples			86.65	86.96	85.36

*Calculated parts per million available chlorine in the cream

** Contains a mixture of sodium hypochlorite and tri-sodium phosphate.

Table III shows higher average scores for the butter made from untreated cream in all groups. The difference in scores between the treated and untreated samples was least in the case of those treated with calcium hypochlorite. The check samples placed .47, .11 and .19 of a point higher at the different scorings than the treated butter. The samples treated with chloramine-T varied from their respective checks by .39, .34 and .33. Butter treated with the deodorant containing a mixture of sodium hypochlorite and trisodium phosphate showed 1.09, .11 and .25 of a point lower average scores than that made from the untreated cream. The greatest variation is noted between the treated and untreated samples in case of the sodium hypochlorite group. The untreated samples have .99, .40 and .56 higher average scores at the different scorings than those made from treated cream.

Effect of Chlorination on the Keeping Quality of Butter. From the comparative scores of all groups of treated and untreated butter, it is evident that the chlorination of cream had no effect on the rate of deterioration of the resultant butter. The untreated or check samples maintained their slight advantage at all scoring periods.

Effect of Chemical Deodorants on the Body and Texture of Butter. There was no apparent variation in body and texture between the butter made from treated and untreated cream.

Effect of Excessive Treatment. While the normal rate of treatment produced no apparent change in the color of the butter, samples made from cream treated at the rate of 400 to 720 p.p.m. available chlorine were decidedly bleached. Chlorine could be tasted in these samples while fresh, but this disappeared after 1 to 5 days in storage. The persistence of the chlorine flavor seemed to be in direct proportion to the amount of the deodorizing material added. A tallowy flavor soon developed in this excessively treated butter, its appearance was noted at the end of one weeks storage in some samples.

Effect of Chlorination on the Microbial Content of Cream and Butter

The microbiological analysis of chlorinated cream and butter was divided into two parts: preliminary studies made on treated cream only and studies on the microbial content of treated cream and the resultant butter plated fresh and after storage for different periods of time.

A total of 24 samples of treated cream with suitable checks were included in the preliminary study. These samples were plated within 2 hours after treating for bacteria, yeast and mold counts. The second phase of the study included 4 duplicate samples of cream and butter. One sample was treated at the lowest rate found to be effective in reducing microbial counts in cream. The other three were

chlorinated at the rate commonly used throughout the experiment (70 to 80 p.p.m.). Table IV and Graphs I to IV present the average microbial counts on the samples included in the second phase of this work.

Table IV

Showing Germicidal Effects of Chemical Deodorants on Cream and Butter

Part 1 Cream

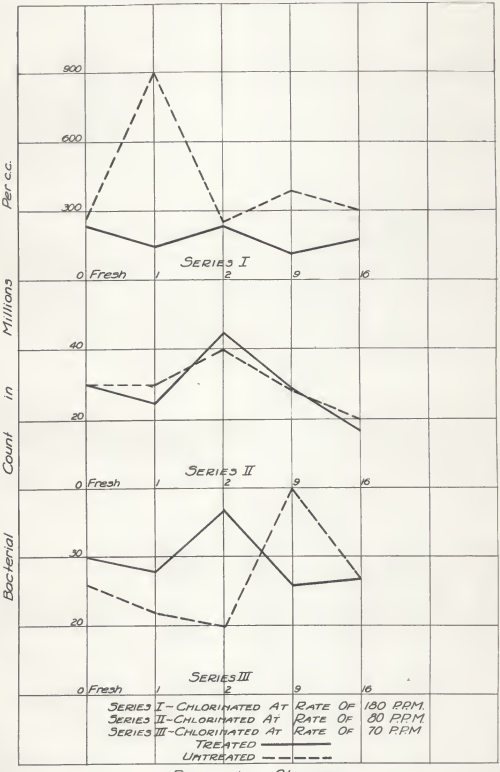
Rate of Treatment*	Effect of Chlorination on Bacteria Counts less than: Time between Treating and Plating 1 hour	1 day	2 days	9 days	15 days
180	240 **	150	250	120	180
None	270	900	265	480	300
80	30	25	45	30	17
None	30	30	40	29	20
	Yeast and Mold Counts				
180	50	30	50	50	Thickly Seeded
None	57	110	38	25	"
80	70	160	65	165	100
None	60	180	105	125	150
70	30,000	20,000	22,000	35,000	40,000
None	60,000	10,000	20,000	42,000	36,000

Part 2 Butter

	Bacterial Count				
180			2,000	500	600
None			2,000	6,000	3,000
80	40,000	125,000	100,000	140,000	50,000
None	30,000	270,000	250,000	260,000	200,000
70	17,000	27,000	24,000	21,000	78,000
None	27,000	34,000	25,000	15,000	43,000
	Yeast and Mold Counts				
180	500	10	20	30	30
None	50				
80	55	5	18	30	35
None	60	10	5	80	50
70		520	520	520	190
None		500	250	10	160

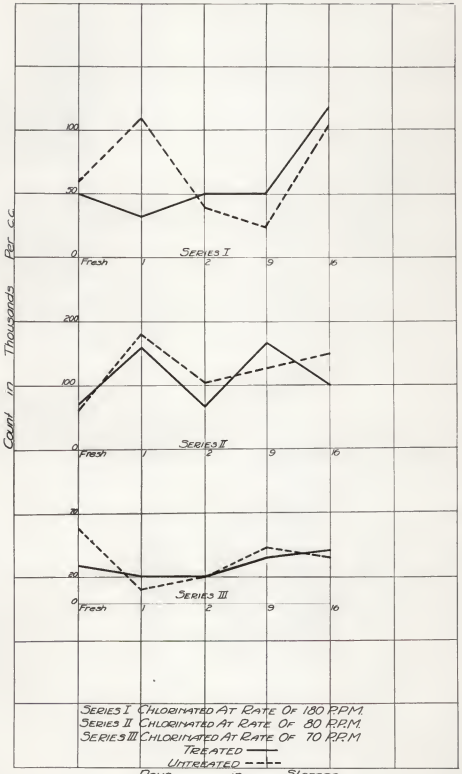
*Treatment in parts per million available chlorine in cream
**Counts in million per cc. for bacteria in the cream samples

GRAPH I
SHOWING EFFECT OF CHLORINATION
ON BACTERIAL COUNT OF CREAM



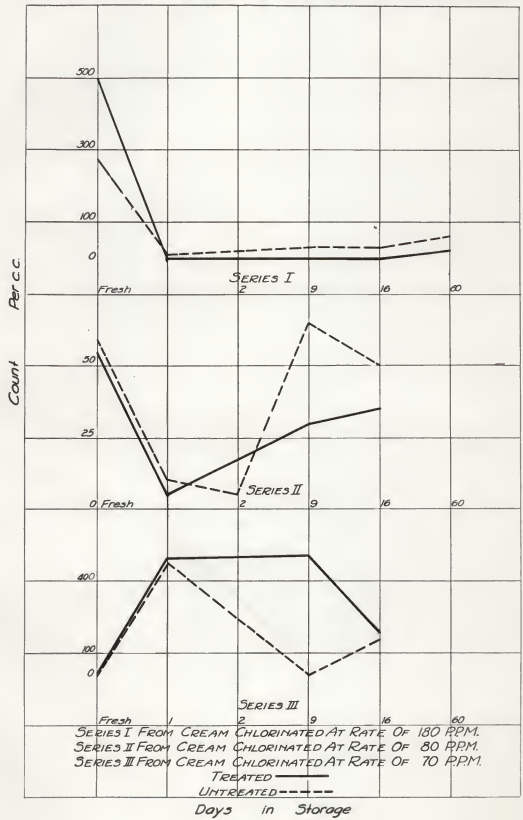
GRAPH II

SHOWING EFFECT OF CHLORINATION ON YEAST AND MOLD CONTENT OF CREAM



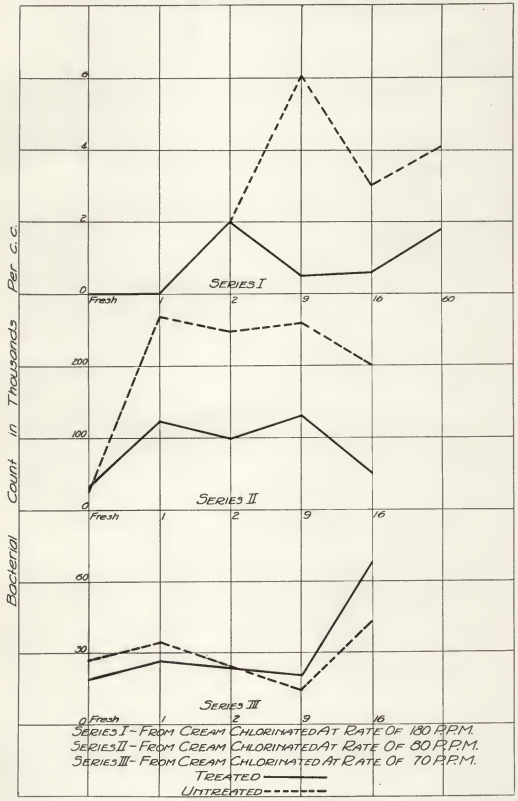
GRAPH III

SHOWING THE EFFECT OF CHLORINATING CREAM ON THE DEVELOPEMENT OF YEAST & MOLDS IN STORED BUTTER



GRAPH IV

SHOWING EFFECT OF CHLORINATION ON DEVELOPMENT OF BACTERIA IN STORED BUTTER



The results of this trial do not agree with those of Hale and Bleecker (4) in their studies on the bactericidal effect of chlorine in milk. They reported some reduction in numbers of bacteria in milk chlorinated at the rate of 10 p.p.m. While the two experiments are not exactly comparable from the standpoint of the product chlorinated, the free chlorine should be more active in the cream than in milk as the cream contains a lower percentage of protein material.

In this experiment no germicidal action could be demonstrated when less than 180 p.p.m. available chlorine were added to the cream. These results are more nearly in accord with those of Davis (1) who states that no material reduction was effected in milk chlorinated at the rate of 200 p.p.m. This is considerable higher than the normal rate of treatment.

A few samples were chlorinated excessively to determine the approximate concentration necessary to cause complete destruction of the microbial flora in cream. The highest concentration used in this trial (5720 p.p.m.) did not produce a sterile product. The bacteria that appeared to be most resistant formed a round, medium sized surface growing colony. The characteristic peach seed colony of S. lacticus appeared to be absent in the plates made from this

highly chlorinated cream.

There was a greater proportional reduction in the microbial content of stored butter made from cream treated at the rate of 180 p.p.m. available chlorine than in the cream treated at the same rate. Bactericidal action of the chlorine was noted after 7 days in one sample of butter made from cream treated at the rate of 80 p.p.m. There was no noticeable change in the microbial content of butter made from cream treated with 70 parts per million available chlorine.

Results of Trials to Determine a Method of Detecting Butter Made from Chlorinated Cream

The iodine number determinations made on butter from treated and untreated portions of the same lot of cream showed no significant variations. The first trial gave 36,95 for the treated and 37.07 for the chlorinated butter. Further tests were made and the slight variation was in the opposite direction, i.e., the treated sample gave a higher iodine value.

This same condition was found to be true in case of the acetyl values. The results of 8 determinations gave acetyl numbers varying from 9 to 35. The variation between any two samples from the same lot of cream were not this wide but

no consistent difference between treated and untreated samples could be expected.

The modification of Rupp's hypochlorite test appears to be satisfactory for detecting butter made from chlorinated cream. This is rather a delicate test but if carefully applied, the color change produced is very evident. It was necessary in some cases to warm the solution slightly to hasten the reaction.

The curd from all samples of treated butter that were in good condition readily gave the iodine starch color reaction. This test is, however, not effective when applied to rancid, stale butter, as a color change was produced under such conditions by both treated and untreated samples. This is probably due to certain materials present which may react with potassium iodide liberating free iodine.

Healthfulness and Vitamin A Studies on Butter Made from Chlorinated Cream

The groups of rats used at the beginning of this study were placed on too low a level of butter. The daily allowance was .039 grams per animal. These groups continued to show marked vitamin A deficiency in all cases and began dying after six weeks.

A second lot was placed on a slightly higher level, .050 grams per day. Since an 8 week test period is necessa-

ry to determine the potency of a feed in vitamin A. Only one half of this time has elapsed since the trial began, so no conclusions can be drawn at this time.

EXPERIMENTAL SUMMARY

1. Samples of off-flavored cream were treated with chlorine chemical deodorants and scored comparatively with their respective checks. Other samples were treated similarly, but were scored after neutralizing, pasteurizing and cooling the cream.

2. More than 125 churnings were made for the purpose of comparing butter made from treated and untreated cream. Three points in the processing of the cream were selected for the adding of the deodorant. In one series of experiments, it was added before standardizing the acid, in another it was added after the acid was reduced and in the third series, the deodorant was added just prior to churning.

3. Chloramine-T, sodium hypochlorite, calcium hypochlorite and a mixture of sodium hypochlorite and alkaline sodium phosphate were compared on the basis of their value as a deodorizing material in cream. Butter made from cream treated with the various deodorants was scored comparatively with the respective checks.

4. Note was made throughout the experiment of the rate of deterioration of butter made from treated and untreated cream. The effect of chlorination on the body and texture of butter was also studied.

5. A few samples of cream were treated excessively (400 to 720 p.p.m.) to determine the effect of high concentrations of chlorine on the resulting butter.

6. Microbiological analysis was made on samples of cream and butter that were treated with definite amounts of available chlorine. Platings were made of the fresh products and after storage for different periods of time.

7. Investigations were made to devise some method of detecting butter made from chlorinated cream. Iodine and acetyl number determinations were made on samples of butter from treated and untreated portions of the same lots of cream. A modified method of Rupp's hypochlorite test was applied to the protein material contained in butter.

8. It is thought that a portion of all the vitamin A in butter may be destroyed by the chlorination process. Feeding trials are now in progress with albino rats to determine whether or not this theory is true.

CONCLUSIONS

1. Off-flavored cream containing a chemical deodorant, if tasted prior to pasteurization, had a chlorine flavor

which partially obliterated other objectionable flavors in the cream, but the judges disagreed as to which of the two was the more objectionable. Cream that was chlorinated and processed in the usual manner, showed no improvement in flavor and odor, prior to churning, over the untreated check sample.

2. Comparative scores on butter made from treated and untreated cream indicated no general improvement in flavor from the deodorization process. Time of adding the deodorant seemed to have no influence on the effectiveness of this practice.

3. Variations in scores between the samples treated with different deodorants and their respective checks were not great enough in any case to recommend one type of material over any other.

4. The rate of deterioration was practically the same in butter made from treated and untreated cream.

5. Chlorination does not seem to affect the body and texture of the resulting butter.

6. Chlorine flavor imparted to butter by excessive treatment disappears within 1 to 5 days, but a tallowy flavor soon develops. Butter made from cream treated in excess of 400 p.p.m. available chlorine was decidedly bleached.

7. In amounts commonly used chemical deodorants show

very little germicidal action. About 180 p.p.m. was the minimum concentration at which reduction in microbial counts could be demonstrated in cream. The reduction in the microbial content of stored butter is proportionately greater than in the cream treated at the same rate.

8. Butter made from treated cream may be detected by a modification of Rupp's hypochlorite test.

9. The vitamin A content and healthfulness of butter made from treated cream is being tested by feeding trials with albino rats.

ACKNOWLEDGEMENT

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