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Relationship of various factors to the keeping quality of salted butter when stored for a month at 0-50C.

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NOTE TO USERS

RELATIONSHIP OF VARIOUS FACTORS TO THE KEEPING QUALITY OF SALTED BUTTER WHEN STORED FOR A MONTH AT 0-5°C.

by

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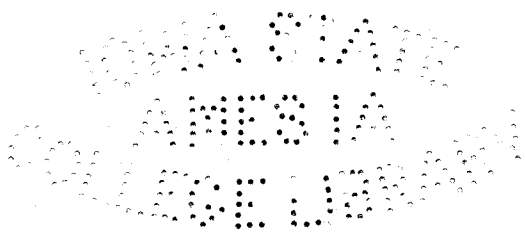

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INTRODUCTION

At ordinary room temperatures, butter is subject to rapid deterioration of flavor through bacterial action, enzymatic action, and purely chemical changes. Usually these are retarded at storage temperatures of -18°C. or lower, because at such temperatures enzymatic action and chemical changes take place very slowly and bacterial action probably is arrested entirely. Considerable amounts of butter produced during the spring and summer months, the period of surplus production, are placed in cold storage at these low temperatures annually in order to take care of reduced production and increased consumption during the fall and winter season. The bulk of the butter produced throughout the year, however, does not enjoy the benefits of such regular cold storage, although at times several weeks may elapse before it is consumed. During this time, while in the hands of manufacturers, wholesalers, retailers, transportation agents, and consumers, it is usually held under comparatively light refrigeration at temperatures somewhat above 0°C. A high keeping quality at these temperatures, therefore, adds materially to the market value of any butter, and manufacturers, as well as buyers of butter, are greatly interested to know the factors which are conducive to high keeping quality at these temperatures, and to find a criterion by means of which this keeping quality can be predicted with a fair degree of accuracy.

The object of this investigation was to study some of the factors

which might be related to the keeping quality of salted butter when held for 1 month at 0-5°C. with a view towards finding a means of foretelling the keeping quality. It probably is impossible to find any single test or observation which could be used to predict definitely the rate of flavor deterioration of a sample of commercial salted butter, even under very specific conditions of storage, because the various chemical and bacterial changes, which are simultaneously taking place in butter, are affected differently by such factors as chemical composition, reaction, and the type and number of microorganisms present. The study reported here, however, should throw some light on a few factors or combinations of factors which have a general bearing on the keeping quality of salted butter, particularly that butter made without the use of butter culture. The factors given consideration in this study were as follows: Organoleptic tests after 1 week at 21°C., bacterial counts, yeast and mold counts, pasteurization temperatures and enzymatic activity, pH values, combinations of pH and salt and salt content alone, acid values of the butter and the butterfat, curd content, and season.

GENERAL CONSIDERATIONS

It was not possible in this investigation to control all of the factors to be studied, but the examination of a large number of samples of similar types of butter received monthly from creameries scattered over the State of Washington gave an opportunity to investigate what might be the most important factors involved in the general trend of the keeping quality of these types of butter. For instance, it was desired to learn, whether the deterioration of salted butter proceeds in the same direction at 0-5°C. as at 21°C., but merely at a reduced rate.

Deterioration of butter, caused by enzymatic action or by purely chemical changes, such as oxidation or hydrolysis of the fat, is no doubt accelerated by an increase in temperature, both within the lower range of storage temperatures and at the higher atmospheric temperatures. Bacterial deterioration, however, at room temperature may differ from that at 0-5°C. not only in speed, but also in kind, because temperature has a selective effect on the bacterial flora, thus permitting one type of organism to predominate at one temperature and another type at a different temperature. It is also possible that at times the action of microorganisms during growth may be in opposition to chemical changes in progress in the butter. Finally, the point at which the activity of an organism ceases entirely, as the temperature is lowered, varies considerably with the type of the organism, and enzymes produced by microorganisms in varying amounts may continue to act at very low temperatures. Nevertheless, since the

temperature spread between 21°C. and 0-5°C. is not extreme, it was thought that various observations made on butter after 1 week at 21°C. might provide a fair index to the keeping quality of the same butter held at 0-5°C. for 1 month. This would be true, especially if chemical and enzymatic action is of greater importance than bacterial action in the deterioration of salted butter.

The presence in butter of yeasts and molds, of proteolytic, lipolytic and other types of bacteria, and of enzymes no doubt has an influence on the keeping quality of butter, providing the conditions for their activity are favorable. It must be remembered, however, that the methods available for enumerating these various organisms in butter give at best only approximate results, and many organisms are no doubt inhibited in their growth by such factors as high salt content, the amount and distribution of moisture present, and many other factors.

The relationship of the pH values and the acid values of butter and butterfat to the keeping quality of the butter at 0-5°C. was studied, because acidity, although not analyzed for its nature, might exert a considerable influence on the speed and direction of bacterial as well as chemical deterioration of salted butter. The optimum pH for microbial, enzymatic, and purely chemical activity, of course, varies with the type of the organism, enzyme, or chemical reaction involved.

Chemical composition itself probably is a factor influencing the keeping quality of butter. Although a knowledge of it alone would be of little value in predicting keeping quality, it might be important when considered in combination with other factors. Thus, various combinations

of pH, salt concentration and curd content of butter might either favorably or adversely affect keeping quality. Finally, since many of the agencies determining keeping quality in butter may vary qualitatively and quantitatively with season, this factor also was given consideration in this study.

REVIEW OF LITERATURE

Organoleptic tests

Because the keeping quality of salted butter is dependent upon many factors, some investigators have sought to predict the keeping quality at one temperature by observing the course of deterioration of the butter during a shorter period of time at a higher temperature. Thus Bouska and Brown (11) found that butter which developed a bad flavor at the low temperatures of regular storage usually showed deterioration within 3 days when stored at 15.6-21°C., while butter of good keeping quality in cold storage still scored fairly high in flavor after 2 weeks at 21°C. They were, however, unable to make reliable predictions on the keeping quality of individual samples of butter.

Jacobsen (62) concluded from bacteriological and organoleptic studies made by him that butter deterioration at 21°C. presaged deterioration at 5°C. and 0°C., but that failure to deteriorate at 21°C. did not insure keeping quality at the lower temperatures. He found a better correlation between the flavor defects developed at 15°C. and lower temperatures than between those appearing at 21°C. and lower temperatures. His work was largely on unsalted butter and on salted butter made with the use of a butter culture.

Guthrie, Scheib and Stark (48) concluded from a study of five series of butter samples that "when all conditions were similar, except the temperature of holding, the quality of all the butters tended to

approach the same level," and that "the rate of spoilage was faster at the higher temperature and slower at the lower temperature." They compared storage temperatures of 5°, 10° and 24°C. Shepard and Olson (113) compared the keeping quality of salted ripened cream butter at 0° and 21°C.; they reported that no pronounced deterioration occurred in the flavor of this butter at either temperature after 14 days. Rogers, Thompson, and Keithley (108) found that deterioration of butter at -18°, -12°, and -7°C. was in a general way directly proportional to the storage temperature. Few investigations seem to be reported comparing flavor deterioration in unripened cream butter held at room temperature and at temperatures near the freezing point of water.

Sutton (124) developed what he called a "bottle test," in which he softened the butter at 40-50°C., emulsified it by shaking, incubated it at 15-20°C., and examined it after 1 and 7 days. From a study of 57 samples of butter he concluded that the test was valuable to supplement both the plate count and practical grading in picking out samples with biological defects. He did not show the correlation of the results of the test with the keeping quality of the butter at a lower temperature.

Minster (76) described a similar test in which the butter was incubated at 37-38°C. and shaken daily. However, he placed less reliance upon this test for predicting keeping quality than upon the catalase and reductase tests and recommended the use of all three tests, together with a bacteriological examination, as a means of forecasting the general keeping quality of butter. Cameron (15) states that the aroma of fresh butter usually is a better indication of keeping

quality than the palate flavor.

Bacterial counts and yeast and mold counts

The total number of microorganisms ordinarily found in salted butter made without butter culture is comparatively small due to the rather effective methods of cream pasteurization in common use today and to the fact that the majority of the organisms surviving pasteurization are left in the buttermilk after churning. Macy, Coulter and Combs (73) in a study of 45 samples of salted butter made without butter culture found that, when fresh, 24.4 per cent of the samples contained less than 1,000 bacteria per ml. and 97.7 per cent contained less than 100,000 per ml. After storage for 1 month at 2°C., 44.4 per cent had less than 1,000 bacteria per ml. and 100 per cent had less than 100,000 per ml. Of 64 samples stored for 9 months at 2°C., 57.8 per cent had bacterial counts of less than 1,000 per ml. and 93.7 per cent less than 100,000 per ml. Mold counts of less than 10 were obtained in 24.5 per cent of the samples when fresh and in 31.1 per cent of the same samples after 1 month at 2°C. When fresh, 97.8 per cent of the samples had mold counts of less than 100 per ml. The yeast counts ran higher than the mold counts, but less than 100 yeasts per ml. were present in 82.2 per cent of the samples when fresh and in 97.7 per cent after 1 month at 2°C. Macy (71) gives similar information for a larger number, 483, of samples of salted butter obtained over a wide area and from many different plants.

Although the above results indicate that the average creamery is

able to produce butter low in bacteria, yeasts, and molds, it is well known that with careless plant operation, faulty equipment, or impure water supplies, butter with a high content of microorganisms may be produced. Fortunately, however, after incorporation into the butter, most microorganisms do not find the conditions for growth favorable in salted butter. Rahn (95) and Rahn and Boysen (96) computed the average size of the moisture droplets and concluded that in well pasteurized sweet cream butter, which was properly worked, about 99 per cent of the total moisture is sterile, because of the much larger number of water droplets than of bacteria in the butter. They state that bacterial growth in butter is greatly restricted by the physical structure of the butter, because the larger water droplets formed by the wash-water contain little food, and the bacteria cannot migrate from water droplet to water droplet in well worked butter.

Many investigators have observed decreases in the bacterial counts of salted butter during storage at temperatures below 10°C. and only slight increases, or even decreases, at temperatures between 10° and 21°C. Such results are indicated above in the discussion of the work of Macy, Coulter and Combs (73). Jacobsen (62) found a marked decrease in the total number of bacteria in salted butter made with and without butter culture after storage for 2-56 days at 0° and 5°C. Salted butter made with butter culture showed a decreased count after 4 and 7 days even at 21°C., although in salted butter made without butter culture there was an increase after 4 and 7 days at 21-26°C. While the total counts of salted butter made with butter culture had decreased after 7 days at 21°C.,

the total counts of the free serum of this butter had increased. Grimes (43) also showed that a larger percentage of the bacteria survived in pasteurized sweet cream butter than in ripened cream butter when stored for 6 months at -21°C. Hammer and Hussong (53) noted decreased numbers of bacteria in salted butter made without butter culture after 1-7 days at both 7° and 21°C. Shepard and Olsen (113) reported that no extensive changes occurred in either the plate count or the direct microscopic count of salted ripened cream butter after 14 days at either 0° or 21°C.

The data of Guthrie, Scheib and Stark (48) indicate that during 36 days at 10°C. salted butter having a pH of 6.35-5.5 and a salt content of 2.05-2.7 per cent supported only a negligible growth of bacteria, except in one case, while butter of a pH of 4.4-4.74 made from the same cream, but soured, showed a consistent and material decrease in bacteria under the same storage conditions. They consider the presence of microorganisms relatively unimportant from the standpoint of their effect on the keeping quality of salted butter at 10°C. Macy (71), studying 483 samples of salted butter, found that the changes in count during storage at -21-23°C. for 5 months, at 0-2°C. for 1-9 months, and at 0-20°C. for 1-2 weeks were all quite similar. Of all samples grouped together only 25.3 per cent increased in bacterial count, 32.3 per cent in yeast count, and 22.6 per cent in mold count during storage. Most of the remaining samples decreased in counts while a few remained the same. That there is little growth of bacteria, yeasts and molds in salted butter made without butter culture during storage for 6 months at -7°C. and no

relationship between the bacterial counts of such butter and its keeping quality at temperatures of 0°C. and below is the conclusion of Arup and Gilmour (4) (5). According to Olson and Hammer (83) salted butter made without butter culture in a highly contaminated churn and containing 249,000 - 13,208,000 bacteria per ml. kept as well in storage for 7 days at 0° and 7°C. as butter made in a clean churn and containing considerably fewer organisms. Davies (20) considers the bacterial content a minor factor in butter deterioration, except for surface effects. On the other hand, Gilmour and Cruess-Calleghan (38) report that in salted sweet cream butter held at 10°C. bacteria grew rather rapidly, especially in the low salt samples. Yeasts also increased in number at 2 - 10°C. and were little affected by salt and acid. At 20°C. yeasts increased markedly, but at -7°C. they decreased slightly.

Using the direct microscopic count on the butter serum of 303 samples of commercial salted butter, Nelson (80) found that the count increased in 59.7 per cent of the samples when held at 21°C. for 7 days. In the remaining samples there was a decrease. In general he noted that a large increase in organisms at 21°C. was associated with deterioration of the butter, but that the growth of microorganisms was not always associated with deterioration.

Demeter and Maier (25) studied the keeping quality of butter made from sour cream pasteurized at 62.8°C. for 30 minutes and found a general correlation between high bacterial counts in butter, especially total counts on casein agar, and low flavor scores in the butter after storage for 10 days at 0°C. They reported a general relationship of keeping

quality to mold counts, but none to the counts for non-acidifying and caseolytic organisms. A low grade in the butter was always associated with total bacterial counts of over 1,000,000 per ml. and mold counts of over 50,000 per ml.

Sutton (124) noticed that an unclean odor developed in 9 out of 10 samples of new South Wales butter with over 500,000 bacteria per ml. when stored for 7 days at 15-20°C., while 29 out of 37 samples with counts below 100,000 bacteria per ml. did not develop the unclean odor.

The relationship of the number of yeasts and molds to keeping quality in butter has been studied extensively. Bouska and Brown (11) tried to predict the keeping quality of butter in cold storage by the number of yeasts and oidia contained in it, but found only a rather general and not a consistent relationship between low counts and high keeping quality.

North and Reddish (82), using a microscopic method of counting yeasts and oidia, found that oidia did not grow in salted butter containing 2-3.3 per cent salt during storage for 5-6 months at 5.6°C. or 2 weeks at 10°C. While yeasts in some cases increased in number, the yeast growth was not accompanied by a change in score. Grimes and Hennerty (45) also observed that a noticeable increase in the yeast count of first grade sweet cream butter during storage for 56-252 days at -9.5°C. did not result in injury to the keeping quality of the butter. Loftus-Hills, Scharp and Bellair (68) found no relationship between keeping quality of salted Victorian butter and the counts for bacteria, yeasts and molds.

Macy and Richie (74) examined large numbers of commercial butter

samples and noticed a general tendency for samples with low yeast and mold counts to have slightly better keeping qualities than those with higher counts. The counts, however, were not reliable indices of keeping quality nor of quality in the fresh product. Gregory (42) showed that of the highest scoring samples of butter containing butter culture entered in a national scoring contest, 66.7 per cent contained less than 50 molds per ml. and 23.9 per cent less than 50 yeasts per ml. There was no correlation between the keeping quality of the butter held 4 months in commercial cold storage and the counts for yeasts, molds, and total bacteria in the fresh butter. Similarly Lund (69) found no correlation of keeping quality with yeast counts and Grimes (44) none with counts for yeasts and molds, total bacteria, proteolytic bacteria, and acidity.

Examining 434 samples of comparatively low grade, salted butter Parfitt (90) detected no relationship between mold content and score and only a slight tendency for low yeast counts to be associated with the higher scores.

Shutt (114) and Thomson (127) and Redfield (99) noted reduced keeping quality in the samples containing the largest number of yeasts and molds. The results of Thomson, however, indicate that a yeast and mold count of 51-100 per ml. in the fresh butter was associated with higher average scores of the butter when fresh and after storage for 3 and 6 weeks at ordinary refrigeration temperatures than a yeast and mold count of 0-50 per ml. Thus it appears that there is no fixed relationship between the number of bacteria, yeasts, or molds and the keeping quality

of butter.

The types of microorganisms present in butter unquestionably have a greater influence on keeping quality than total numbers, because the ability of certain organisms to produce specific defects in butter is well known. Ruehle (109) concluded that microorganisms may cause many different off-flavors in butter, including metallic flavors. That proteolytic and lipolytic organisms are at times involved in the deterioration of butter might be expected because of the presence of some protein and a very large amount of fat together with other food materials and moisture in butter. Frequently caseolytic bacteria are also lipolytic, as has been shown by Stark and Scheib (122). These authors, as well as Safford and Stark (111), concluded that the presence of casein-digesting gram negative rods in butter or cream might well be used as an indication of probable spoilage of butter. They found that small numbers of these proteolytic gram negative rods in fresh, highly salted, sweet cream butter, held at temperatures which would permit the growth of these organisms, was invariably followed by large numbers of the organisms and a poor quality butter. Nelson (80) noticed that clumps of well stained gram negative rods appearing in smears of butter were indicative of deterioration of the butter at 21°C. Eckles (31) reported that proteolytic organisms produced putrid butter.

Large numbers of lipolytic or proteolytic organisms may not be necessary to cause the development of undesirable flavors in butter. Guthrie (46) found that a small amount of butyric acid gives a characteristic odor of rancidity and Davies (21), citing Grossfeld and Battay,

states that the smell of butyric acid is detectable in concentrations of less than 80 parts per million of fat. Hammer and Collins (52) showed that pronounced decreases in the numbers of lipolytic organisms followed the increases that were presumably responsible for rancidity development. One sample of commercial salted butter, which was criticized as slightly rancid, contained 150,000 lipolytic and 650,000 total bacteria per ml. while another sample criticized as distinctly rancid contained only 2,000 lipolytic and 77,000 total bacteria per ml. Of 2 samples criticized as having a Roquefort flavor, 1 contained less than 1,000 lipolytic and 20,000 total bacteria per ml., while the other contained 500,000 lipolytic and 42,500,000 total bacteria per ml. Hammer (51) was unable to produce fishiness in butter by inoculating the butter with an organism, which produced a fishy odor in cream. Sayer, Rahn and Farrand (112) found few fat splitting bacteria in fresh butter and none in old butter, although they noted that the number of liquefying bacteria decreased less during storage than that of other types.

Collins and Hammer (17) noted that certain lipolytic bacteria, when inoculated into sterile cream before churning, produced rancidity along with other flavor defects, that others produced no rancidity but various off-flavors, and still others produced no flavor changes at all in unsalted butter at 21°C.

Bendixen and Ellington (8) found no correlation between the number of proteolytic bacteria nor the extent of protein decomposition in fresh salted butter and the keeping quality of such butter when held for 3 or 6 months at -25°C. Grimes (43) showed that proteolytic bacteria when

inoculated into ripened salted butter did not affect the keeping quality of the butter when held for 6-7 months at -21°C. The lactic acid bacteria apparently inhibited the action of the other organisms. Ferris (32) was unable to appreciably increase the protein decomposition products in butter by inoculating the pasteurized cream used in its manufacture with proteolytic organisms. By incubating the cream inoculated with peptonizing, spore forming aerobes for 6 days at room temperature and then 3 days at 2.8-4.4°C., he produced butter of a very low score, but the amino nitrogen content was only slightly higher than that found in neutralized, clean acid cream butter. He detected a slightly greater increase in the amount of soluble nitrogen in neutralized sour cream butter than in sweet cream butter during cold storage for 1 month. This same investigator (33) found that with decreasing scores of the fresh butter, the percentage of the total nitrogen in the form of amino nitrogen and ammonia was higher.

Jacobsen (61) discovered no correlation between the increase in amino nitrogen and loss in flavor score of butter in cold storage, although the highest amounts of amino nitrogen were always found in the butter of the lowest score.

Spitzer, Parfitt, Manhart and Epple (120) showed that in salted and unsalted butter made from pasteurized cream inoculated with proteolytic organisms, a definite, progressive protein hydrolysis occurred during storage of the butter for 30-180 days at 0-4°C. and concluded that the keeping quality of butter is closely related to the activity of proteolytic organisms in the butter.

Brown, Smith, and Ruehle (14) also reported that the soluble nitrogen compounds of butter increased during storage and the results of Rahn, Brown, and Smith (97) showed that the poorest butter had the highest increase in amid nitrogen, while Rogers, Berg, Potteiger and Davis (106) found no increase in soluble nitrogen in butter at 0°C., even after long standing.

Enzymes

Since it appears then that the keeping quality of butter correlates more closely with protein hydrolysis than with the numbers of proteolytic or other types of microorganisms in the butter, and since it is known (104) that proteolysis, like sugar decomposition, is not dependent upon the life of the microorganisms but in many cases continues after the death of the cells, enzymes may play a part in thedeterioration of salted butter. Various types of enzymes capable of acting on proteins, fats, carbohydrates, and hydrogen peroxide may be present in milk, cream, and butter. They vary materially in their sensitivity to heat, and their activity may be increased or decreased by such factors as pH, salt concentration, the presence of metallic salts, free oxygen, and other conditions in the substrate. However, the knowledge of the nature and behavior of the enzymes, especially in butter, is still rather incomplete.

Guthrie (46) stated that enzymic development did not produce rancidity in butter and Palmer (86) concluded that cows' milk does not normally contain active lipase except during the advanced stages of lactation (85). Rice and Markley (101) and Rice (100) demonstrated the

presence of lipase in milk and sweetened condensed milk. According to Hunziker (56) rancidity appears to be due to hydrolysis of the butterfat caused largely by bacterial and mold action but also by enzymatic action and that lipase hydrolyzes fat even at fairly low temperatures. Davies (20) observed that in butter from unpasteurized sweet cream lipase very quickly caused a strong taste and smell. The same author (21) concluded that in the presence of metallic salts it may act as an antioxygen. Manus and Thurston (75) concluded that lipase action is involved in the production of bitter flavors in cream. Rogers (103) attributed the increase in acidity and off-flavors in canned butter to the action of fat splitting enzymes, which were weakened by pasteurization at 45°C. for 10 minutes and entirely destroyed at 60°C. for 10 minutes. According to Rogers, Berg and Davis (105) the enzyme was destroyed in sweet cream by flash heating at 70°C. Rice and Markley (101) stated that preliminary experiments indicated the critical temperature for the destruction of lipase to be near the pasteurizing temperature usually employed in factory practice. Nair (79) detected no lipase action in whole milk powder desiccated by a drying system in which the fluid milk had undergone a preliminary pasteurization at 63-64.5°C. for 30 minutes or 85°C. for 1 minute. Dorner and Widmer (29) found the following critical temperatures for lipase inactivation: 55°C. for 20 minutes, 59°C. for 10 minutes, 63°C. for 5 minutes and 70°C. for 1 minute. They showed some evidence of the existence of two types of lipase. The one type was sensitive to heat, but produced a sharp, bitter taste in milk while the other resisted heating to 70°C. for 5 minutes and produces a

milder and more aromatic rancidity without considerable increase in acidity. Using increases in titratable acidity and decreases in pH and surface tension as indices of lipase activity in homogenized milk, Doan (28) concluded that lipase was inactivated by flash pasteurization at 62.8-64.4°C.,by pasteurization at 56.1-58.3°C. for 15 minutes and at 53.3-55.6°C. for 30 minutes.

According to Ramsey and Tracy (98) the natural lipase of milk is greatly reduced by heating to 54.4°C. and is rendered innocuous at 61.1°C. Davies (20), quoting Euler, states that lipase is weakened by heating to 60°C., is almost completely destroyed by flash pasteurization up to 71°C. and is completely destroyed at 80°C. The associates of Rogers (104), however, consider it questionable, whether or not pasteurization at 63°C. for 30 minutes entirely destroys the enzyme activity. Soehngen according to these authors (104) found that the lipase of some organisms was markedly heat resistant and that some thermophilic bacteria could split fat.

While the enzyme lipase seems to be destroyed by comparatively low temperatures of pasteurization, other enzymes appear to resist higher temperatures. The proteolytic enzyme galactase, which according to Babcock, Russell and Vivian (6) and Thatcher and Dahlberg (125) is present in larger amounts in cream than in milk, has been shown to survive at very high temperatures. Thus Babcock, Russell, and Vivian (6) concluded that the enzyme was materially weakened at 71°C. for 10 minutes and killed at 76°C. for 10 minutes, while Rogers, Berg and Davis (105) found that the enzyme was weakened by flash heating at 71-77°C., but not

completely destroyed by heating even at 93°C. for 30 minutes. Davies (20) states that galactase is destroyed by a temperature of 75-80°C. at a pH of 6.4-7.2 and by a lower temperature (72°C.) under more acid conditions. Virtanen (130) reported that cheesy, putrid and rank flavors in butter are caused by the enzymes of proteolytic water bacteria and sometimes by those of yeasts and molds, and that the enzymes are not destroyed by pasteurization.

Hunziker, Spitzer, Mills, and Switzer (60), working with cream of an acidity of 0.3-0.7 per cent which was not neutralized, found that such cream produced butter of a low keeping quality if churned raw and of high keeping quality when pasteurized at 85°C. by the flash method. They concluded that protein hydrolysis plays an important role in the deterioration of butter in storage and that pasteurization at 85°C. probably destroys the activity of the proteolytic enzymes responsible for the protein hydrolysis.

Spitzer and Parfitt (118) noted a relationship between the count of proteolytic bacteria and the activity of proteolytic enzymes in separator slime. About 70 per cent of the enzymatic activity was inactivated at 62.8°C. for 30 minutes or 73.9°C. for 10 minutes.

Spitzer, Parfitt, and Epple (119) showed that the proteolytic enzyme autolysate of Bacillus ichthyosmius was considerably inactivated at 65°C. for 30 minutes and was approximately 80 per cent inactivated at 74°C. for 10 minutes or 82°C. for 1 minute.

Another heat resisting enzyme which, according to Kende (64), may be found in butter is oleinase. Kende (63) believes that the

enzyme is the cause of an oily flavor in milk, especially when the milk is pasteurized at high temperatures, that it is closely related to an oily-metallic flavor in butter made from sour neutralized cream and that it is activated by an exogen or endogen contamination with heavy metals. He (64) found that oleinase was not destroyed in milk by pasteurization at 65°C. but that milk heated to 80-85°C. was protected because of the formation of reducing substances.

Peroxidase is another enzyme which does not seem to be inactivated by temperatures of 70°C. or below. Lane-Claypon (65) showed the inactivation temperatures of peroxidase according to a considerable number of authors to vary from 69-70°C. for 1 hour to over 90°C. by the flash method. Rogers, Berg, and Davis (105) found that peroxidase was destroyed by flash heating at 79°C. but not always at 77°C., and never at 74°C. Spitzer and Taylor (121) reported that peroxidase in milk was 40 per cent inactivated at 76°C. for 1 minute and 92.5 per cent at 85°C. for 1 minute. According to Zilva (135) the time required to reduce the activity of peroxidase to 10 per cent of the normal was 75 minutes at 70°C., 35 minutes at 71°C., 15 minutes at 72°C., 7 minutes at 73°C., 3 minutes at 74°C., and less than 1 minute at 80°C. Palmer and Millar (88) demonstrated that, although peroxidase is the most abundant and most potent oxidizing ferment normal to milk, the addition of a preparation of peroxidase from horse-radish roots to cream pasteurized at 82.2°C. for 10 minutes did not affect the keeping quality of the butter made from it when held for 3-10 months at 0°C. or at room temperature. According to Balls and Hale (7) the activity of peroxidase is almost zero at ice

bath temperatures, although catalase is still quite active at such temperatures. Similar results were reported by Thatcher and Dahlberg (125).

Hammer (50) states that the enzyme catalase, which, like peroxidase, is more abundant in cream than in milk, is apparently of little importance in milk and its derivatives. Thatcher and Dahlberg (125) found twice as much catalase associated with the nitrogen in butter than in milk and that cold storage did not weaken this enzyme. According to Rogers, Berg and Davis (105), catalase is inactivated by flash pasteurization at 70-71°C., while Davies (20), on the other hand, cites some investigators giving 65-70°C. for 30 minutes as the inactivation temperatures of catalase and others who found that complete inactivation occurs at 90-92°C. for 20-30 minutes.

Minster (76) considers the catalase test of some value in predicting the keeping quality of butter, especially when used together with the reductase test, a bottle test and a bacteriological examination. Arup and Gilmour (5) and Loftus-Hills, Sharp and Bellair (68) found no correlation between the catalase number and keeping quality in sweet cream butter. Osols (84) reported that many organisms which are preferably to be avoided in the dairy, lower the catalase number, while the lactic acid streptococci may increase it. He also found that salt increased the catalase number, and that buttermilk may affect it and concluded, therefore, that the catalase number is not suited for judging butter quality. Virtanen (130) stated that a negative catalase test is no guarantee that spoilage will not occur in butter. Thatcher and Dahlberg (125) found no oxidase in milk or butter, but Palmer and Combs (87) concluded

that natural oxidases are factors in producing tallowiness in butter and Guthrie and Brueckner (47) were able to prevent the development of oxidized flavors in milk by heating to 76.7°C. for 30 minutes.

Aldehydrases able to resist temperatures of 65°C. for 30 minutes and active up to 78-80°C. have also been reported present in cows' milk (104).

Combs and Eckles (18) found that mold spores worked into butter did not grow during 30 days in an ice box, but that the keeping quality of the butter was greatly reduced when the cream was inoculated with molds and with 5 per cent of a S. lactis culture and then incubated at 21°C. for 8 days. The pasteurization of such cream at 63°C. for 20 minutes improved the keeping quality of the butter made from it but did not prevent deterioration. Pasteurization at 74°C. for 5 minutes was more effective in improving the keeping quality of the butter and heating to 100°C. prevented deterioration. They concluded that the higher temperatures destroyed more of the enzymes in the cream. Larsen, Fuller, Jones, Gregory, and Tolstrup (66) comparing cream pasteurization at 60°C. for 25 minutes, 71.1°C. for 10 minutes, and 82.2°C. without holding found that the higher temperatures were the most effective in killing microorganisms and caused the butter to keep best and to develop less acidity in storage for 1, 2, qnd 3 months at 4.5°C. The cream was ripened with 8-12 per cent butter culture to an acidity of 0.45-0.55 per cent. Zakariasen (134) stated that a better keeping quality of sweet cream butter during a 4 week storage period always resulted when the cream was pasteurized at 74°C. for 30 minutes than when lower temperatures were used.

Raising the pasteurization temperature of the milk from 63°C. to 83°C. with a holding period of 30 minutes improved the keeping quality of milk powders according to Holm, Greenbank and Deysher (55), although heating to 93°C. for 30 minutes reduced it. Hunziker (56) concluded that vat pasteurization at 62.8°C. does not inactivate the enzymes in cream, but that the flash process at 82.2-85°C. will inactivate most of them. Thus it seems that a pasteurization temperature of 63°C. for 30 minutes does not destroy all enzymes in cream and that flash pasteurization at 82-85°C. will reduce enzymatic activity to a greater extent.

Enzymatic action and chemical changes, however, are affected not only by heat but also by the activity of microorganisms, the pH of the substrate, the salt concentration, the presence of metallic salts, and other agencies. Furthermore, it has been suggested by Diehl (27) that proteolytic enzymes elaborated by bacteria possess specificity for different amino acids composing the proteins and Davies (20) considers lipase to be specific for the fat. It seems also that agents of deterioration may occasionally oppose one another in their action. Thus Davies (21) states that in the presence of metallic salts lipase may act as an antioxygen. Ramsey and Tracy (96) also noted some antagonism between the agents of tallowiness and rancidity in raw milk. Kende (63) believes that oily flavors caused by the enzyme oleinase may be counteracted by bacterial activity and Gondos (39) actually proposed the use of a special bacterium of high reducing power, Bact. frigid. neutrale (Kertész), in order to reduce the first products of fat spoilage, the peroxides. Davies (19) also maintains that a high bacterial content inhibits the development of oxidized taints in milk, because the high oxygen

demand of the bacteria reduces the supply of oxygen which might otherwise be activated by metallic salts, acid, light, heat, or other catalytic agents so that it would react with the fat.

Tracy, Ramsey and Ruehe (128) were able to reduce tallowiness in market milk and butter by incubating the milk and the cream used in the manufacture of the butter at room temperature previous to contamination with metallic salts. The incubation markedly increased the bacterial count of the milk. Inoculation of milk with live yeast cells also effectively retarded fat oxidation in the milk at 4.4°C., but the same yeast cell suspension heated to 76.7°C. did not prevent tallowiness. The incubation of the milk and cream was only of benefit when metallic salts were present. Excessive incubation of the cream also produced tallowiness in the butter. They concluded that the metabolism of bacteria and yeast cells in dairy products plays an important part in the control of tallowy flavors and that the effect is probably that of oxygen removal. Davis (24) stated that bacteria control oxidation not only by removing molecular oxygen through respiratory processes but also by setting up systems of high reducing intensity in the medium. He concluded that a flora of yeasts and cocci would in general not reduce the oxidizing intensity produced by copper or light as much as coliform organisms, streptococci and other bacteria.

pH and acidity

The pH of butter no doubt has an effect on the activity of microorganisms and enzymes present in the butter as well as on the speed of

various chemical reactions taking place in it. Thus Guthrie, Scheib, and Stark (48) found no significant numbers of proteolytic and lipolytic bacteria in sour cream butter. Grimes (43) also concluded that the acidity in ripened butter inhibited the growth of proteolytic organisms. Collins and Hammer (16), when growing lipolytic organisms on Nile-blue sulphate agar of pH values of 5.3, 6.7, and 7.8, noted that with many of the organisms the most alkaline reaction seemed to favor the hydrolysis of simple tri-glycerides and natural fats. Sadler and Vollum (110) found that butter from over-neutralized cream (acidity below 0.25 per cent) showed much more deterioration than that from cream of higher acidity when inoculated with the organisms obtained from deteriorated butter.

Davies (20) stated that the acidity in ripened cream prevented lipase action even in unpasteurized cream and that the presence of heavy metal salts inhibited it.

Dorner and Widmer (29) found that lipase was inhibited by an acid reaction but that distinctly alkaline raw milk became rancid after homogenization. Soehngen (116) reported several fat splitting organisms producing two lipases, of which one acts both in acid and in alkaline solutions and the other is formed in acid media, but becomes active only after neutralization. Galactase is also retarded by acid according to Babcock, Russell, and Vivian (6). Davies (20) and Rogers (104) reported it to be most active in the pH range of 6.4-7.2 at temperatures of 37-42°C. Spitzer, Parfitt and Epple (119) found the most active proteolytic enzymes to be produced by Bacillus ichthyosmius

and Achromobacter putrefaciens and other putrefactive organisms and that the optimum pH for their activity was at 7. Their activity diminished rapidly at pH 4 and 3.

The enzyme peroxidase, according to Davies (20), is active over a wide range of pH, but Zilva (135) found that the inactivation of peroxidase in milk by heat was retarded by the presence of small amounts of acid and accelerated by alkalis.

Davies (20) states that acidity exerts a preserving action also on catalase during heating. However, according to the same author, the optimum pH for the activity of the enzyme is 7.0 and a slight inhibition occurs under acid conditions. Balls and Hale (7) reported the maximum activity at 0°C. to occur at pH 6.8-7.0 and Guthrie, Scheib, and Stark (48) concluded that the action of all enzymes was inhibited by a pH of 4.4-4.64 in unsalted butter.

Hagemann (49) was unable to produce rancidity by inoculating fresh butter with rancid butter or with lipolytic organisms but quickly produced rancidity by mixing the butter with lactic acid and holding at a temperature too low for bacterial growth.

Rogers (102) found fishiness in butter to be associated with high acidity in the cream and Rogers and Gray (107) concluded that the deleterious effect of lactic acid was not due to any organism, enzyme, or other substance which would be destroyed by pasteurization at 77-82°C. (flash) or at 70°C. for 10 minutes but that acid itself was responsible. Dyer (30) showed that the development of undesirable flavors in butter held in cold storage at -17.8°C. is due to the oxidation of non-fatty

substances in the butter and that the extent of this chemical change is directly proportional to the quantity of acid present in the cream from which the butter was made.

Greenbank and Holm (41) concluded that increases in the acidity of fat increase its susceptibility to oxidation, and that fatty acids probably act indirectly as catalysts for autoxidation through the liberation of unsaturated acids, which are strongly catalytic. Similar results were obtained by Briggs (12).

Rahn (95) and Rahn and Boysen (96) state that acid will diffuse in butter through the medium of the hydrated colloid films connecting many of the water droplets, but that the diffusion is reduced in overworked butter. If this statement is correct, the acid in such butter would remain more concentrated in certain parts of the butter than in others, which would help to explain the accelerating effect of overworking the butter on the development of fishy flavors. That the production of trimethylamine, the cause of fishy flavors in butter, is accelerated by the presence of acid was shown by Sommer and Smit (117). These authors attribute the formation of trimethylamine to the hydrolysis of lecithin, whereas Davies (20) points out that trimethylamine can only be liberated by a hydrolytic-oxidative action. The presence of acids and metallic salts, according to the latter author, catalyzes the oxidation of the choline residue of lecithin by organic peroxides.

According to Davies (22) acidity decreases the concentration of metal proteinates absorbed at the fat globule surfaces and that the ratio of metal to curd nitrogen is highest in neutralized cream butter.

Hunziker and Hosman (59) concluded that overneutralization of the cream may produce a tallowy flavor in the butter made from it, because an unnatural alkaline condition may render lactose and glycerol more susceptible to oxidation with the formation of glycollic acid, which when combined with oleic acid produces tallowiness. Palmer and Combs (87) found that overneutralization previous to the addition of copper lactate and ripening did not accelerate tallowiness in either raw or pasteurized cream.

Bouska (10) stated that butter tends to be low in keeping quality at a pH of less than 6.0, keeps better at a pH of 6.0-6.8, develops surface flavors readily at pH 7.0, and tallowy flavors at a higher pH. Parfitt (91) found that as the score of butter entered in a national exhibition decreased, the pH decreased, excepting with butter scoring over 94 and under 89. According to Loftus-Hills, Scharp, and Bellair (68) high acidity and a low pH correlated rather closely with low keeping quality in sweet cream butter. Similar results were obtained by Arup and Gilmour (4), Gilmour (36), and Gilmour and Arup (37). The latter investigators concluded that a consideration of pH values was more valuable in selecting butter for cold storage than a knowledge of the acid values, that butter with a pH of over 6.7 kept better than butter of a lower pH, and that a pH of 7.0 would be desirable for Irish Free State butter. They also found a high curd content associated with high acidity.

Loftus-Hills, Scharp and Bellair (68) found no relationship between pH and the peroxide values after storage and, therefore, con-

cluded that fat oxidation was not the principal cause of deterioration in salted Victorian butter. The results of Patrick, Leighton, and Bisbee (93), Patrick, Leighton, and Heilsman (94), Rogers, Thompson, and Keithley (108) Mortensen (7 8), and Grimes (43) (44) all indicated that the butter of the lowest acidity, whether made from raw or pasteurized cream, had the best keeping quality at various storage temperatures up to 10°C. Larsen, Lund, and Miller (67) noticed that the percentage of the acidity found in the fat increases with the age and rancidity of the butter. Frielinghaus (35) examined many samples of butter for their acid ratio which is the ratio of the acid value of the butterfat to the acid value of the butter. He found that the acid ratio of butter made from cream inoculated with yeasts gradually increased during storage of the butter for 20 days at 4°C. At the same time the flavor became increasingly stronger. He obtained similar results when inoculating the cream with cladosporium and concluded that in the development of rancid flavors the acid ratio will increase, while in the development of high acid flavors it will decrease. When tallowy flavors developed, both the acid values of the butter and of the butterfat were raised, leaving the acid ratio little changed. In the case of combinations of defects existing in the butter, he suggested holding the butter for 12-24 hours at 15-20°C. to bring out the principal defect.

Salt concentration

That increased salt concentrations reduce the growth of microorganisms is well known, but the salt tolerance varies considerably with

various organisms. For instance, Macy (70) and Gilmour and Cruess-Callaghan (38) found that salt retarded the growth of bacteria more than that of yeasts. Molds, according to Macy (72), varied greatly in their sensitivity to salt. Macy (71) and Macy, Coulter and Combs (73) showed that, while unsalted butter provided much better conditions for the growth of bacteria, yeasts, and molds than salted butter, there was little difference between butter with 1 percent salt and butter with 3 per cent salt. Rahn, Brown, and Smith (97) found organisms able to multiply slowly in salted butter even at -6°C.

Derby and Hammer (26) showed that the development of surface taint by Achromobacter putrefaciens was greatly inhibited by salt. Jacobsen (62) detected only negligible numbers of proteolytic and lipolytic bacteria in salted butter and according to Hammer and Collins (52) lipolytic organisms vary greatly in their salt tolerance. Spitzer, Parfitt, Manhart, and Epple (120) reported that salt inhibited the growth of total bacteria, acid formers, proteolytic bacteria, yeasts, and molds in butter, but that the proteolytic bacteria were inhibited the least and yeasts the most. Salt had little influence, however, on protein hydrolysis in the butter.

Rogers, Berg, Potteiger, and Davis (106) found that the action of galactase was almost entirely inhibited by 18 per cent salt in raw cream buttermilk at -18°C. although the enzyme was more active at room temperature. However, even at -6.7°C. and in the presence of a high salt concentration milk proteins were hydrolyzed by bacterial enzymes according to these investigators. Thatcher and Dahlberg (125) showed that 15

per cent of salt in skimmilk entirely prevented proteolysis and concluded that the salt content of normal butter eliminates the action of galatase. According to Spitzer, Parfitt, and Epple (119) the activity of the proteolytic enzymes of several putrefactive organisms was slightly reduced by 2-4 per cent of salt, distinctly by 10 per cent of salt, and reduced 60-80 per cent by 20 per cent of salt.

Davies (21) noticed little difference in the activity of lipase in salted and unsalted butter and Zilva (135) reported that the presence of sodium chloride and other salts greatly retarded the rate of inactivation of peroxidase by heat in milk and whey and that the retardation varied with different salts.

Sommer and Smit (117) showed that salt increased the development of fishy flavors in butter probably by aiding in the solution of the lecithin. Gray and McKay (40) found that low salt butter made from ripened cream kept better than high salt butter when stored for 8 months at temperatures of -25°C. to 0°C., although the difference was apparently very slight in the case of the ripened sweet cream butter. Washburn and Dahlberg (131) showed that salted butter made from raw cream ripened to an acidity of 0.58 per cent lost more heavily in score than the same butter without salt when stored 9 months at -26°C. and also during subsequent holding for 20 days at 15°C. During the low temperature storage the bacterial count decreased in both salted and unsalted butter and during storage at the higher temperature they decreased in the salted and increased in the unsalted butter, suggesting that the combination of high acid and salt has an accelerating effect on chemical changes in the butter.

Hunziker (56) stated that salt postponed the initial hydrolysis of fat, which leads to rancidity and M'Kay and Larsen (77) found that salt improved the keeping quality of raw cream butter.

Curd content

Curd content may affect the keeping quality of butter in various ways. According to Davies (22) (23) curd is the carrier of metallic salts which act as oxygen activators in the oxidation of butterfat. The metal proteinates are strongly adsorbed at the fat globule surfaces. On the other hand, the lecithin, cholesterol, and soluble non-protein nitrogen materials in the curd may, according to the same author (20) act as anti-oxygens by reacting with free oxygen and thus reducing oxidation of the fat until they are oxidized to non-anti-oxygenic compounds. Finally Davies (19) states that the galactase content of butter depends on the curd content. Thatcher and Dahlberg (125) also found that a high galactase content was associated with a high casein content and Zilva (136) concluded that the enzyme peroxidase was linked with the albumin fraction of milk. Doan (28) showed the lipase of milk to be resident in the plasma and not in the fat of cream and Darner and Widmer (29) found it to be associated with the casein and not with the albumin, fat, or whey. Thus it seems that the curd of butter may be important as the carrier of the various enzymes.

Dyer (30) attributed the production of off-flavors in butter during storage at -17.8°C. to a slow oxidation in the non-fatty substances occurring in the buttermilk and found that unwashed, high curd butter lost more heavily in score than low curd butter. Macy (72) showed

that purified butterfat was not readily utilizable food for molds, unless water was present, and that the addition of curd from butter, enabled luxuriant growth. Patil and Hammar (92) also concluded that constituents other than fat are the important ones from the standpoint of deterioration. They found, however, that the addition of sterile water to ghee heated to 122-130°C. accelerated deterioration more than the addition of curd.

Arup and Gilmour (4) (5) reported that a high curd content in sweet cream butter was generally associated with low keeping quality, although some individual samples with high curd content kept well. Loftus-Hills, Scharp and Bellair (68) found no relationship between curd and keeping quality in Victorian salted butter. Brown (13) concluded that the presence in butter of abnormal amounts of curd derived from fresh, untainted cream was not usually marked by rapid deterioration of the butter, but that curd from tainted cream or curd which had already commenced to decompose would seriously reduce the keeping quality of the butter. M'Kay and Larsen (77) found that unwashed, high curd, raw, ripened cream butter kept as well and sometimes better than washed low curd butter.

Wiesehahn (133), discussing various anti-oxygens which, according to him, belong to the unsaponifiable part of the fat and which probably are hydroxy compounds, pigments, and in some cases protein material, considered soyabean lecithin, carotene, and other materials to be anti-oxygenic. Briggs (12) reported that curd, when heated to 100°C., had a strong anti-oxygenic effect, due probably to the production of an amino compound with anti-oxygenic properties, but that lactose did not affect oxidation.

Season

Thomas and Morgan (126) noted that the keeping quality of raw, ripened cream butter was lowest during the months of December to February and improved gradually between March and November with only a slight reduction in keeping quality during July and August.

Hileman and Courtney (54) demonstrated that lipase activity in cream was the lowest during the months of June to September, and the highest in the months of November to February. At the same time bacterial counts were the highest during the months of June to September. They also concluded that lipase was present in the cream in largest amounts toward the end of the lactation period of cows. Fouts and Weaver (34) found that rancid flavors were less common in milk during the spring and summer months and Manus and Thurston (75) noticed that bitter flavors, caused by lipolytic activity in cream, occurred most frequently during the winter months.

On the other hand, Spitzer and Parfitt (118) showed that total bacterial counts, proteolytic counts, and the activity of the proteolytic enzymes in separator slime was higher during the months of May to September than during the remainder of the year, but the values fluctuated considerably from month to month. Tracy, Ramsey, and Ruehe (128) and Tracy and Ruehe (129) found tallowiness in market milk and in butter to be more common in winter than in summer due probably to lack of bacterial metabolism in the milk and cream during that season of the year. Similarly Webb and Hileman (132) reported that summer milk resisted the development

of oxidized flavors even in the presence of a high oxidation-reduction potential.

Kende (64) stated that the tendency of milk to become tallowy even with metallic catalysts varies due to certain types of feed, which produce protective substances in milk. Anderson, Hardenbergh, and Wilson (3) reported oxidized and rancid flavors to be eliminated by adding carrots to the cow's ration and concluded that carotene may be related to good flavor in milk. Newton, according to Davies, (20) and Wiesehahn (133) cited carotene as a naturally occurring anti-oxygen and Gondos (39) concluded that fresh hay increased the anti-oxidizing materials in milk. These feeds would be ingested by the cow in largest amounts during the spring of the year. Leucocytes, which are most abundant in milk during the early stages of the lactation period of cows, have also been mentioned (128) as possible antioxygens. Stebnitz and Sommer (123) found that, although oxidized flavors were not common when cows were on grass, the stability of butterfat toward oxidation did not seem to be associated with the feed of the cow nor with the stage of the lactation of the cow, nor with the carotene content of the butterfat. Their results indicated a close relationship, however, between the rate of fat oxidation and the percentage of linoleic acid in the butterfat. Guthrie and Brueckner (47) also reported oxidized flavors in milk to be more pronounced and widespread in winter than in summer, but conclude that the feed of the cow is not responsible, because variations were found in the flavor intensity of milk from different quarters of the same udder.

Thus it is evident that the course of butter deterioration is

dependent upon many factors, which may or may not be under the control of the manufacturer. With this in mind and since slight irregularities in processing procedures might materially change the course of deterioration in individual samples, it seems that the general trend of deterioration of various types of butter might best be studied by an analysis of the average results obtained on comperatively large numbers of samples.

METHODS USED

Organoleptic tests

Unfortunately there does not as yet exist an absolutely accurate yardstick for determining the keeping quality of butter, because the market quality of butter is dependent primarily upon flavor and this is measurable only by the rather indefinite human senses of taste and smell. In this study flavor was judged on the basis of a numerical score placed upon the butter by experienced graders using the standard United States score card which allows 45 points for a perfect score. All references to the score of butter in this study allude only to the flavor score.

The accuracy of the scoring was enhanced by using, as nearly as possible, the same group of 3 or 4 judges for all scorings. These included Mr. R. L. Nelson and Mr. J. C. Austell of the Washington State Department of Agriculture, Doctor N. S. Golding of the Washington Agricultural Experiment Station, and the author. The loss in score during storage for 1 month at 0-5°C. was used as the principal measure of keeping quality, but in many cases the score itself after storage also was considered. It was recognized that there is a tendency with most judges to be slightly less discriminating when judging the poorer grades of butter, causing the reduction of flavor scores during storage to be the highest with the better grades of butter.

The scoring for flavor after 1 week at 21°C. was referred to as the bottle test. In the bottle test, the samples were packed into

sterile straight-sided 4-ounce screw top jars. Care was taken that no odor was present in the bottle or on the cap after sterilization and before introduction of the butter. In some instances, as indicated later, only the odor of the butter was noted after storage for 1 week at 21°C., but in most cases the samples were scored in the regular way.

Counts of total and proteolytic organisms

The methods recommended by the Committee on Bacteriological Methods of the American Dairy Science Association (1) were followed, using beef infusion agar. No lactose was added but 0.5 ml. of sedimented skimmilk or litmus skimmilk was added to each plate to determine the proteolytic as well as the total bacterial count. The medium was adjusted to a pH of 6.8-7.0 by the colorimetric method. Dilutions from 1:100 to 1:10,000 were used on the fresh butter and the butter held for 1 month at 0-5°C., while dilutions of 1:1,000 to 1:100,000 were used on the butter held for 1 week at 21°C. and on the fresh and held butter serum. The plates were counted after 5 days at 21°C. A clear area around the colony was taken as an indication of proteolysis.

In some cases bacterial counts were made on the butter serum as well as on the butter itself. The butter serum was obtained by the following procedure: A 50 ml. sterile centrifuge tube was filled with butter, placed in a waterbath at 40-45°C. until the butter was melted, and whirled for 1 minute at 1,000-1,500 revolutions per minute in a centrifuge with a diameter of 15 inches. The tube containing the butter oil and serum then was placed in an ice water bath, or preferably an ice

cream hardening room for a short time, after which the hardened fat could be easily and completely removed from the tube by means of a glass rod placed in the fat previous to hardening. The serum in the bottom of the tube was removed by pouring or pipetting. If any slight separation of solids had occurred in the serum, the tube was shaken in order to obtain a fairly uniform suspension of the curd in the aqueous portion of the serum. In some cases the serum was obtained by boring through the hardened fat along the wall of the tube by means of a sterile cheese trier, and then pouring or pipetting the serum from the tube through this opening.

Counts of lipolytic organisms

For the lipolytic counts a method described by Hammer and Collins (52) was used. With a few of the earlier counts butterfat was used as the test fat, but with all other platings Wesson oil was employed. In some cases the fat emulsion was added to the hot agar and in others it was placed in the plate together with the dye, the portion of the sample being plated, and 0.5 ml. of sedimented skimmilk. The beef infusion agar was added immediately and carefully mixed with all the materials in the plate. The skimmilk was used to note the proteolytic action of the organisms since it is known that many lipolytic organisms are also proteolytic. Dilutions used were 1:10, 1:100, 1:1,000.

Counts of yeasts and molds

The number of yeasts and molds was determined by plating 1 ml. of a 1:10 dilution of the carefully sampled butter on a medium made from

Bacto Dehydrated Malt Agar and adjusted to a pH of 3.5 by the addition of sterile 10 per cent lactic acid, incubating at 21°C. for 5 days, and otherwise following the methods recommended by the American Dairy Science Association Committee on Bacteriological Methods (1).

pH values of the butter serum

Hunziker, Cordes and Nissen (58) have shown that, due to the non-conductive property of the butterfat, the butter serum must be used in a pH determination of butter and that the quinhydrone electrode gives essentially the same results on butter serum as the standard hydrogen electrode. In this study the pH of the serum was determined by means of a Leeds and Northrup quinhydrone pH indicator (catalog No. 7654), using a rectangular plate gold electrode, together with a saturated calomel half-cell and a saturated KCl agar bridge. About 3 ml. of the butter serum were placed in a vial of 7 ml. capacity (5 cm. high and 1½ cm. in diameter). Quinhydrone, in the amount of about 0.15-0.20 grams, was added and the mixture adjusted to a temperature of 25°C. Readings were made at once at this temperature. The electrodes were checked regularly against standard buffer solutions. The serum was obtained by the same procedure as was used in connection with the total and proteolytic counts described above.

Acid values of the butter

The butter was prepared for titrating by macerating 70-80 grams in a clean, dry cup by means of a spatula until it appeared glossy and

salvy. A 10 gram sample was weighed into a tared porcelain casserole or Erlenmeyer flask on a torsion butter moisture balance. Then 50 ml. of neutral ethyl alcohol and a few drops of phenolphthalein were added and the mixture brought to a boil on an electric hot plate. The boiling hot mixture was titrated with N/50 NaOH while being stirred constantly. The number of milliliters of N/50 NaOH used to produce a pink color stable for at least 1 minute was taken as the acid value. This is essentially the method recommended by Bird and Breazeale (9).

Acid values of butterfat

The butterfat was obtained by filling a 50 ml. centrifuge tube with butter, melting it in a water bath at 40-45°C. and centrifuging the tube of melted butter. A sample of 10 grams of the unfiltered oil was titrated immediately by the procedure described above for butter in order to determine its acid value. The percentage of the butter acidity closely associated with the fat was computed and referred to as the acid ratio.

Chemical composition

All butter, when fresh, was analyzed for fat, water, salt, and curd by means of the Kohman method, as recommended by the Committee on Chemical Methods of the American Dairy Science Association (2), using the Mafis method for the salt determination.

GENERAL PROCEDURE

Samples of commercial salted butter received at the State College of Washington over a period of about 3½ years for monthly educational scorings were used in this study. The butter came from large and small plants in all parts of the state and was made from different types of cream handled in different ways. Each entry consisted of 2 prints of butter weighing 1 pound each, which were taken from the regular daily output of the plant and mailed in by the plant operator upon call from the college. Manufacturing reports filled out by the buttermakers accompanied the entries. The age of the butter, when examined, varied from 3 days to about 2 weeks but usually was about 1 week. All the butter was made from pasteurized cream but varied considerably in quality and was classified as type I, consisting of butter made without butter culture from cream not neutralized; type II, consisting of butter made without butter culture from neutralized cream; and type III, which was butter made with butter culture from neutralized cream. Type I butter was studied the most intensively.

The initial and churning acidities of the cream used in the manufacture of the 3 types of butter occasionally were not recorded by the buttermakers and, when reported, might be subject to criticism. However, according to the reported vat tests, the percentages of the initial acidity of the cream used for type I butter ranged from 0.11 to 0.26 (average 0.157), for type II butter from 0.18 to 0.77 (average 0.507), and for

type III butter from 0.34 to 0.67 (average 0.528). The percentages of the churning acidity of the cream used for the 3 types of butter were 0.11-0.26 (average 0.16), 0.16-0.35 (average 0.24), and 0.18-0.32 (average 0.23), respectively.

On arrival at the college laboratory, the butter was placed in a room at 0-5°C. Before being subjected to the various observations, the samples were rewrapped in plain parchment paper and provided with key numbers in order to conceal the identity of the samples from the judges and thus obtain impartial treatment in every test. The complete number of each sample begins with the initial letter or letters of the month, during which the sample was received; the last figure denotes the year (3 for 1933, 4 for 1934); and the preceding figures denote the number of the sample for the month.

Of each entry, 1 print was always subjected to the various observations when fresh. A part of the other print was carefully introduced into a sterile bottle and incubated at 21°C. for 1 week. The remaining portion was held at 0-5°C. for 1 month. All individual sample data are presented in the tables of the appendix.

RESULTS

Organoleptic Tests After 1 Week at 21°C.

Odor tests

To determine whether the keeping quality of salted butter at 0-5°C. bears any relation to the odor developed in the butter when held in a closed bottle for 1 week at 21°C., 67 samples of butter were studied. These samples were not judged for palate flavor after storage in the bottle at 21°C., but the intensity and undesirability of the odor were noted. The odors were described as good, fair, poor, and bad. The butter was scored in the regular manner when fresh and after storage for 1 month at 0-5°C. to determine its keeping quality.

The detailed results are given in table I of the appendix, which clearly indicates that the odor developing in the individual samples of salted butter during 1 week at 21°C. did not give an indication of the keeping quality of each sample when held for 1 month at 0-5°C. Table 1, in which the results are summarized, shows that of the 19 samples of type I butter, those with the best odor after 1 week at 21°C. actually lost the most points in flavor score during storage for 1 month at 0-5°C. and showed the lowest average flavor scores at the end of this storage period. If the deterioration of the butter during 1 week at 21°C. was at all comparable with that taking place during 1 month at 0-5°C., it must have been a deterioration in palate flavor rather than in aroma.

Table 1

The odor of salted butter held in a closed bottle for 1 week at 21°C. as related to the keeping quality of such butter when held for 1 month at 0-5°C.

Number of samples	Odor after 1 week at 21°C.	After 1 month at 0-5°C. loss in score average	loss in score range	score average	score range
I Butter made without butter culture from cream not neutralized					
8	good	1.06	0 to 2.5	35.81	34.0 to 38.0
7	fair	0.64	-0.5 to 2.5	36.14	35.5 to 37.0
3	poor	0.67	0 to 1.5	36.50	36.0 to 37.0
1	bad	0	0 to 0	37.00	37.0
19		0.79	-0.5 to 2.5	36.11	34.0 to 38.0
II Butter made without butter culture from neutralized cream					
9	good	0.56	-0.25 to 1.5	35.17	34.5 to 36.5
16	fair	0.72	-0.5 to 3.0	34.59	34.0 to 36.0
10	poor	0.65	-1.0 to 2.0	34.85	34.0 to 37.0
5	bad	1.10	0 to 2.0	34.40	33.0 to 35.5
40		0.72	-1.0 to 3.0	34.76	33.0 to 37.0
III Butter made with butter culture from neutralized cream					
1	good	1.00	1.0 to 0	34.00	34.0
4	fair	0.50	0.5 to 0	34.75	34.0 to 36.0
2	poor	2.25	1.0 to 3.5	34.00	33.0 to 35.0
1	bad	2.00	2.0 to 0	32.50	32.5
8		1.19	0.5 to 3.5	34.19	32.5 to 36.0
IV Summary - butter made from various types of cream					
18	good	0.82	-0.25 to 2.5	35.39	34.0 to 38.0
27	fair	0.67	-0.50 to 3.0	35.02	34.0 to 37.0
15	poor	0.87	-1.00 to 3.5	35.07	33.0 to 37.0
7	bad	1.07	0 to 2.0	34.50	32.5 to 37.0
67		0.79	-1.00 to 3.5	35.07	32.5 to 38.0

Noting the results on the 40 samples of type II butter, there is a slight, but inconsistent increase in the average flavor score losses during storage for 1 month at 0-5°C. as the odor becomes more objectionable in the bottle test. At the same time the average flavor scores after storage showed a slight tendency to decrease.

The number of samples of type III butter was too small to permit definite conclusions, but little correlation is apparent between the bottle test and the keeping quality of this type of butter when held for 1 month at 0-5°C.

Considering all 67 samples of butter combined, the odor observations after 1 week at 21°C. showed only a slight and inconsistent general relationship to the average flavor score losses and to the average flavor scores themselves after storage for 1 month at 0-5°C. Finally, the range of the scores and of the losses in scores during the month is so wide in each individual group of samples that the test must be considered of no practical value for predicting the keeping quality of butter.

Flavor and odor tests

In another set of 101 samples, the butter after being held for 1 week at 21°C. was given a regular flavor score, in which both taste and odor were considered, and the relationship of this score to the score after storage for 1 month at 0-5°C. was studied. The results for the individual samples may be found in table V of the appendix. They are summarized in table 2 and 3. In table 2, the samples, comprising butter of type I, II and III, are grouped according to their flavor scores when

Table 2

The score of salted butter when fresh as related to the accuracy of the bottle test in predicting the keeping quality of such butter when held for 1 month at 0-5°C.

Butter made with and without butter culture from cream neutralized and not neutralized

Number of samples	Score of fresh butter	Average loss in score during 1 week at 21°C.	Average loss in score during 1 month at 0-5°C.	Average difference*	Accuracy of bottle test % of samples for which keeping quality was predicted within 0.5 points	Accuracy of bottle test % of samples for which keeping quality was predicted within 1.0 points
10	38.0	1.65	1.45	0.20	60.0	100.00
9	37.5	1.56	1.56	0	66.7	100.0
8	37.0	0.94	1.00	-0.06	75.0	87.5
12	36.5	0.79	0.83	-0.04	75.0	83.3
10	36.0	1.15	0.95	0.20	60.0	90.0
16	35.5	0.69	0.63	0.06	81.3	93.8
19	35.0	0.16	0.26	-0.10	73.7	89.5
84	35.0 - 38.0	0.87	0.85	0.02	71.4	79.8
9	34.5	-0.44	0.28	-0.72	44.4	66.7
5	34.0	-0.60	-0.30	-0.30	40.0	80.0
3	33.5	-0.83	-0.17	-0.66	33.3	100.0
17	33.5 - 34.5	-0.56	0.03	-0.59	41.2	76.5
101	all scores	0.63	0.71	-0.08	66.3	89.1

*Average difference between the score losses during 1 week at 21°C. and those during 1 month at 0-5°C. and also the average difference between the scores after 1 month at 0-5°C. and the scores after 1 week at 21°C.

fresh. This was done, because it is a common observation, brought out also by the table, that high quality butter always loses more heavily in flavor score during storage than low quality butter, due to the fact that judges are generally less discriminating when scoring low quality butter. The table shows that with decreasing scores of the fresh butter there is a general downward trend of the losses in score during 1 week at 21°C. and during 1 month at 0-5°C. During these storage periods the samples scoring 35 or over in flavor lost 0.87 and 0.85 points respectively and the samples scoring below 35 gained 0.56 points and lost 0.03 points respectively. The average losses in the flavor scores of the butter during 1 week at 21°C. and during 1 month at 0-5°C. did not differ by more than 0.2 points in any quality group scoring 35 or over in flavor. The average difference was 0.02 points for the 84 samples scoring 35 and over when fresh, -0.59 points for the 117 samples scoring less than 35 when fresh, and -0.08 points for the entire group of 101 samples. For each of the 3 groups of butter scoring below 35 in flavor when fresh, this difference was as large as or larger than the average loss or gain in score during the month at 0-5°C., indicating that the bottle test is of no value for predicting the keeping quality of the low scoring butter. A satisfactory keeping quality test for this type of butter, however, could hardly be expected because of the small change in score during the test period, which varied from a loss of 1 point to a gain of 0.5 point, and because experienced butter judges frequently do not agree within 0.5 point on the score of a sample during one scoring. From one scoring to another, a week or a month apart, the standards of the judges may show considerably greater

variation.

Considering a prediction of the flavor score to within 0.5 point as satisfactory, it was found that the bottle test predicted the keeping quality of butter scoring 35 or more in flavor with an average accuracy of 71.4 per cent compared with 41.2 per cent for the lower scoring butter. In 20.2 per cent of the higher scoring samples, however, the bottle test score varied over 1 point from the flavor score after 1 month at 0-5°C. Nevertheless, the accuracy of the test was the greatest for the high scoring samples, which lost most heavily in score during storage and for which a keeping quality test, therefore, is most needed. For that reason the bottle test offers some promise of usefulness when applied to butter of high quality when fresh.

In table 3 the same samples, except for 3 which could not be definitely classified, are grouped according to type of butter and loss in flavor score during storage for 1 week at 21°C. The average flavor score losses during 1 month at 0-5°C. increased as the flavor score losses during 1 week at 21°C. increased. The range of flavor score losses was greater during 1 week at 21°C. than during 1 month at 0-5°C. because when the score losses during 1 week were low they were lower than the average losses during 1 month, but when the losses during 1 week were high they were higher than those during 1 month at 0-5°C. This was true for all types of butter examined. Thus it seems that butter deterioration manifests itself in a more pronounced manner at 21°C. than at 0-5°C.

As the losses in flavor score during 1 week at 21°C. increased, the average scores of the butter after storage for 1 month at 0-5°C. decreased,

Table 3

The loss in the flavor score of salted butter in the bottle test as related to the keeping quality of such butter when held for 1 month at 0-5°C.

Number of samples	Score loss during 1 week at 21°C. range	Score loss during 1 month at 0-5°C. average	average difference*	Average score after 1 month at 0-5°C.	Accuracy of bottle test % of samples for which scores were predicted within 0.5 point	1.0 point
I Butter made without butter culture from cream not neutralized						
15	0 to 0.5	0.77	-0.53	35.73	53.3	86.7
7	1.0 to 1.5	1.07	0.14	36.79	57.1	100.0
8	2.0 to 2.5	1.63	0.56	35.75	62.5	87.5
3	3.0	2.33	0.67	35.33	66.7	100.0
33	Ave. 1.17	1.18	-0.02	35.92	57.6	90.9
II Butter made without butter culture from neutralized cream						
15	-1.5 to 0.5	-0.03	-0.80	34.60	46.7	73.3
19	0 to 0.5	0.39	-0.18	35.05	89.5	94.7
18	1.0 to 1.5	0.69	0.42	34.92	72.2	94.4
4	2.0 to 2.5	1.50	0.63	34.75	75.0	75.0
56	Ave. 0.37	0.46	-0.09	34.87	71.4	87.5
III Butter made with butter culture from neutralized cream						
3	-1.5 to-0.5	0	-1.00	34.00	33.3	66.7
3	0 to 0.5	0.5	-0.17	34.67	100.0	100.0
2	1.0 to 1.5	0.75	0.50	35.00	100.0	100.0
1	2.0	1.0	1.0	34.50	0	100.0
9	Ave. 0.28	0.44	-0.17	34.50	66.7	88.9

*The average difference between score losses during 1 week at 21°C. and score losses during 1 month at 0-5°C.

excepting those samples, which during 1 week at 21°C. lost only 0 to 0.5 points. These latter samples, however, had a very low average score when fresh and this probably accounts for the low average flavor score losses of these samples during the week.

The last two columns of table 3 indicate the degree of accuracy with which the flavor score losses during 1 week at 21°C. predict the score losses during 1 month at 0-5°C. when individual samples are considered. The score losses during 1 month at 0-5°C. as well as the scores after such storage checked within 0.5 points with those recorded after 1 week at 21°C. for 57.6 per cent of the 33 type I samples of butter. The agreement within 0.5 point improved as the score losses in the bottle test increased. Agreement within 1.0 point was obtained in 90.9 per cent of the samples of this type of butter.

In the case of the 56 samples of type II butter, the percentages of agreement within 0.5 point and 1.0 point were 71.4 and 87.5 respectively and for the samples of type III butter 66.7 and 88.9 respectively. The variations in the flavor scores, after 1 week at 21°C. and after 1 month at 0-5°C., were not in the same direction, but sometimes the bottle test score was higher than the score after a month and sometimes lower, the cases being about equal in each group of samples. Individual samples, as shown in table V of the appendix, scored as much as 1.5 points higher and as much as 1.5 points lower after 1 week at 21°C. than after 1 month at 0-5°C. Thus, although the average difference between the two flavor scores was only 0.02 points for the samples of type I butter and 0.09 points for the samples of type II butter, the accuracy of predict-

ing the score of such butter after 1 month at 0-5°C. from the score after 1 week at 21°C. is not as great as might be desired. The number of samples of type III butter was too small to warrant definite conclusions but the above statements seem to hold true for this type of butter as well.

There were 43 samples of butter which lost 1 or more points in flavor score during storage for 1 week at 21°C. Considering only these samples, the score losses during 1 month at 0-5°C. agreed within 0.5 points with the losses during 1 week at 21°C. in 61.1 per cent, 72.7 per cent and 66.7 per cent of the samples of types I, II and III butter respectively. Agreement was within 1 point in 94.4 per cent of the type I butter samples, 95.5 per cent of the type II samples and 100 per cent of the type III samples.

It seems, therefore, that the bottle test was of some aid for predicting the keeping quality of butter which scored above 35 in flavor when fresh and of butter which lost heavily during storage for 1 month at 0-5°C. It seemed to be of no value with low scoring butter which usually did not lose very heavily in score during storage as compared with the high scoring butter. The course of the deterioration of salted butter during 1 week at 21°C. evidently does not in every case parallel that at 0-5°C. for 1 month, indicating that other than purely chemical factors probably are involved in the deterioration of such butter.

Bacterial Counts

Because of the small importance attributed by most investigators to bacterial counts as a criterion of the keeping quality of salted butter and because of rather unpromising results obtained in this investigation, only comparatively few data are presented here. The number of certain types of bacteria in salted butter, however, might conceivably have a bearing on the keeping quality of such butter held for 1 month at 0-5°C. For instance, proteolytic and lipolytic organisms, if active in the butter, would be expected to have a detrimental effect on keeping quality. Since many butter samples examined organoleptically after storage were criticized as slightly rancid, stale, old, unclean, old cream, or oily, which criticisms suggest fat decomposition, it was decided to study the relationship of the numbers of total, proteolytic, and lipolytic bacteria to the keeping quality of a limited number of butter samples when held for 1 month at 0-5°C.

Total bacteria

Table II of the appendix shows the counts on 24 samples of type I and 31 samples of type II butter. The samples of type I butter contained from about 500 to 1,800,000 total bacteria per ml. when fresh and from 2000 to 20,000,000 per ml. after storage for 1 month at 0-5°C. The samples of type II butter varied from 3300 to 2,320,000 total bacteria per ml. when fresh and from 8500 to 1,200,000 per ml. after storage.

Table 4, compiled from the data in table II of the appendix, in-

Table 4

The number of total bacteria found in salted butter as related to the keeping quality of such butter when held for 1 month at 0-5°C.

	Number of total bacteria per ml. in range		average	Number of samples	After 1 month at 0-5°C. average loss in score	average score
	I Butter made without butter culture from cream not neutralized					
Fresh butter	1,000,000 or over		1,675,000	2	0.50	34.25
	100,000 -	990,000	565,000	2	2.25	34.75
	10,000 -	99,000	34,182	11	1.45	35.73
	Below	10,000	4,972	9	1.11	36.06
	II Butter made without butter culture from neutralized cream					
	Over	1,000,000	1,590,000	4	0.06	34.44
	100,000 -	990,000	297,231	13	0.65	34.38
	10,000 -	99,000	43,833	12	0.88	34.58
	Below	10,000	4,950	2	1.50	33.75
	I Butter made without butter culture from cream not neutralized					
Fresh butter serum	1,000,000 or over		6,833,333	3	1.17	35.67
	100,000 -	990,000	262,208	12	1.42	35.75
	10,000 -	99,000	35,875	4	0.88	36.13
	II Butter made without butter culture from neutralized cream					
	10,000,000 or over		12,966,660	3	0.17	34.50
	1,000,000-	9,900,000	3,172,000	5	0.85	34.35
	100,000 -	990,000	529,667	12	0.63	34.88
	10,000 -	99,000	46,500	1	0.50	34.50
	I Butter made without butter culture from cream not neutralized					
Butter after 1 month at 0-5°C.	1,000,000 or over		10,525,000	2	2.00	35.25
	100,000 -	990,000	159,667	3	1.50	35.33
	10,000 -	99,000	22,470	10	1.35	35.60
	Below	10,000	3,575	4	0.63	36.63
	II Butter made without butter culture from neutralized cream					
	1,000,000 or over		1,200,000	1	0.50	35.50
	100,000 -	990,000	350,200	10	0.73	34.38
	10,000 -	99,000	38,000	7	0.71	34.57
	Below	10,000	8,500	1	0	35.00

dicates that the butter of type I tended to show higher keeping quality as the total count of the fresh butter decreased. No such trend was apparent with type II butter. With the latter samples of butter the average flavor score losses actually increased as the counts decreased so that deterioration here probably was not linked primarily with bacterial growth but may have been caused by enzymes or other agencies. Great inconsistencies occurred in the relationships between flavor score losses and the bacterial counts of individual samples as may be seen from table II of the appendix, so that the total count cannot be considered a definite index of keeping quality, even in the case of type I butter.

The situation is similar when the total counts of the fresh butter serum are considered. Here again the sample of type I butter showed a general correlation between high counts and low keeping quality, but the type II butter samples did not. The counts of the serum were considerably higher than those of the butter.

The best correlation was obtained between the total bacterial count in type I butter after 1 month at 0-5°C. and the keeping quality during such storage. The average flavor score losses decreased and the average scores after storage increased definitely with decreasing counts. The counts after storage, of course, would be of no help in predicting keeping quality, but the relationship lends weight to the supposition that the deterioration of type I butter during 1 month at 0-5°C. was caused to a considerable extent by microorganisms or their enzymes.

No relationship was found between the total bacterial counts of either the butter or the butter serum after 1 week at 21°C. and the keep-

ing quality of types I and II butter. The lack of correlation may be seen in table II of the appendix. Apparently bacterial development during 1 week at 21°C. was entirely different from that which occurred during 1 month at 0-5°C.

The change in the counts of total bacteria during storage for 1 month at 0-5°C. is of interest and may be studied from table II of the appendix. Of the 19 samples of type I butter, plated before and after storage, 11 increased and 8 decreased in total count. The 11 samples which increased in count lost an average of 1.41 points in flavor score during storage and those which decreased in count lost 1.13 points. The average flavor score after storage was 35.82 for the samples that increased in count and 35.63 for those that decreased.

Of the 19 samples of type II butter which were plated for total bacterial counts before and after storage for 1 month at 0-5°C., 8 increased in count during storage and 11 decreased. The average flavor score loss of the 8 samples which increased and the 11 samples which decreased in count was 1.19 and 0.30 points respectively. The average flavor scores after storage were 34.38 and 34.57 respectively. It seems, therefore, that the butter samples in which the bacteria were increasing in number during storage on the average lost most heavily in score during storage.

After storage for 1 week at 21°C. pronounced increases occurred in the total count of all but one of the samples of type I butter and in all but four of the samples of type II butter. The amount of the increases does not correlate with keeping quality. Reduction in numbers of bac-

teria occurred principally in those samples with high original counts.

As may be seen from table II of the appendix, large and sometimes tremendous increases occurred in the total count of the separated butter serum when held for 1 week at 21°C. Only in three cases was a decrease observed in the count. The increases were greatest when the salt in serum concentration was below 10 per cent but some considerable increases were noticed even when the percentage of salt in the serum exceeded 14.0. The curd material in the serum had a tendency to settle out and for that reason the organisms present in this curd may have been somewhat protected against the salt. It seems, however, that the ordinary salt concentrations used in all commercial butter made without butter culture, are not sufficient to prevent marked bacterial activity at 21°C. The increases in count of the serum held at 21°C. for 1 week, however, offered no clue to the keeping quality of the butter held for 1 month at 0-5°C.

Thus it was shown that in the case of type I butter the average score losses were lowest and the average scores after storage highest when the total bacterial counts of the fresh butter and butter serum and of the butter after storage were low. A general trend toward improved keeping quality seems to be associated, therefore, with low bacterial counts in this type of butter, although individual samples with high counts may keep well and others with low counts may keep poorly. With the samples of type II butter, the total bacterial count of both butter and butter serum, when fresh, and after 1 month at 0-5°C., showed absolutely no relationship to keeping quality.

The counts of the butter or butter serum after 1 week at 21°C. offered no clue to the keeping quality of either type I or type II butter, but samples of each type in which the bacteria decreased in number during storage lost more heavily in score on the average than those in which the counts decreased.

Whether the change in total bacterial count during 1 week at 0-5°C. would give an indication of the keeping quality of type I butter held for 1 month at this temperature, was not studied. Such a possibility exists but it is not probable that the increased number of bacteria will give a sure basis for predicting keeping quality even under such conditions.

Proteolytic bacteria

The numbers of proteolytic organisms were determined along with the number of total bacteria for the samples discussed above and are shown in table II of the appendix. It can be seen at a glance that the numbers of these types of organisms occurring in salted butter are rather insignificant. The numbers were so small that frequently no colonies or very few were found on the higher dilution plates necessary to determine total counts in the butter and butter serum after holding. Usually after 1 month at 0-5°C., the number had decreased. After 1 week at 21°C., occasionally there were increases in number, but usually the change was slight.

The proteolytic counts on the serum were, of course, very much larger than those on the butter. After 1 week at 21°C. only a few of the samples of serum had increased numbers of proteolytic organisms and most of them showed very few organisms of this type. The proteolytic bacteria

constituted from less than 1.0 per cent to 45.0 per cent of the total count but usually this percentage was around 10.0.

The relationship of the proteolytic counts to keeping quality is shown in table 5. Of the type I butter samples, 12 had proteolytic counts of 1000 per ml. and over when fresh and the same number had counts below 1000 per ml. The keeping quality was about the same for both groups. The samples which had proteolytic counts after storage for 1 month at 0-5°C. of 1000 or over per ml. on the average lost more heavily in score and received a lower score after storage than those samples with less than 1000 proteolytic organisms per ml. after storage. The samples which increased in proteolytic count during storage for 1 month at 0-5°C. showed a markedly higher loss of score and a lower score after storage than those which decreased in proteolytic count during the month of storage. The counts of the butter after storage for 1 week at 21°C. and the change in count during such storage bore no relation to keeping quality when held for 1 month at 0-5°C.

A high proteolytic count in the fresh serum was actually accompanied by improved keeping quality although a high count after 1 week at 21°C. and an increase in count during such holding produced higher average flavor score losses and lower average scores after storage.

There was no relationship between proteolytic counts and keeping quality for the samples of type II butter. The average loss in score during storage at 0-5°C. was practically the same and in some cases higher when the proteolytic counts were low in the butter and butter serum before and after storage than when they were high. Neither did

Table 5

The number of proteolytic bacteria found in salted butter and its serum as related to the keeping quality of such butter when held for 1 month at 0-5°C.

Proteolytic bacteria in	number per ml.	Number of samples	After 1 month at 0-5°C. average loss in score	average score
I Butter made without butter culture from cream not neutralized				
Fresh butter	1000 or over	12	1.29	35.46
	Below 1000	12	1.33	35.71
Butter after 1 month at 0-5°C.	1000 or over	8	1.44	35.50
	Below 1000	11	1.18	35.77
Butter during 1 month at 0-5°C.	increase	6	2.00	35.17
	decrease	11	1.00	36.05
Butter after 1 week at 21°C.	1000 or over	8	1.38	35.38
	Below 1000	8	.69	34.94
Butter during 1 week at 21°C.	increase	7	1.43	35.43
	decrease	4	1.38	35.00
Fresh butter serum	10,000 or over	9	1.00	36.11
	Below 10,000	10	1.50	35.55
Serum after 1 week at 21°C.	10,000 or over	6	1.58	34.92
	Below 10,000	9	1.50	35.61
Serum during 1 week at 21°C.	increase	4	1.88	34.88
	decrease	8	1.25	35.69
II Butter made without butter culture from neutralized cream				
Fresh butter	1000 or over	25	0.74	34.40
	Below 1000	6	0.63	34.54
Butter after 1 month at 0-5°C.	1000 or over	10	0.60	34.50
	Below 1000	9	0.75	34.47
Butter during 1 month at 0-5°C.	increase	3	0.33	35.17
	decrease	16	0.73	34.36
Butter after 1 week at 21°C.	1000 or over	8	0.88	33.75
	Below 1000	9	0.86	34.31
Butter during 1 week at 21°C.	increase	5	1.40	33.90
	decrease	7	0.86	33.86
Fresh butter serum	10,000 or over	9	0.64	34.92
	Below 10,000	11	0.61	34.48
Serum after 1 week at 21°C.	10,000 or over	5	0.65	34.15
	Below 10,000	12	0.71	34.58
Serum during 1 week at 21°C.	increase	2	0.25	34.50
	decrease	6	1.29	34.21

the increases or decreases in the proteolytic counts, occurring during storage in the butter and butter serum, show any relationship to keeping quality.

Thus proteolytic counts seem to offer comparatively little aid in predicting the keeping quality of salted butter. Some of the highest proteolytic counts were obtained on butter samples of good keeping quality and some very low counts were associated with poor keeping quality. These observations are particularly true for the samples of type II butter.

The results may perhaps justify the conclusion that an increase in proteolytic organisms during storage for 1 month at 0-5°C. tends to reduce the keeping quality of type I butter.

Lipolytic bacteria

Lipolytic counts were made on 100 samples of commercial salted butter, 38 of which were of type I and 62 of type II butter. The detailed results are given in table III of the appendix. From this table it may be seen that only 6 of the 38 type I butter samples showed the presence of lipolytic bacteria when fresh. Of these six samples, 4 showed no lipolytic colonies after storage for 1 month at 0-5°C. nor after 1 week at 21°C. The other 2 samples had increased lipolytic counts after storage for 1 month at 0-5°C. Only 1 sample appeared to contain lipolytic bacteria after 1 week at 21°C. The highest count before storage was 750 per ml. and the highest after storage was 1500 per ml.

Of the 62 type II butter samples, 27 showed the presence of a few lipolytic organisms, either when fresh, after 1 month at 0-5°C. or after

1 week at 21°C. The highest number recorded was 2500 per ml.

The actual number of the lipolytic organisms found would, therefore, not be suspected of being responsible for butter deterioration. All of the samples of type I butter in which lipolytic organisms were found, however, were criticized by the judges as being rancid, stale, old, or oily after storage and lost heavily in score. These criticisms were made on only about 50 per cent of the samples of this type of butter which showed no lipolytic organisms on the plates. A great many of the type II butter samples showing lipolytic organisms also received similar criticisms.

Since the presence of lipolytic organisms in butter must indicate inefficient pasteurization methods, contamination after pasteurization, or high heat resistance on the part of the surviving lipolytic organisms, it was considered possible that lipolytic enzymes might be associated with the lipolytic organisms and that these enzymes might be able to effectively hydrolyze the butterfat causing the development of rancidity. For that reason table 6 was compiled. It shows that the samples in which lipolytic organisms were increasing in number during storage lost, on the average, a little more heavily in score than those samples in which these organisms were decreasing in number or were not present at all. The flavor score, itself, after storage also averaged a little lower for the samples with increasing counts of lipolytic organisms than for those with decreasing counts. The trend is most noticeable in samples of type I butter. The average keeping quality of samples, in which no lipolytic organisms were found, was similar to that of the samples

Table 6

The number and activity of lipolytic bacteria in salted butter as related to the keeping quality and to the acid values of such butter when held for 1 month at 0-5°C.

Number of samples	Number of lipolytic bacteria per ml. and their activity during storage	After 1 month at 0-5°C. average loss in score	After 1 month at 0-5°C. average score	Average acid value of butter when fresh	Average acid value of butter increase during 1 month at 0-5°C.	Average acid value of butterfat when fresh	Average acid value of butterfat increase during 1 month at 0-5°C.	Average acid ratio when fresh	Average acid ratio increase during 1 month at 0-5°C.
I	Butter made without butter culture from cream not neutralized								
7	increasing	1.86	35.29	5.01	0.14	4.03	-0.06	80.76	- 3.63
4	decreasing	0.75	35.63	4.53	0.50	3.64	0.30	81.53	- 1.65
27	None found	1.22	35.87	5.05	0.39	3.89	0.86	77.56	11.20
II	Butter made without butter culture from neutralized cream								
12	increasing	0.83	34.54	5.88	1.08	4.41	0.80	75.48	4.44
15	decreasing	0.75	34.73	5.66	0.81	4.73	0.10	84.16	- 8.15
35	None found	0.81	34.71	5.61	1.03	4.08	0.98	73.76	9.35
I	Butter made without butter culture from cream not neutralized								
	100 or over								
4	increasing	1.75	35.38	4.78	0.49	3.68	0.40	77.85	0.60
1	decreasing	1.50	35.50	4.25	0.50	3.05	0.75	71.80	8.20
	Under 100								
3	increasing	2.00	35.17	5.34	-0.34	4.50	-0.66	84.63	-12.20
3	decreasing	0.50	35.67	4.61	0.50	3.84	0.15	84.77	- 4.93
27	None found	1.22	35.87	5.05	0.39	3.89	0.86	77.56	11.20

Table 6 (cont'd)

Number of samples	Number of lipolytic bacteria per ml. and their activity during storage	After 1 month at 0-5°C. average loss in score	After 1 month at 0-5°C. average score	Average acid value of butter when fresh	Average acid value of butter increase during 1 month at 0-5°C.	Average acid value of butterfat when fresh	Average acid value of butterfat increase during 1 month at 0-5°C.	Average acid ratio when fresh	Average acid ratio increase during 1 month at 0-5°C.
II	Butter made without butter culture from neutralized cream								
	100 or over								
7	increasing	0.93	34.64	5.93	1.34	4.63	0.91	78.96	5.08
7	decreasing	1.00	34.71	5.71	0.86	4.79	0.21	83.64	- 4.80
	Under 100								
5	increasing	0.70	34.40	5.80	0.70	4.10	0.70	70.74	3.80
8	decreasing	0.53	34.75	5.61	0.79	4.69	0.04	84.61	-10.25
35	None found	0.81	34.71	5.61	1.03	4.08	0.98	73.76	9.35

with decreasing counts.

The lowest keeping quality resulted when 100 or more lipolytic bacteria per ml. were present or when a smaller number of such organisms were found per ml. and this number showed an increase during storage. These observations, however, do not warrant the conclusion that the deterioration was entirely due to the action of the lipolytic bacteria or their enzymes. The presence of these organisms may indicate a generally low sanitary efficiency in the plant and, therefore, the presence of various deteriorating agencies in the butter.

The data presented in table 6 also indicate that the average acid values for either the butter or the butterfat were no higher when lipolytic organisms were found in the butter than when none were present. Neither was any difference detected in the acid ratios, representing the percentage of acidity most closely associated with the butterfat.

Furthermore, the change in the acid values of the butter and of the butterfat during storage for 1 month at 0-5°C. and the change in the acid ratios during such storage showed no relationship, whatsoever, either to the number of lipolytic organisms found or to their activity during storage. Great individual variations in all of the data are apparent in table III of the appendix. It must be concluded, therefore, that the occasional presence of lipolytic organisms in a sample of salted butter, although a sign of an undesirable type of contamination, does not always indicate that the butter will deteriorate markedly during 1 month at 0-5°C.

Yeast and Mold Counts

Since neither total bacterial counts, proteolytic counts, nor lipolytic counts alone gave any definite indication of the keeping quality of salted butter and since a number of investigators have reported at least a general correlation between yeast and mold content and keeping quality in butter, a large number of yeast and mold counts were made in this investigation. On 54 samples of fresh type I and II butter, counts were made for total bacteria as well as for yeasts and molds and the data are shown in table IV of the appendix. It is apparent from this table that there is no direct relationship between the yeast and mold counts and the total bacterial counts of individual samples.

The data of appendix table IV are summarized in table 7. Here a general correlation between yeast and mold counts and total bacterial counts becomes apparent. The samples with yeast and mold counts of 500 or over per ml. had a median count for total bacteria of 340,000 per ml., whereas those samples containing less than 10 yeasts and molds per ml. showed a median total bacterial count of 6,550 per ml. There was a general decrease in the median total bacterial counts with decreasing yeast and mold counts.

It was also considered to be of interest to note the relationship of the yeast and mold count to the pH of type I butter. Since the samples, for which yeast and mold counts as well as total bacterial counts were made, comprised both type I and type II butter, and since the neutralizer used in the manufacture of type II butter would affect the pH of

Table 7

The number of yeasts and molds found in fresh salted butter as related to the number of total bacteria and to the pH of such butter when fresh

Number of yeasts and molds per ml.	Butter made without butter culture from cream not neutralized and neutralized cream: number of samples	Median counts: yeasts and molds per ml.	Median counts: bacteria per ml.	Butter made without butter culture from cream not neutralized: number of samples	Median counts of yeasts and molds per ml.	pH
500 and over	6	2215	340,000	29	1400	6.34
300 - 499	5	365	124,000	10	400	6.41
100 - 299	15	200	80,000	39	150	6.41
30 - 99	10	40	43,500	48	50	6.46
10 - 29	10	18	23,450	54	15	6.48
0 - 9	8	0	6,550	36	0	6.54

the butter, a group of 216 samples of type I butter was classified according to yeast and mold count and included in table 7 for a study of the pH. The data indicate that with decreasing yeast and mold counts there was a general increase in the average pH values, suggesting that a low pH value in type I butter is perhaps frequently due to a high activity of microorganisms in the serum of the cream, from which the butter was made or in the part of the serum retained by the butter as buttermilk. Since many harmless bacteria normally survive pasteurization while yeasts and molds should be destroyed by this process, it seems that the efficiency of pasteurization and the extent of later contamination harmful to the keeping quality of butter would be more correctly indicated by the number of yeasts and molds present in the butter than by the number of total bacteria.

All yeast and mold counts made in this study, including those shown in table IV of the appendix and those averaged in table 7, are recorded in table V of the appendix. From these data also table 8 was constructed, which shows the relationship of the number of yeasts and molds to the keeping quality of 216 samples of type I butter and 338 samples of type II butter. Here it may be seen that type I butter had by far the greatest losses in score during storage as well as the lowest final scores when the yeast and mold counts were 500 per ml. or over. As a matter of fact, the average losses in score decreased and the average scores after storage increased as the count dropped from 1000 and over per ml. to 50-99 per ml. As the counts dropped below this range, the average losses in score again increased and the average final scores

Table 8

The number of yeasts and molds in salted butter as related to the keeping quality of such butter when held 1 month at 0-5°C.

Butter made without butter culture

Range in number of yeasts and molds per ml. of fresh butter	Butter made from cream not neutralized after 1 month at 0-5°C.			Butter made from neutralized cream after 1 month at 0-5°C.		
	number of samples	average loss in score	average score	number of samples	average loss in score	average score
1000 and over	18	1.94	35.36	46	0.82	34.46
500 - 999	11	1.41	34.91	25	0.53	34.43
100 - 499	49	1.22	35.87	104	0.68	34.45
50 - 99	25	0.65	36.53	56	0.67	34.55
30 - 49	23	0.91	36.28	33	0.73	34.58
20 - 29	26	1.17	36.27	30	0.59	34.70
10 - 19	28	1.39	36.11	20	0.68	34.88
0 - 9	36	1.32	35.92	24	0.64	34.68
100 and over	78	1.42	35.62	175	0.69	34.45
20 - 99	74	0.92	36.36	119	0.67	34.59
0 - 19	64	1.35	36.00	44	0.65	34.77

decreased rather consistently. Thus the butter of type I seems to have kept best when it contained from 20-99 yeasts and molds per ml. or, more particularly, from 50-99 yeasts and molds per ml.

In the case of the butter of type II the relationship between yeasts and molds and keeping quality was less definite. The average figures indicate a slight general improvement in keeping quality to be associated with decreasing counts. The differences in keeping quality between the various groups of samples, however, were very small and the trend was not as uniform and, therefore, of less significance than in the case of type I butter. On the other hand, the losses in score in this type of butter were low because of the low initial scores and for that reason smaller differences would be expected.

The consistency of the trend indicated for the type I butter invites speculation as to its possible causes. No doubt there are several deteriorating agencies at work at the same time during the storage of butter. The poor keeping quality of the type I butter with the high counts of yeasts and molds probably was due to biological action combined with purely chemical action such as oxidation. When the yeast and mold counts were less than 100 per ml., the numbers of organisms present were probably insufficient to effect the breakdown of butter ingredients, leaving chemical action as the principal deteriorating factor. Although the numbers of organisms were insufficient to cause chemical breakdown, their demand on the oxygen supply present in the butter may have been great enough to reduce oxidation by purely chemical means. Thus, in view of the average figures obtained on a large number of samples, it may be assumed

that the presence of up to 100 yeasts and molds per ml. indicates such biological activity as might be desirable to check oxidative processes in type I butter held for 1 month at 0-5°C., but that larger numbers indicate the presence of biological factors destructive by their own powers of chemical decomposition.

To give support to the above theory, table 9 was compiled from the data in table V. Since it is well known that microbial activity commonly is retarded by the presence of increased concentrations of salt, and if the above speculation is correct, a high salt concentration should improve the keeping quality of butter in the high ranges of yeasts and molds, where the latter are exerting a harmful effect, while on the other hand, high salt should reduce keeping quality in the range where yeasts and molds are helpful in reducing oxidation. Table 9 indicates exactly that, since salt lowers the score losses in all yeast and mold ranges except the ranges of 50-99 per ml. and 30-49 per ml.

That an improvement in keeping quality was associated with the higher salt concentrations in the samples showing the lowest yeast and mold counts, may perhaps be due to the fact that the number of organisms was too low to be helpful in reducing oxidation, and at the high pH range of the type I butter the salt would have no accelerating effect on the chemical reactions which might tend toward the production of fishy or other flavors caused primarily by chemical changes.

Table 9

The salt concentration as related to the keeping quality of butter of various yeast and mold counts

Butter made without butter culture from cream not neutralized

Number of yeasts and molds per ml. of fresh butter	% salt in serum*	Number of samples	Average loss in score during 1 month at 0-5°C.	Average score after 1 month at 0-5°C.
1000 and over	Below 12.0	13	2.15	35.31
	12.0 and over	4	1.40	35.50
500 - 999	Below 12.0	4	1.81	34.63
	12.0 and over	7	1.18	35.07
100 - 499	Below 12.0	28	1.36	35.82
	12 and over	21	1.05	35.93
50 - 99	Below 12.0	12	.56	36.44
	12 and over	13	.73	36.62
30 - 49	Below 12.0	15	.87	36.20
	12 and over	8	1.00	36.44
20 - 29	Below 12.0	10	1.45	36.20
	12 and over	16	1.00	36.31
10 - 19	Below 12.0	17	1.50	36.06
	12 and over	11	1.23	36.18
0 - 9	Below 12.0	24	1.43	36.10
	12 and over	12	1.10	35.56

*100 x % salt : (100 x % fat)

Pasteurization Temperatures and Enzymatic Activity

It is quite generally accepted that pasteurization at temperatures of 82.4-85°C. (180-185°F.) by the continuous method and at temperatures of 62.8-65.6°C. (145-150°F.) for 30 minutes by the holding method destroys most of the vegetative bacteria, yeasts and molds ordinarily found in cream, but that the flash method at the temperatures mentioned will inactivate more of the enzymes than the holding method. For this reason the samples of type I butter were grouped according to the method of pasteurization of the cream used in their manufacture. Samples pasteurized at temperatures of 81.1-85°C. (178-185°F.) by the continuous method were placed in one group and samples pasteurized by the holding method at temperatures of 65.6°C. (150°F.) or below for 20-30 minutes in another. The temperatures and exposures were taken from the buttermakers' report blanks and for that reason cannot be vouched for. They are believed to be fairly reliable. The butter samples of each of the two groups described above were subdivided still further according to their yeast and mold content. This was done to enable a comparison of the importance of microbial and enzymatic action in the deterioration of butter during storage for 1 month at 0-5°C.

The samples of butter made from cream pasteurized at the higher temperatures and showing the presence of few yeasts and molds were considered to be lowest in enzymes and microorganisms and, therefore, subject chiefly to chemical deterioration. The samples made from

cream pasteurized at the lower temperatures and containing few yeasts and molds were considered to be subject principally to enzymatic deterioration. High pasteurization temperatures linked with a high count of yeasts and molds would suggest that heavy contamination with microorganisms of all kinds occurred after pasteurization and that deterioration in the butter might be due principally to the action of the yeasts and molds together with other microorganisms which make up the contamination. When the cream was pasteurized at the lower temperatures and the butter also contained large numbers of yeasts and molds, both enzymes and microorganisms were assumed to be active in deteriorating the butter. However, the activities of enzymes and microorganisms may not always be cumulative. They may be, to a certain extent, conflicting and thus produce confused results.

Table 10 shows the keeping quality of the butter samples grouped as explained above. The table was compiled from the individual data contained in table V of the appendix. The 28 samples of butter containing only 0-29 yeasts and molds per ml. and made from cream pasteurized by the continuous method at 81.1-85°C. showed the lowest loss in flavor score during storage and the highest score after storage, indicating that they were comparatively low in deteriorating agencies of all kinds. The next group of 56 samples containing 0-29 yeasts and molds per ml. and made from cream pasteurized at temperatures of 65.6°C. or below for 20-30 minutes was considered to be low in microorganisms but comparatively high in enzymes, and it appears that these samples on the average lost more heavily in flavor score during storage and had a lower average score after storage than the first

Table 10

Cream pasteurization temperatures as related to the keeping quality of salted butter whenheld for 1 month at 0-5°C.

Butter made without butter culture from cream not neutralized

Number of yeasts and molds per ml. of fresh butter	Cream pasteurization temperatures	Number of samples	After 1 month at 0-5°C. average loss in score	After 1 month at 0-5°C. average score	Assumed activity in butter: microbial	Assumed activity in butter: enzymatic
0 - 29	81.1 - 85°C.	28	1.04	36.27	Low	Low
0 - 29	65.6°C. or below	56	1.33	36.08	Low	High
100 or more	81.1 - 85°C.	20	1.88	35.50	High	Low
100 or more	65.6°C. or below	43	1.28	35.62	High	High
30 - 99	81.1 - 85°C.	23	1.01	36.45	Medium	Low
30 - 99	65.6°C. or below	23	0.59	36.37	Medium	High

group. The third group of 20 samples, containing 100 or more yeasts and molds per ml. and made from cream pasteurized by the continuous method at 81.1-85°C., lost most heavily in score and had a very low score after storage, presumably due principally to the high content of microorganisms. The fourth group, consisting of 43 samples containing 100 or more yeasts and molds per ml. and made from cream pasteurized at 65.6°C. or below for 20-30 minutes is the group, which might have been expected, for reasons stated above, to yield confusing end results. The table indicates that the keeping quality of this group of samples, as judged both by the loss of flavor score and the score after storage, was slightly better than that of the third group of samples. A possible explanation may be, that enzymatic action was reduced somewhat by the oxygen requirements of the microorganisms present. In each of the two remaining groups of butter samples in which the yeast and mold counts ranged from 30-99 per ml. there were 23 samples. The samples in one group were again made from cream pasteurized by the continuous method at 81.1-85°C. and in the other by the holding method at 65.5°C. or below for 20-30 minutes. It is seen that these groups of samples showed a lower loss in flavor score and a higher final score than did the other groups. The samples in the last group, on the average, lost less in score during storage but scored lower after storage than those in the preceding group again indicating confusing results when both enzymes and microorganisms may be active. The results for these last two groups of samples again seem to point to a beneficial effect of the presence of a certain small number of microorganisms in butter.

Generally speaking, flash pasteurization, coupled with reasonably low counts, produced the highest keeping quality. When the butter is heavily contaminated with microorganisms, flash pasteurization may not necessarily improve the keeping quality of type I butter. In this investigation, such butter actually showed a reduced keeping quality when compared with the butter made from cream pasteurized at 65.6°C. or below for 20-30 minutes.

Heavy contamination with microorganisms after pasteurization seemed to have a greater deteriorating influence on the keeping quality of butter than a reduction of the pasteurization temperatures of the cream from 82.4°C. by the flash method to 65.6°C. for 20-30 minutes. From these results it might be concluded that the keeping quality of butter made without butter culture from cream not neutralized when stored for 1 month at 0-5°C. is affected more seriously by the activity of microorganisms than by the activity of enzymes.

To study the effect of salt concentration on the activity of microorganisms as compared with the effect on enzymatic activity in butter, each group of samples presented in table 10 was further subdivided on the basis of salt concentration in the butter serum. Those samples in which the salt in serum concentration was below 12 per cent were compared for keeping quality with those having a salt in serum concentration of 12 per cent or more. These data are presented in table 11.

It is seen that in each group of samples a salt in serum concentration of 12 per cent or more, was associated with the lowest

Table 11

The salt concentration as related to the activity of enzymes and microorganisms in salted butter when held for 1 month at 0-5°C.

Butter made without butter culture from cream not neutralized

Number of yeasts and molds per ml. of fresh butter	Cream pasteurization temperature	% salt in serum	Number of samples	After 1 month at 0-5°C. average loss in score	After 1 month at 0-5°C. average score	Assumed activity in butter microbial	Assumed activity in butter enzymatic
0 - 29	81.1 - 85°C.	Below 12.0	14	1.29	36.39	Low	Low
		12.0 and over	14	0.79	36.14	"	"
	65.6°C. or below	Below 12.0	33	1.40	36.09	Low	High
		12.0 and over	23	1.23	36.05	"	"
100 and over	81.1 - 85°C.	Below 12.0	14	2.07	35.29	High	Low
		12.0 and over	6	1.42	36.00	"	"
	65.6°C. or below	Below 12.0	22	1.44	35.70	High	High
		12.0 and over	21	1.11	35.52	"	"
30 - 99	81.1 - 85°C.	Below 12.0	12	0.69	36.73	Medium	Low
		12.0 and over	11	1.36	36.14	"	"
	65.6°C. or below	Below 12.0	15	0.77	35.97	Medium	High
		12.0 and over	8	0.25	37.13	"	"

average loss in flavor score, except in the group of samples made from cream pasteurized at 81.1-85°C. by the flash method and containing a medium number of microorganisms as indicated by a yeast and mold count of 30-99 per ml. In this group of samples the enzyme content should be comparatively low and the higher salt concentration appeared to be actually detrimental to the keeping quality of the butter, perhaps because of its inhibiting effect on the anti-oxidative activity of the limited number of microorganisms present.

To compare the effect of high salt, of low pH, and of these two factors combined on chemical, enzymatic and microbial activity in the butter, table 12 was prepared. Here the number of samples within some of the groups becomes rather small, thus lessening the significance of the results. The range of pH values found in type I butter also was small and may, therefore, have no marked effect on the activity of microorganisms and enzymes. Nevertheless, the data presented are of interest in some cases.

The samples of the first group, in which both microbial and enzymatic activity was assumed to be low and where purely chemical changes may have been chiefly responsible for deterioration, were not definitely improved in keeping quality by high salt. Insufficient samples were available to study the relationsip of a low pH and a combination of low pH and high salt on keeping quality. However, the one sample with a low pH showed markedly reduced keeping quality. Thus chemical deterioration was not inhibited by high salt and was probably increased by a low pH.

Table 12

The number of yeasts and molds, cream pasteurization temperature, pH and salt concentration as related to the keeping quality of salted butter when held for 1 month at 0-5°C.

Butter made without butter culture from cream not neutralized

pH of fresh butter	% salt in serum	Number of samples	After 1 month at 0-5°C. average loss in score	After 1 month at 0-5°C. average score	Assumed activity in butter microbial	Assumed activity in butter enzymatic
Butter showing 0-29 yeasts and molds per ml. when fresh						
Cream pasteurized at 81.1 - 85°C. (flash)					Low	Low
6.5 6.85	Below 12.0	13	1.19	36.5		
	12.0 and over	12	0.79	36.17		
Below 6.5	Below 12.0	1	2.50	35.00		
	12.0 and over	2	0.75	36.00		
Cream pasteurized at 65.6°C. or below for 20-30 minutes					Low	High
6.5 - 6.85	Below 12.0	25	1.51	35.96		
	12.0 and over	3	1.17	36.50		
Below 6.5	Below 12.0	8	1.06	36.50		
	12.0 and over	20	1.24	35.99		
Butter showing 100 or more yeasts and molds per ml. when fresh						
Cream pasteurized at 81.1 - 85°C. (flash)					High	Low
6.5 - 6.85	Below 12.0	11	1.86	35.50		
	12.0 and over	3	2.50	35.17		
Below 6.5	Below 12.0	3	2.83	34.50		
	12.0 and over	3	0.33	36.83		
Cream pasteurized at 65.6°C. or below for 20-30 minutes					High	High
6.5 - 6.85	Below 12.0	11	1.20	36.14		
	12.0 and over	4	1.38	35.13		
Below 6.5	Below 12.0	11	1.68	35.27		
	12.0 and over	17	1.04	35.62		
Butter showing 30-99 yeasts and molds per ml. when fresh						
Cream pasteurized at 81.1 - 85°C. (flash)					Medium	Low
6.5 - 6.85	Below 12.0	7	0.68	36.82		
	12 and over	6	1.42	36.17		
Below 6.5	Below 12.0	5	0.70	36.60		
	12 and over	5	1.30	36.10		
Cream pasteurized at 65.6°C. or below for 20-30 minutes					Medium	High
6.5 - 6.85	Below 12.0	8	0.69	36.13		
	12 and over	4	0.38	37.63		
Below 6.5	Below 12.0	7	0.86	35.79		
	12 and over	4	0.13	36.63		

In the second group of samples the relationship of high salt, of low pH, and of both together on the activity of enzymes may be studied. The results seem to show that enzymatic activity is retarded by each one of these factors. A low pH had the greatest inhibiting effect and the combination of a low pH and high salt the least.

In the third group of samples, where microbial activity is assumed to be chiefly responsible for deterioration, the number of samples is too small to yield conclusive data. High salt as well as a low pH seemed to actually aid the deterioration of the butter through microorganisms, although a combination of the two apparently retarded it markedly. The 6 samples low in pH, however, averaged higher in keeping quality than the 14 samples high in pH.

In the fourth group, where both microorganisms and enzymes are assumed to be active, high salt as well as low pH seemed to accelerate deterioration but a combination of high salt and low pH was less destructive to keeping quality.

In the fifth group, where a desirable number of microorganisms was assumed to be active, all factors, namely high salt, a low pH, and the combination of the two reduced keeping quality, possibly by reducing the anti-oxidative activity of the microorganisms.

In the last group, high salt and a combination of high salt and a low pH seemingly checked the harmful activity of the enzymes without greatly inhibiting the useful activity of the medium number of organisms present. A low pH alone proved detrimental to keeping quality.

The results for the last three groups, however, are difficult to

interpret, as might be expected, because of the complexity of the deteriorative factors in these samples. In general, the results indicate that the keeping quality of type I butter for 1 month at 0-5°C. is influenced more markedly by its content of microorganisms than by the enzymes surviving pasteurization at 62.8-65.6°C. for 20-30 minutes and the usual variations of pH and salt in that type of butter. For butter containing low yeast and mold counts, pasteurization at the higher temperatures seemed to be preferable to pasteurization at the lower temperatures from the standpoint of keeping quality. Within the group of samples low in microorganisms, as indicated by a low yeast and mold count, and made from cream pasteurized at the higher temperatures, the highest pH values were associated with the best average keeping quality. Finally, with butter made from flash pasteurized cream, low in yeast and mold count and high in pH, the normal variations of salt in serum concentration (from 10-13 per cent) had a comparatively small effect on keeping quality. The keeping quality of butter low in yeasts and molds and made from cream pasteurized at the lower temperatures, was improved by the higher salt in serum concentrations and lower pH values. This was not true for the heavily contaminated samples, although a combination of high salt and low pH seemed to be beneficial.

It seems, therefore, that the best keeping quality in type I butter will be obtained under conditions conducive to low yeast and mold counts and high pH values and by using the higher temperatures of pasteurization. With such butter, a high salt content is of no great advantage for attaining high keeping quality.

pH Values

Range of pH values

In all studies pertaining to the chemical changes occurring in various products, increasing attention is being given to true acidity, as indicated by the pH value, especially since the development of accurate and simple methods for its determination. For that reason the pH values of a large number of butter samples were studied and the detailed results are shown in table V of the appendix. Table 13 gives a summarization of the pH values listed in table V.

The lowest pH value found in the 651 determinations was 5.3 and the highest 7.8. The average pH values for the 221 samples of type I butter, the 389 sample of type II butter and the 41 samples of type III butter were 6.45, 6.53 and 6.36 respectively. The five samples of type I butter which had a pH of less than 6.0 were made no doubt from cream no longer sweet as indicated by the manufacturing records for some of them. Omitting these, the average pH value of the remaining 216 samples of type I butter was 6.47. For 48 of these, the acidity of the cream from which they were made was known to be less than 0.2 per cent, averaging 0.15 per cent. The average pH value of these samples was 6.49, the minimum 6.0 and the maximum 6.8. Eleven samples of type I butter made from cream with an acidity of 0.2 per cent acid or over (average 0.22 per cent) had an average pH value of 6.24.

Table 13

Distribution of butter samples according to their pH values

pH value	Number of samples of butter made without butter culture from cream not neutralized	without butter culture from neutralized cream	with butter culture from neutralized cream	from various types of cream
5.3 - 5.39		1		1
5.4 - 5.49		1	1	2
5.5 - 5.59	2	1	2	5
5.6 - 5.69		2	1	3
5.7 - 5.79		1		1
5.8 - 5.89	3	8		11
5.9 - 5.99		9	2	11
6.0 - 6.09	6	19	1	26
6.1 - 6.19	10	19	5	34
6.2 - 6.29	17	38	6	61
6.3 - 6.39	27	37	5	69
6.4 - 6.49	47	46	2	95
6.5 - 6.59	48	48	3	99
6.6 - 6.69	29	40	2	71
6.7 - 6.79	21	24	2	47
6.8 - 6.89	11	19	3	33
6.9 - 6.99		21	3	24
7.0 - 7.09		16	2	18
7.1 - 7.19		8	1	9
7.2 - 7.29		7		7
7.3 - 7.39		8		8
7.4 - 7.49		3		3
7.5 - 7.59		8		8
7.6 - 7.69		3		3
7.7 - 7.79		1		1
7.8 - 7.89		1		1
Total	221	389	41	651
average pH	6.45	6.53	6.36	6.48

Hunziker and Cordes (57) report an average pH of 6.34 and a maximum of 6.49 for butter made from cream of 0.15 per cent acidity, and an average of 5.79 (range 5.7-5.89) for butter made from cream of 0.25 per cent acidity. Thus their maximum pH of 6.49 corresponds with an average of 6.49 found in Washington butter. No attempt is made here to account for the higher level of pH for the western butter. The conclusion of Hunziker and Cordes that pH values in the range of 6.5 to 7.0 or above might indicate the use of neutralized cream, therefore, does not seem to hold generally. Of the type I butter samples in this study, over 45 per cent fell within this range and the maximum pH for this type of butter was 6.85.

Of the 216 samples of type I butter with pH values of 6.0 or over, 44 per cent fell within the pH range of 6.4-6.59. This range also was the most common with the samples of type II butter but the samples in this range constituted only 24.2 per cent of the total, the remaining samples being scattered over a wide pH range. The pH values of the samples of type III butter also were widely scattered.

All of the butter of type I, 74.6 per cent of type II butter, and 70.7 per cent of type III butter had pH values within the range of 6.0-6.8. Of all samples included in this study, 82.2 per cent had pH values falling within this range. Parfitt (89) reported the pH range of 468 samples of butter from Indiana and neighboring states as 4.6-8.0. Table 14 compares the distribution in various pH ranges of the Indiana samples as shown by Parfitt with that for the Washington butter included in this study. The percentage of samples in the highest range of pH was similar in the Indiana butter and in the

Table 14

Distribution of butter samples in various pH ranges

pH range	Indiana butter % of 468 samples according to Parfitt (89)	Washington butter % of 651 samples of all types	Washington butter % of 430 samples of types II and III
Over 7.0	10.03	6.1	9.3
7.0 - 6.51	25.42	29.6	30.7
6.5 - 6.01	38.23	55.0	48.6
6.0 - 5.51	18.58	8.0	10.0
5.5 - 5.01	4.06	1.2	1.4
Below 5.0	3.65	0	0

type II Washington butter. The considerably larger proportion of the Indiana samples in the lower pH ranges may have been due to the more widespread use of butter culture in Indiana.

Table 15 shows the general relationship of the pH value of fresh butter to the quality of the butter when fresh and after a month at 0-5°C. It includes the results on all samples listed in table V for which the scores when fresh and after storage were available, with the exception of the November, 1936, and December 1936 samples. For the latter months only the type I butter samples are shown in table V for use in later summary tables.

The data reveal that for the 204 samples of type I butter the average flavor scores, when fresh and after a month, increased with fair consistency with an increase in the pH values. At the same time as the pH values increased, the average losses in score during the month decreased with the exception of the few samples showing pH values of less than 6.0. These probably were made from cream in which considerable amounts of acid had developed. The data, therefore, suggest that the highest possible pH values commonly found in type I butter is desirable from the standpoint of both the quality and the keeping quality at 0°-5°C. of that type of butter. The trend of the butter with a high pH value to show lower losses in flavor score during storage combined with higher original scores gives double justification for the conclusion that a high pH value (6.6-6.89) is desirable in type I butter because high scoring butter normally tends to lose more heavily in flavor score than lower scoring butter. The average fresh flavor score was noticeably reduced when the pH value dropped below 6.3 and was markedly lowered

Table 15

The pH value of fresh salted butter as related to the quality when fresh and to the keeping quality of such butter when held for 1 month at 0-5°C.

pH values of fresh butter	Number of samples	Average score of butter when fresh	Average score of butter after 1 month at 0-5°C.	Average score of butter decrease during 1 month at 0-5°C.
I Butter made without butter culture from cream not neutralized				
5.4 - 5.69	2	36.00	35.25	0.75
5.7 - 5.99	3	36.50	35.67	0.83
6.0 - 6.29	28	37.01	35.59	1.42
6.3 - 6.59	113	37.21	35.95	1.25
6.6 - 6.89	58	37.30	36.19	1.12
Average 6.44	204	37.19	35.96	1.26
II Butter made without butter culture from neutralized cream				
5.4 - 5.69	4	34.25	33.13	1.13
5.7 - 5.99	17	35.65	34.50	1.15
6.0 - 6.29	69	35.43	34.75	0.68
6.3 - 6.59	113	35.28	34.56	0.73
6.6 - 6.89	75	35.22	34.60	0.63
6.9 - 7.19	39	35.08	34.39	0.69
7.2 - 7.49	17	34.87	34.38	0.49
7.5 - 7.80	11	34.86	34.09	0.77
Average 6.53	345	35.25	34.54	0.71
III Butter made with butter culture from neutralized cream				
5.4 - 5.69	3	34.33	33.50	0.83
5.7 - 5.99	1	34.00	34.50	-0.50
6.0 - 6.29	11	35.36	34.59	0.77
6.3 - 6.59	10	35.40	34.80	0.60
6.6 - 6.89	6	35.08	34.50	0.58
6.9 - 7.19	6	35.17	34.67	0.50
Average 6.39	37	35.18	34.55	0.62

with pH values above 6.3.

In the case of the type II butter samples, the relationship of pH values to scores was entirely different. As the pH values increased from the range of 5.7-5.99 to the highest pH range, 7.5-7.8, there was a steady decrease in the average scores of the fresh butter. Below pH 5.7, however, the scores were markedly reduced. After a month at 0-5°C., the highest average flavor scores were found in the samples which, when fresh, had pH values of 6.0-6.29 and the scores decreased as the pH values both decreased and increased from this range. However, the differences in score were very slight for the pH range of 6.0-6.89.

The average losses in scores were very high in the pH range of 5.4-5.99, but did not vary markedly in the higher ranges of pH, except that they increased somewhat in the extremely high range of 7.5-7.8. Since the low fresh scores of the butter high in pH should tend to lower the score losses during storage, the best keeping quality of this type of butter when held for 1 month at 0-5°C. was obtained when the fresh butter had a pH of 6.0-6.89, which is the same range of pH previously found to be normal for type I butter. Since for type II butter the fresh scores averaged highest at a pH of about 5.8 and the month old butter a pH of about 6.2, and since the losses in scores showed a slight general decrease with an increase in pH, it seems logical to assume that type II butter to be stored for a longer period than a month should have a pH value higher than 6.2 in the fresh state. The reason that the losses in scores for these samples were much lower than for type I butter is due partially to the much lower

initial scores of the type II butter.

For the samples of type III butter the average pH values were slightly lower and keeping quality was slightly better than for type II butter. The difference, however, was very slight and the number of samples was small. The average flavor scores of the type III butter, when fresh and after a month at 0-5°C., were lower when the pH values dropped below 6.0. Scores were highest within the pH range of 6.3-6.59. The average losses in scores during storage were only slightly lower at the higher pH ranges.

Thus it appears from table 15, the highest average fresh scores for types I, II and III butter were obtained at the pH ranges of 6.6-6.89, 5.7-5.99 and 6.3-6.59 respectively, and the highest scores after 1 month at 0-5°C. within the pH ranges of 6.6-6.89, 6.0-6.29 and 6.3-6.59 respectively. To produce a butter combining the best possible flavor when fresh with a fair keeping quality for a month at 0-5°C., the optimum pH values would seem to lie within the range of pH 6.3-6.89 for type I butter, pH 6.0-6.89 for type II butter and pH 6.0-6.59 for type III butter. For highest keeping quality during longer storage periods, higher pH ranges might be desirable. This seems to be substantitated by the work of Arup and Gilmour (4) who concluded that the keeping quality of butter in storage for six months at -7°C. was better when the pH was above 6.7 than when it was below 6.7.

A knowledge of the pH value of salted butter, therefore, is of some value in predicting its keeping quality at 0-5°C., especially in the case of type I butter. For butter made from cream, which had to be neutralized, the effect of the pH value on keeping quality was

no doubt over-shadowed in many cases by other important factors entering into the picture.

Change of pH during holding

The changes in the pH values of salted butter during storage for a month at 0-5°C. were observed on a limited number of samples. It was noted that the changes were comparatively slight and seemingly of no particular significance. For that reason pH values after storage were determined only on 70 samples of type I butter, 138 samples of type II butter, and 9 samples of type III butter. The individual results are recorded in table V of the appendix.

The changes in the pH values of the 70 samples of type I butter varied from +0.4 to -0.6. An increase in pH value was shown by 32 samples, a decrease by 36 samples and no change by 2 samples. For 16 samples, (23 per cent), the change in pH value, either upward or downward, was less than 0.1 and for 42 samples,(60 per cent), the change was less than 0.2. The average change in pH for this type of butter as indicated in table 16 was -0.02. Arup and Gilmour (4) found an average decrease in pH of 0.05 during storage at -2°C. and a decrease of 0.01 at -6°C. and -12°C. for six months. Parfitt (91), using the colorimetric method of pH determination, found an increase of 0.3 in the average pH value of 186 samples of contest butter during commercial cold storage for four months. The latter samples included butter made with and without butter culture.

In the 138 samples of type II butter, the maximum increase

in pH was 0.85 and the maximum decrease 0.65. The pH value increased during storage in 47 samples, decreased in 79 samples and remained the same in 12 samples. The change in pH was less than 0.1 in 43 of the samples (31 per cent) and less than 0.2 in 86 samples (over 60 per cent). The average change in pH was -0.06.

Of the 9 samples of type III butter 1 sample showed an increase in pH of 0.9. The greatest decrease was 0.3. The data for this type of butter are considered insufficient to warrant further discussion.

Since the optimum pH value in the fresh butter from the standpoint of the resulting flavor seemed to be higher for butter to be stored for 1 month at 0-5°C. than for fresh butter, one might assume that an increase in pH during storage would act favorably toward keeping quality. From table 16 it may be seen that for each type of butter an increase in pH values of 0.2 or more was associated with a slightly lower average loss in flavor score and a slightly higher average score after storage than a decrease of 0.2 or more. The difference, however, was very small and, therefore, of little significance.

Examining further the relationship of change in pH value to change in score in table 16, it will be seen that for type I butter the average loss in score was lowest and the average score after a month highest when the pH value increased 0.20 to 0.29 during storage. As the increase in pH during 1 month at 0-5°C. became greater than 0.29 or smaller than 0.2, the average keeping quality of this type of butter was lowered as judged by loss in score and score

Table 16

The change in the pH value of salted butter during storage as related to the keeping quality of such butter when held for 1 month at 0-5°C.

Number of samples	After storage of butter for 1 month at 0-5°C. increase in pH value	average loss in score	average score
I	Butter made without butter culture from cream not neutralized		
3	+0.4	1.17	35.67
5	+0.39 to +0.30	1.00	36.20
5	+0.29 to +0.20	0.10	36.70
42	+0.19 to -0.19	1.00	36.14
8	-0.20 to -0.29	1.25	35.69
7	-0.30 to -0.60	2.18	34.86
70	Average -0.02	1.10	35.99
II	Butter made without butter culture from neutralized cream		
4	+0.85 to +0.40	0	35.13
3	+0.39 to +0.30	0.75	35.00
8	+0.29 to +0.20	1.00	34.31
86	+0.19 to -0.19	0.66	34.52
19	-0.20 to -0.29	0.79	34.46
18	-0.30 to -0.69	0.51	34.46
138	Average -0.06	0.66	34.52

after storage. A marked decrease in pH value, however, was more harmful to keeping quality than a marked increase. In the case of the type II butter, keeping quality apparently was slightly improved when the pH value increased 0.3 or more during storage. A decrease in pH value had little effect on keeping quality.

The pH changes occurring in butter during 1 week at 21°C. usually were found to be very slight. They progressed generally in the same direction as those occurring during 1 month at 0-5°C. Table 17, however, shows the general nature of the results obtained with a few samples of type I butter. It may be seen that, here too, increases in pH, even though small, were associated with lower average losses in score, both after 1 month at 0-5°C. and after 1 week at 21°C. than decreases in pH. However, since the changes often were so slight as to be within the range of possible experimental errors, it is doubtful whether they are of practical importance as an aid in predicting the keeping quality of butter.

Combinations of pH and Salt and Salt Content Alone

Under the heading of "Pasteurization Temperatures and Enzymatic Activity," the influence of salt concentration and pH on certain agencies, such as enzymes and microorganisms, associated with the deterioration of type I butter, was studied. It was considered desirable also to note the relationship of various combinations of pH and salt concentration to the keeping quality of this type of butter when nothing was known regarding its content of enzymes and microorganisms. Therefore, table 18 was constructed from the data in

Table 17

The change in the pH value of salted butter during storage for 1 week at 21°C. as related to the keeping quality of such butter when held for 1 month at 0-5°C. and for 1 week at 21°C.

Butter made without butter culture from cream not neutralized

Sample number	After 1 week at 21°C. change in pH	pH	Loss in score during 1 month at 0-5°C.	Loss in score during 1 week at 21°C.	Score after 1 month at 0-5°C.	Score after 1 week at 21°C.
N 45	+0.10	5.60	0	1.0	37.0	36.0
Jy 85	+0.06	6.16	1.5	0.5	36.0	37.0
Jy105	+0.05	6.50	1.5	1.0	36.5	37.0
Jy165	+0.02	5.80	-0.5	0	35.5	35.0
Jy175	+0.01	6.67	0	0	36.5	36.5
	+0.06		0.50	0.50	36.3	36.3
Jy145	-0.01	6.45	1.5	1.5	36.0	36.0
Jy 35	-0.08	6.42	1.0	2.0	37.0	36.0
D 86	-0.08	6.64	1.5	1.0	36.5	37.0
	-0.06		1.33	1.50	36.5	36.3
Jy125	-0.11	6.35	1.0	1.5	36.5	36.0
O 75	-0.11	6.39	1.5	2.0	33.5	33.0
N 145	-0.13	6.47	0	3.0	38.0	35.0
N 205	-0.15	6.65	1.0	2.0	37.0	36.0
	-0.13		0.9	2.13	36.3	35.0
N 105	-0.20	6.00	1.5	1.5	36.0	36.0
D 156	-0.22	6.38	2.0	2.0	36.0	36.0
D 126	-0.39	6.05	0.5	-0.5	35.5	36.5
D 106	-0.44	6.16	1.0	2.5	37.0	35.5
	-0.31		1.25	1.38	36.1	36.0

Table 18

Variations of pH and salt content as related to the keeping quality of salted butter when held for 1 month at 0-5°C.

Butter made without butter culture from cream not neutralized

Number of samples	pH value of fresh butter	% salt in serum*	After 1 month at 0-5°C. average loss in score	average score
10	Below 6.3	8.2 - 10.9	2.05	35.00
14	(average 6.07)	11.0 - 12.9	1.23	35.54
2		13.0 - 14.4	0.83	36.11
13	Below 6.4	8.2 - 10.9	1.96	35.08
25	(average 6.17)	11.0 - 12.9	1.13	35.72
19		13.0 - 15.2	1.03	35.89
30	6.4 - 6.59	7.2 - 10.9	1.44	35.92
47	(average 6.47)	11.0 - 12.9	1.24	36.16
20		13.0 - 15.4	0.83	36.15
20	6.6 and over	9.5 - 10.9	0.93	36.23
39	(average 6.67)	11.0 - 12.9	1.24	36.20
4		13.0 - 14.2	1.50	36.00
10	6.4 - 6.59	7.2 - 9.9	1.68	35.85
20	(average 6.47)	10.0 - 10.9	1.33	35.95
28		11.0 - 11.9	1.35	36.02
19		12.0 - 12.9	1.09	36.38
12		13.0 - 13.9	1.00	36.04
8		14.0 - 15.4	0.56	36.31

*100 x % salt : (100 - % fat)

table V, using all samples of type I butter, for which all of the necessary information was available.

The table presents some rather striking results. It seems to show a marked effect of salt concentration on the keeping quality of the butter with pH values of less than 6.3. As the salt percentage in serum increased from less than 11 to over 13 the keeping quality of this butter improved uniformly and definitely, as indicated by reduced average losses in flavor score and by higher average flavor scores after storage for 1 month at 0-5°C. The same result is seen, only to a slightly lesser extent, when the group includes all samples with pH values below 6.4. In the large group of samples with pH values of 6.4-6.59, still the same result was apparent.

A different result, however, appears in the group of samples with pH values of 6.6 and over. It appears that salt was destructive to the keeping quality of this group of samples because the average losses in flavor score increased and the scores after storage decreased with an increase in the salt concentration.

Because of the large number of samples available with pH values of 6.4-6.59, this group was subdivided into 6 gradations of salt concentration and the rather uniform improvement in keeping quality with each small increase in the salt concentration.

It is possible that a low pH value in type I butter in a general way indicates a product of low biological purity and that an increased salt concentration in the serum checks the decomposing action of microorganisms and enzymes. If, on the basis of a similar

assumption, a high pH value in such butter is indicative of a small number of microorganisms in the butter, then the activity of such small numbers of organisms may be actually desirable because of their ability to reduce general oxidative processes taking place in the butter and increased salt concentrations would check this desirable function in the butter. It may be possible also that the salt catalyzes certain chemical changes which might be taking place at a high pH.

The contention that a low pH indicates a high degree of contamination in type I butter, is supported further by the fact that, the keeping quality of the samples of low salt concentration uniformly improved as the pH value increased, while this was not uniformly true for the samples high in salt.

The serum of butter is merely a remnant of the serum of the original cream. Its pH value, therefore, should reflect the activity of bacteria and enzymes in the cream before pasteurization and the larger the original contamination the larger will be the number of organisms and the amount of enzyme material remaining after pasteurization. It also must be remembered that the samples studied in this investigation were always several days old when examined and organisms and enzymes might have been active during these days in the butter.

Finally it may be seen from table IV of the appendix and the data summarized in table 19 that there is some actual correlation between the pH values and the numbers of yeasts and molds found in type I butter. As the pH values shown in table 19 increased, the median counts for yeasts and molds decreased with fair consistency.

Table 19

The pH value of fresh salted butter as related to the number of yeasts and molds and the amount of curd found in such butter

Butter made without butter culture from cream not neutralized

pH value of fresh butter	Number of samples	Median counts of yeasts and molds in fresh butter	Average % curd in butter
Below 6.10	11	260	0.70
6.1 - 6.19	10	148	0.84
6.2 - 6.29	17	105	0.76
6.3 - 6.39	27	60	0.75
6.4 - 6.49	48	35	0.71
6.5 - 6.59	55	45	0.72
6.6 - 6.69	33	20	0.74
6.7 - 6.79	22	18	0.76
6.8 - 6.89	11	20	0.72

As a matter of interest, the average per cent of curd found in the samples with the various pH values also is given in this table. The amount of curd material, which represents the most important source of food for the microorganisms in the butter, does not appear to bear any relationship to the pH values of the butter. It was very nearly the same in the samples with pH values of less than 6.1 as in the samples with pH values of 6.8-6.89.

To show the effect of salt alone on the keeping quality of type I butter and to present further proof of the biological nature of the deterioration which occurred in this type of butter at temperatures of 0-5°C., table 20 was compiled from the data in table V. There was a definite trend toward lower flavor score losses during storage and higher scores after storage as the salt in serum concentration increased. The differences, naturally, were not pronounced, because salt content was probably only one of several factors influencing the keeping quality of the butter. Nevertheless, the average figures obtained on a considerable number of samples must be considered of some significance.

Acid Values of Butter and Butterfat

Range of acid values

Acid values were determined on 87 samples of butter and on the butterfat separated from them. The determinations were made when the samples were fresh, after a week at 21°C. and after a month at 0-5°C.

Table 20

The salt in serum concentration of butter as related to its keeping quality when held for 1 month at 0-5°C.

Butter made without butter culture from cream not neutralized

% salt in serum	Number of samples	After 1 month at 0-5°C.	
		average loss in score	average score
Below 10.0	21	1.15	35.90
10.0 - 10.9	42	1.50	35.81
11.0 - 11.9	60	1.32	36.07
12.0 - 12.9	52	1.11	36.07
13.0 - 13.9	25	1.04	35.94
14.0 and over	18	0.94	36.14

Table VI of the appendix gives the individual values and table 21 gives the average, maximum, and minimum of those values converted into percentage of acid, calculated as lactic. The maximum acidity found in fresh type I butter was 0.170 per cent, and in the butterfat of such butter 0.115 per cent. These results, however, were obtained on a sample of butter which showed a serum pH of 5.5 indicating that the cream from which the butter was made was not sweet when churned, although it was churned without being neutralized. Omitting this sample and another one which had a pH of less than 6.0, the maximum acidity found in fresh type I butter was 0.130 and 0.115 per cent respectively. The maximum acidity found in these samples after storage, either for 1 week at 21°C. or 1 month at 0-5°C., was 0.145 per cent in the butter and 0.115 per cent in the butterfat, the figures 0.203 and 0.152 indicated in table 21 being again from the sample with the low pH. The minimum acidity encountered in type I butter was 0.070 per cent and in the butterfat of such butter 0.038 per cent.

The minimum acidity of any ffesh type II butter sample was 0.072 per cent, which is higher than the minimum acidity found in type I butter, even though the maximum pH in type II butter was 7.6 compared with a maximum pH of 6.8 for type I butter. Such observations are in harmony with the results of Hunziker and Cordes (57) who found that neutralized sour cream produced butter with a decidedly higher pH than the same cream not neutralized and churned at the same acidity.

The average per cent acidity of the fresh type I butter was 0.096

Table 21

Maximum, minimum and average acidities found in butter and butterfat and calculated from the acid values as percentages of lactic acid

	Percent acidity calculated as lactic acid in butter			butterfat		
	when fresh	after 1 week at 21°C.	after 1 month at 0-5°C.	when fresh	after 1 week at 21°C.	after 1 month at 0-5°C.
I Butter made without butter culture from cream not neutralized (28 samples)						
Maximum	0.170	0.203	0.169	0.115	0.152	0.131
(Maximum)*	0.130	0.145	0.131	0.113	0.115	0.112
Minimum	0.070	0.072	0.079	0.038	0.045	0.051
Average*	0.096	0.109	0.103	0.067	0.076	0.078
II Butter made without butter culture from neutralized cream (51 samples)						
Maximum	0.178	0.207	0.176	0.129	0.203	0.152
Minimum	0.072	0.079	0.083	0.038	0.050	0.063
Average	0.122	0.140	0.132	0.084	0.102	0.099
III Butter made with butter culture from neutralized cream (8 samples)						
Maximum	0.160	0.198	0.167	0.162	0.182	0.157
Minimum	0.110	0.119	0.144	0.070	0.065	0.098
Average	0.138	0.158	0.155	0.096	0.116	0.125

*Considering only the 26 samples with pH of 6.0 or over

and of the butterfat 0.067. The average per cent acidity of the fresh butter and butterfat of type II butter was higher, namely 0.122 and 0.084 respectively, and for the butter of type III the figures were highest, as would be expected, being 0.138 and 0.096 respectively. Nissen (81) reported the titratable acidity of butter in an aqueous mixture to range from 0.02 to 0.04 per cent, if made from cream of about 0.15 per cent acidity, and from 0.03 to 0.05 per cent if made from cream testing 0.25 per cent in acidity. The values in an alcoholic mixture are always considerably higher than those in an aqueous mixture, probably because of the release of fatty acids from the fat by the alcohol. The pH at the endpoint of the butter titration in alcohol as conducted in this study usually was 7.8-7.95 compared with 7.33-7.73 as reported by Nissen in his titrations in water. Even the pH of 7.9 as obtained in this work is considerably below the accepted endpoint of pH 8.2-8.4 of phenolphthalein.

Nissen suggests that the low pH at the endpoint may be due to high dilution, a high sodium chloride content of the butter, or the release of salts absorbed by the proteins. It is a well known fact that the pH of the endpoint of phenolphthalein varies with the shade of color produced in titration and that the endpoint color becomes obscured to a varying extent when titrating solutions of varying shades of color, such as milk, cream and butter. If the first appearance of a permanent pink color in a water solution of lactic acid is used as the endpoint of titration, the pH at the endpoint is always very much below 8.2-8.4, while cream titrated to the same shade of

color shows a pH of about 8.3. The explanation for the difference, no doubt, lies in the fact that the color is partially masked by the various constituents of the cream.

Furthermore, the endpoint pH varies with the material in which the acid is being titrated. It was found, for instance, in a number of trials that the presence of NaCl lowers the pH at the endpoint of acid titration, while the presence of alcohol and of certain fatty acids such as oleic acid raises the pH at the endpoint of lactic acid titration. The presence of salt in butter will, therefore, lower the pH of the phenolphthalein endpoint and tend to lower the acid value obtained. The titratable acidity of butter in alcohol is higher than that in water, because, no doubt, the alcohol releases certain fatty acids present in the butterfat which raise the pH of the endpoint. Due to the effects of salt, oleic acid and the color of butter on the endpoint pH of the acid titrations, the acid values of various types of butter may not be absolutely comparable.

Table 22 was compiled from table VI of the appendix to show the relationship of the acid values of the butter and of the butterfat to the loss in flavor score after storage for 1 month at 0-5°C. No close correlation is in evidence. Considering type I butter there appeared to be no definite trend for the average acid values to either increase or decrease with a decrease in flavor score losses, except that after storage for 1 month the average acid values of the butterfat decreased with a decrease in the score losses of the butter. In the case of the type II butter, there was a slight general trend for the average acid

Table 22

The acid values of butter and butterfat as related to the loss in flavor score of salted butter during storage for 1 month at 0-5°C.

Number of samples	Loss in score after 1 month at 0-5°C.	Average acid value of the butter: when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	increase during week	Average acid value of the butterfat: when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	increase during week
I	Butter made without butter culture from cream not neutralized								
9	2.0 to 2.5	5.34	5.73	6.28	0.94	3.36	4.63	4.36	1.11
12	1.0 to 1.5	5.82	6.03	6.63	0.81	4.08	4.53	4.46	0.38
6	0 to 0.5	5.38	5.65	5.93	0.55	3.84	4.23	3.99	0.15
1	-1.0 to -0.5	6.10	6.60	6.60	0.50	4.50	4.00	4.20	-0.30
28	Average 1.29	5.58	5.88	6.37	0.79	3.81	4.49	4.35	0.54
II	Butter made without butter culture from neutralized cream								
2	2.0 to 2.5	8.75	8.30	10.15	1.40	6.90	7.03	8.20	1.30
13	1.0 to 1.5	6.74	7.07	8.11	1.37	4.82	5.88	6.30	1.48
29	0 to 0.5	6.49	7.23	7.47	0.98	4.35	5.19	5.20	0.85
7	-1.0 to -0.5	7.39	7.83	7.84	0.46	4.84	5.73	5.53	0.70
51	Average 0.81	6.77	7.32	7.79	1.02	4.64	5.50	5.64	1.01
III	Butter made with butter culture from neutralized cream								
0	2.0 to 2.5	-	-	-	-	-	-	-	-
2	1.0 to 1.5	8.30	8.65	10.50	2.20	7.05	8.10	9.85	2.80
4	0 to 0.5	7.68	8.78	8.34	0.66	5.10	6.48	5.71	0.61
2	-1.0 to -0.5	6.98	8.10	7.93	0.95	4.20	5.45	4.40	0;20
8	Average 0.38	7.66	8.59	8.78	1.12	5.36	6.92	6.42	1.06

Table 22 (cont'd)

Number of samples	Loss in score after 1 month at 0-5°C.	Average acid value of the butter				Average acid value of the butterfat			
		when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	increase during week	when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	increase during week
IV	Summary - butter made from the 3 types of cream								
11	2.0 to 2.5	5.96	6.80	6.99	1.02	4.00	5.07	5.15	1.15
27	1.0 to 1.5	6.45	6.71	7.63	1.19	4.66	5.43	5.75	1.09
39	0 to 0.5	6.44	7.08	7.32	0.88	4.35	5.12	5.07	0.72
10	-1.0 to -0.5	7.18	7.46	7.74	0.56	4.68	5.48	5.18	0.50
87	Average 0.75	6.47	6.90	7.42	0.96	4.44	5.24	5.30	0.86

values to decrease with a decrease in the flavor score losses. The trend was rather indefinite for this type of butter, but was much more pronounced in the case of the type III butter.

However, it may be seen from the detailed data in table VI of the appendix that there is a very great range of acid values for the individual samples in each group and for that reason the acid values of either the butter or the butterfat are of no great value for predicting the keeping quality of individual samples of butter.

As pointed out before, a high loss in flavor score was of less significance for high scoring butter than for the lower grades. Since, therefore, loss in score alone was not an absolutely true measure of the keeping quality in butter, the relationship of the acid values to the actual flavor scores of the butter after storage also was studied. The summarized results are shown in table 23. They reveal that for the groups of type I and type II butter, which include a rather large number of samples, definitely increased average acid values of both the butter and the butterfat were associated with decreasing scores of the butter after storage. The relationship was not evident for type III butter, but the number of samples of this type was too small to warrant conclusions. It also may be that the improvement of the flavor by the butter culture overshadowed any ill effect which the high acidity might have had on the keeping quality.

When considering the 87 samples of butter of all 3 types combined, the trend toward higher acid values with lower scores after storage was quite distinct and this trend was apparent with the acid values of both the butter and butterfat when fresh, after storage for 1 week

Table 23

The acid values of butter and butterfat as related to the flavor score of salted butter during storage for 1 month at 0-5°C.

Number of samples	Score after 1 month at 0-5°C.	Average acid value of the butter: when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	increase during week	Average acid value of the butterfat: when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	increase during week
I	Butter made without butter culture from cream not neutralized								
5	37 and over	5.32	5.99	5.85	0.53	3.92	4.18	4.02	0.10
9	36 - 36.5	5.33	5.59	6.08	0.74	3.59	4.27	4.29	0.70
13	35 - 35.5	5.56	5.75	6.39	0.83	3.72	4.53	4.21	0.48
0	34 - 34.5	-	-	-	-	-	-	-	-
1	33 - 33.5	9.45	9.40	11.30	1.85	6.40	7.25	8.45	2.05
28	Average 35.86	5.58	5.88	6.37	0.79	3.81	4.49	4.35	0.54
II	Butter made without butter culture from neutralized cream								
2	37 and over	6.18	7.08	7.43	1.25	4.45	4.85	5.18	0.73
5	36 - 36.5	5.81	6.34	6.32	0.51	3.85	4.86	4.48	0.63
23	35 - 35.5	6.50	7.01	7.53	1.03	4.32	5.34	5.21	0.90
20	34 - 34.5	7.40	7.86	8.51	1.12	5.23	5.87	6.46	1.24
1	33 - 33.5	6.50	-	7.50	1.00	4.60	-	6.10	1.50
51	Average 34.97	6.77	7.32	7.79	1.02	4.64	5.50	5.64	1.01
III	Butter made with butter culture from neutralized cream								
0	37 and over	-	-	-	-	-	-	-	-
1	36 - 36.5	7.30	-	8.40	1.10	4.10	-	4.30	0.20
3	35 - 35.5	8.67	8.95	9.72	1.05	6.63	7.23	7.82	1.18
2	34 - 34.5	6.98	8.10	7.93	0.95	4.20	5.45	4.40	0.20
2	33 - 33.5	7.00	8.00	8.40	1.40	5.25	7.45	7.40	2.15
8	Average 34.25	7.66	8.59	8.78	1.12	5.36	6.92	6.42	1.06

Table 23 (cont'd)

Number of samples	Score after 1 month at 0-5°C.	Average acid value of the butter: when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	increase during week	Average acid value of the butterfat: when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	increase during week
IV	Summary - butter made from the 3 types of cream								
7	37 and over	5.56	6.35	6.30	0.74	4.07	4.40	4.35	0.28
15	36 - 36.5	5.62	5.82	6.31	0.69	3.71	4.45	4.36	0.64
30	35 - 35.5	6.35	6.74	7.32	0.97	4.29	5.22	5.08	0.78
22	34 - 34.5	7.36	7.87	8.46	1.10	5.13	5.85	6.27	1.14
4	33 - 33.5	7.49	8.70	8.90	1.41	5.38	7.35	7.34	1.96
87	Average 35.21	6.47	6.90	7.42	0.96	4.44	5.24	5.30	0.86

at 21°C., and after storage for 1 month at 0-5°C. The average flavor score after storage of the type I butter was higher and the average acid values were lower than the corresponding figures for type II butter. In turn, the average score after storage of type II butter was higher and the average acid values were higher than in the case of the butter of type III. It is evident, therefore, that high acid values usually were associated with low flavor scores of salted butter stored for 1 month at 0-5°C.

Table VI of the appendix and summary and tables 22 and 23 indicate that the acid values of all 3 types of butter usually were higher after 1 week at 21°C. than after 1 month at 0-5°C. The acid values of the butterfat averaged higher after 1 month at 0-5°C. than after 1 week at 21°C. although the differences were slight.

Increase in acid values

It was thought possible that the change of the acidity during storage of the butter might indicate biological and chemical activities and thus have a bearing upon keeping quality. Examining table 22, it is noted that the average increases in acid values of both butter and butterfat after 1 week at 21°C. become larger as the losses in flavor score during 1 month at 0-5°C. increased. In addition, table 23 shows that there is also a greater increase in these same acid values as the actual flavor scores after 1 month at 0-5°C. decrease. Thus there would seem to be a definite trend toward reduced keeping quality as measured by both score losses and scores after storage when the acid values of

the butter and especially the butterfat show a high increase after 1 week at 21°C.

Since the increases in the acid values of the butterfat indicate the best correlation with keeping quality, table 24 was prepared from the data in table VI of the appendix to show the resulting average flavor scores after storage for 1 month at 0-5°C. and the average score losses during such storage for samples classified according to the amount of acidity increase in the butter after 1 week at 21°C. The table shows a rather definite trend toward reduced keeping quality measured by both average score losses and average scores after storage with the higher increases in butterfat acidity during 1 week at 21°C. The trend was most pronounced with type I butter, but also was noticeable to a slighter degree for type II butter. The number of type III butter samples was again too small to warrant conclusions. It seems, therefore, that a high increase of the acid value of the butterfat during 1 week at 21°C. tends to be associated with low keeping quality in salted butter, especially in the case of type I butter.

Incidentally, it may be noticed from table VI of the appendix and table 22 and 23 that the increase in the acid values of all types of butter was usually higher during 1 week at 21°C. than during 1 month at 0-5°C. The increase in the acid values of the butterfat averaged nearly as high during 1 month at 0-5°C. as during 1 week at 21°C. and in many individual samples, especially of type I butter, it was greater. Whether acid development is greater at 21°C. or at 0-5°C. depends, no doubt, on the type, number, and physiological activity of the microorganisms and

Table 24

The increase in the acid value of butterfat during 1 week at 21°C. as related to the keeping quality of salted butter when held for 1 month at 0-5°C.

Number of samples	Increase in acid value of butterfat during 1 week at 21°C.			Average loss in score during 1 month at 0-5°C.	Average score after 1 month at 0-5°C.
I	Butter made without butter culture from cream not neutralized				
6	Below	-	0	0.58	36.42
8	0	-	0.45	1.06	36.00
6	0.5	-	0.95	1.67	35.67
5	1.0	-	1.45	1.70	35.70
1	1.5	-	1.95	2.00	35.50
2	2.0	-	2.45	1.75	34.75
0	2.5 and over			-	-
28	Average		0.54	1.29	35.86
II	Butter made without butter culture from neutralized cream				
5	Below	-	0	0.40	35.20
12	0	-	0.45	0.33	35.17
11	0.5	-	0.95	0.32	35.00
9	1.0	-	1.45	0.89	34.67
8	1.5	-	1.95	0.69	34.88
4	2.0	-	2.45	0.25	35.13
2	2.5 and over			1.00	34.50
51	Average		1.01	0.51	34.97
III	Butter made with butter culture from neutralized cream				
2	Below	-	0	0	33.50
1	0	-	0.45	0.50	36.00
2	0.5	-	0.95	0	34.75
1	1.0	-	1.45	1.00	35.00
1	1.5	-	1.95	0.50	35.00
0	2.0	-	2.45	-	-
1	2.5 and over			1.00	33.50
8	Average		1.06	0.38	34.25
IV	Summary - butter made from the 3 types of cream				
13	Below	-	0	0.42	35.50
21	0	-	0.45	0.62	35.52
19	0.5	-	0.95	0.71	35.18
15	1.0	-	1.45	1.17	35.03
10	1.5	-	1.95	0.80	34.95
6	2.0	-	2.45	0.75	35.00
3	2.5 and over			1.00	34.17
87	Average		0.86	0.75	35.21

enzymes present.

Acid ratios

Since the deterioration of the butter during storage, especially in the case of the type I butter, very often seemed to be in the nature of fat deterioration as judged from the criticisms of the judges, and since Frielinghaus (35) noted that the development of rancidity is accompanied by a significant increase in the ratio of butterfat acidity:butter acidity, it was thought to be of interest to study the effect of this ratio on the keeping quality of the samples listed in table VI of the appendix. Table 25 was constructed to show this relationship. It shows the ratio mentioned above as the percentage which the fat acidity constituted of the butter acidity. These percentage figures will henceforth be referred to as the acid ratios.

Table 25 indicates that the average acid ratios of the butter, when fresh, after 1 week at 21°C. and after 1 month at 0-5°C. generally increased as the losses in flavor score increased. The only exception was in the fresh butter of type I, where higher average acid ratios were found associated with the best keeping butter. However, after a week and after a month, this relationship for type I butter was reversed so that a much larger increase in the acid ratio was associated with the large score losses than with the small score losses. For instance, in the samples which lost 2.0 to 2.5 points in flavor score during storage, the butterfat acidity was 62.4 per cent of the butter acidity in the fresh butter, and this percentage increased to 72.1 after 1 week

Table 25

The acid ratio of salted butter as related to the loss in flavor score of such butter when held for 1 month at 0-5°C.

Number of samples	Loss in score during 1 month at 0-5°C.	The average acid ratio in the butter when fresh	after 1 week at 21°C.	increase during week	after 1 month at 0-5°C.	increase during month
I	Butter made without butter culture from cream not neutralized					
9	2.0 to 2.5	62.4	72.1	9.7	81.0	18.6
12	1.0 to 1.5	70.8	67.7	-3.1	74.9	4.1
6	0 to 0.5	71.8	66.7	-5.1	74.0	2.2
1	-1.0 to -0.5*	73.8	63.6	-10.2	60.6	-13.2
28	Average 1.29	68.4	68.8	0.4	75.3	7.9
II	Butter made without butter culture from neutralized cream					
2	2.0 to 2.5	78.9	81.2	2.4	85.3	6.4
13	1.0 to 1.5	71.3	76.8	5.5	83.8	11.9
29	0 to 0.5	66.8	69.0	2.2	72.1	3.4
7	-1.0 to -0.5	64.8	71.0	6.1	74.5	9.9
51	Average 0.51	68.2	71.7	3.5	75.7	7.5
III	Butter made with butter culture from neutralized cream					
0	2.0 to 2.5	-	-	-	-	-
2	1.0 to 1.5	83.7	93.9	10.3	93.6	10.0
4	0 to 0.5	67.3	68.6	1.3	73.9	10.3
2	-1.0 to -0.5	60.6	55.4	-5.3	67.3	10.0
8	Average 0.38	69.7	71.6	1.9	80.4	10.7
IV	Summary - butter made from the 3 types of cream					
11	2.0 to 2.5	65.4	73.8	8.4	81.7	16.3
27	1.0 to 1.5	72.0	74.0	2.0	80.4	8.4
39	0 to 0.5	67.6	68.6	1.0	72.5	4.9
10	-1.0 to -0.5	64.9	67.1	2.2	71.8	6.9
87	Average 0.75	68.4	70.8	2.4	76.2	7.8

*The sign indicates a gain in score instead of a loss

at 21°C. and to 81.0 after 1 month at 0-5°C. In the samples which lost little or even gained in score during storage, the average acid ratio decreased or increased only very slightly during storage. The smaller the loss in score was during storage the smaller was the average increase in the acid ratio. Thus it seems that the keeping quality of type I butter was increased when the acidity of the fat increased at a slower rate than the acidity of the butter. The relationship is not quite as apparent in the samples of type II butter but still holds true to a certain extent when the combined samples of all types of butter are considered.

To show still more distinctly the effect of the change of the acid ratio on the keeping quality of salted butter, table 26 is presented. It indicates that when the acid ratio in type I butter decreased during 1 week at 21°C., the average loss in flavor score during storage at 0-5°C. for 1 month was only about half as great as when the ratio increased. Furthermore, the average score itself after storage was distinctly higher when the acid ratio decreased than when it increased. In the case of type II butter, the loss in score under these conditions was nearly the same, although the actual score after storage averaged somewhat higher, when the acid ratio decreased during the week at 21°C. than when it increased.

In the case of type III butter samples, the loss in score was smaller but the final score the same, when the acid ratio decreased, as compared with an acid ratio increase.

Considering the effect of the change in acid ratio on the keep-

ing quality of individual samples, it was found that as the acid ratio increased or, in other words, when the acid values of the fat during the week at 21°C. increased faster than those of the butter, 8 of the 28 samples of type I butter lost 2-2.5 points in score during storage, whereas when the ratio decreased, only one sample lost as heavily in score. On the other hand, when the acid ratio increased, only 3 samples lost 1 point or less in score during storage, while 10 samples lost 1 or less points when the acid ratio decreased. Thus, a knowledge of the change in the acid ratio seems to offer a valuable aid in foretelling keeping quality, at least for type I butter. Although the acid ratio itself after 1 week at 21°C. is of some value for this purpose, it is not as significant as the change in ratio.

Table 26 also shows the relationship of the change in the acid ratio during a month at 0-5°C. to the keeping quality of the butter. Here an increase in the acid ratio was associated with a marked decrease in keeping quality of type I and type II butter considering both loss in score and score after storage. There were not enough samples of type III butter available for comparison. In 22 of the 26 type I butter samples, in 37 of the 44 type II samples and in 4 of the 5 type III samples studied, the acid ratio changed in the same direction during the week at 21°C. as during the month at 0-5°C. The average acid ratio for each type of butter studied was higher after storage than when fresh and higher after 1 month at 0-5°C. than after 1 week at 21°C. The figures are shown in table 25.

It is of incidental interest to note the relationship of the

Table 26

The change in the acid ratio of salted butter during storage at 21°C. and 0-5°C. as related to the keeping quality of such butter when held for 1 month at 0-5°C.

Number of samples	Increase in acid ratio during 1 week at 21°C.		Loss in score during 1 month at 0-5°C.	Score after 1 month at 0-5°C.
	range	average	average	average
I	Butter made without butter culture from cream not neutralized			
10	- 5.0* and less	-11.80	0.90	36.25
5	- 4.9 to - 0.1	- 2.36	0.90	35.80
4	0 to 4.9	2.10	1.63	35.63
9	5.0 and over	14.54	1.78	35.56
15	-24.2 to - 1.2	- 8.65	0.90	36.10
13	0.2 to 39.1	10.72	1.73	35.58
II	Butter made without butter culture from neutralized cream			
16	-39.6 to - 1.7	-10.81	0.59	35.19
35	0.1 to 34.7	10.18	0.47	34.87
III	Butter made with butter culture from neutralized cream			
5	- 9.4 to - 1.1	- 6.80	0.20	34.50
3	4.8 to 29.8	16.37	0.67	34.50

	Increase in acid ratio during 1 month at 0-5°C.			
	range	average		
I	Butter made without butter culture from cream not neutralized			
10	-20.3 to - 0.7	- 8.33	0.95	36.20
16	1.1 to 42.7	19.34	1.56	35.69
II	Butter made without butter culture from neutralized cream			
15	-43.8 to - 0.2	- 7.79	0.20	35.27
29	1.2 to 42.6	13.62	0.64	34.81

acidity of the fresh butter and butterfat to the quality of the fresh butter. Table 27 compiled from the data in table VI brings out this relationship. It shows that with decreasing scores of the fresh butter, the average acid values of both the fresh butter and butterfat increase, except in the case of the few samples of type III butter. The number of samples of the latter type of butter are insufficient to warrant conclusions.

As the scores of the fresh butter samples of type I decreased, the average pH values decreased, indicating that high acidity or a low pH was not conducive to high quality in the fresh salted butter of this type. No trend is indicated between scores and pH values in the case of the type II butter. Apparently high acid values in this type of butter were not associated definitely with low pH values. This relationship was studied further and is discussed below.

Summarizing the results of this study of the acid values of butter and butterfat, it must be said that no correlations exist which are definite enough to enable the prediction of keeping quality for every sample of butter. At the same time, certain trends may be noticed which should be helpful information to the person trying to anticipate the keeping quality of salted butter. Furthermore, since the nature of butter deterioration may vary greatly, and since the accuracy of butter scoring standards is far from what is desirable, such general trends, as were observed in this study, may have greater significance than they appear to warrant.

On the basis of the observations made here, it seems that the

Table 27

The acid values of fresh butter and butterfat and the pH of fresh butter as related to the flavor score of fresh butter

Number of samples	Score of fresh butter	Average acid value of fresh butter	Average acid value of fresh butterfat	Average pH value of fresh butter
I	Butter made without butter culture from cream not neutralized			
20	37 and over	5.18	3.51	6.50
7	36 - 36.5	6.20	4.31	6.31
1	35 - 35.5	9.45	6.40	5.50
0	Below 35.0	-	-	-
28	37.14	5.58	3.81	6.42
II	Butter made without butter culture from neutralized cream			
3	37 and over	5.27	3.03	6.43
13	36 - 36.5	6.63	4.76	6.48
29	35 - 35.5	6.81	4.65	6.52
6	Below 35.0	7.62	5.11	6.52
51	35.46	6.77	4.64	6.50
III	Butter made with butter culture from neutralized cream			
0	37 and over	-	-	-
2	36 - 36.5	8.1	6.55	6.15
2	35.5	8.55	5.45	6.75
4	Below 35	6.74	4.73	6.20
	34.88	7.66	5.36	6.33

most valuable aid in the prediction of the keeping quality of type I butter would be the change, during 1 week at 21°C., in the percentage of the butter acidity which is closely associated with the butterfat. When this acid ratio increased during 1 week at 21°C. the loss in score during storage for 1 month at 0-5°C. was much greater, as a general rule, than when the ratio decreased. The ratio itself after 1 week at 21°C. also averaged higher in the butter of the poorer keeping qualities. Another rather definite trend observed in this study was the trend toward reduced keeping quality of salted butter when the increase in the butterfat acidity during 1 week at 21°C. was high. The acid values themselves, either in the butter or in the butterfat, when fresh and after 1 week at 21°C. apparently are of less significance as an index of keeping quality. Acidity develops independently in butter and in butterfat during storage. It is the acidity increase of the fat in relation to the acidity increase of the butter taking place during storage, which appears to be the most significant factor in indicating the keeping quality of butter when stored for 1 month at 0-5°C.

Higher average acid values of both the butter and the butterfat also were found associated with lower flavor scores of the fresh butter. This relationship holds true especially for type I butter, but for type II butter a similar trend, although less pronounced, was noticeable.

Curd Content

A high curd content of butter frequently has been considered as

detrimental to keeping quality, for the reason that it contains nutrients, particularly nitrogenous materials, that are readily fermented by microorganisms. There is little doubt that the curd in the butter serum is one of the principal seats of activity of the microorganisms contained in butter. However, it is so rich in food material for bacteria that the ordinary variations, in which it occurs in butter, would hardly be expected to have a serious effect on biological activity. This is especially true, because the substances responsible for off-flavors need to be produced in only minute quantities to be detectable by taste and smell.

Table 28 was compiled from the data in table V of the appendix pertaining to type I butter. The table indicates no relationship between the curd content of this type of butter and its keeping quality when held for 1 month at 0-5°C. although the greatest average flavor score loss amounting to 1.54 points was associated with the group of samples containing the largest amount of curd recorded in this study, namely, 1.0 per cent or more. Neither the average score losses nor the average scores after storage for 1 month at 0-5°C. showed any definite relationship however to the percentage of curd in the butter.

As a matter of interest, the average pH values of each group of samples differing in curd content were computed and included in table 28. The average pH values are shown to be nearly the same for all groups of the fresh butter regardless of curd content.

It must, therefore, be concluded that the normal variations in the curd content of type I butter have no major effect on the keeping quality of type I under average conditions.

Table 28

Curd content as related to the keeping quality of salted butter held for 1 month at 0-5°C.

Butter made without butter culture from cream not neutralized

% curd in butter	Number of samples	After 1 month at 0-5°C. average score loss	After 1 month at 0-5°C. average score	Average pH values when fresh
Below 0.5	22	1.25	35.86	6.43
0.5 - 0.59	31	1.07	36.08	6.48
0.6 - 0.69	36	1.38	35.83	6.44
0.7 - 0.79	36	1.29	35.89	6.46
0.8 - 0.89	36	0.95	36.31	6.43
0.9 - 0.99	34	1.15	35.99	6.44
1.0 and over	21	1.52	35.94	6.44

Season

Because certain off-flavors in milk and cream, including oxidized, tallowy and bitter flavors, have been observed to be more or less seasonal in occurrence, it was decided to note the effect of season on the keeping quality of salted type I and type II butter when held for 1 month at 0-5°C. The samples of butter tabulated in table 29 include samples received during different years. The November and December samples were received during these months in four different years, while the January, August, September, and October samples were scattered over three years, and the April, May, June and July samples over two years. Unfortunately, February and March samples were available only during one year. The plants furnishing the samples were approximately the same ones each month. Thus the data presented should be fairly representative and comparable.

Considering type I butter, it appears that the average score losses during 1 month at 0-5°C. vary from 0.47 for July butter to 1.93 for March butter and the flavor scores after storage from 36.77 for July butter to 35.25 for January butter. Score losses go up and down considerably from month to month. It will be noticed, however, that the July samples had the highest keeping quality considering both average score during storage and average scores after storage and that the three months of May, June, and July averaged high in keeping quality compared with the other months. The month of February alone compared favorably with these months in the average score losses but the average scores for February butter were lower when fresh

Table 29

Season as related to the keeping quality of salted butter when held for one month at 0-5°C.

Months	Number of samples	After 1 month at 0-5°C. average score loss	When fresh average score	When fresh average pH
I Butter made without butter culture from cream not neutralized				
January	25	1.54	35.25	36.79	6.58
February	8	0.50	36.13	36.63	6.48
March	7	1.93	35.36	37.29	6.37
April	12	1.58	35.50	37.08	6.53
May	12	0.92	36.21	37.13	6.50
June	14	0.89	36.36	37.25	6.41
July	15	0.47	36.77	37.23	6.32
August	24	1.33	36.06	37.40	6.40
September	21	1.57	35.88	37.45	6.34
October	23	1.41	35.91	37.33	6.45
November	27	0.98	36.39	37.37	6.39
December	29	1.22	36.03	37.24	6.57
Jan. - Apr.	52	1.44	35.46	36.90	6.52
May - July	41	0.74	36.46	37.21	6.40
Aug. - Dec.	124	1.28	36.07	37.35	6.44
II Butter made without butter culture from neutralized cream					
January	42	0.72	34.30	35.02	6.56
February	14	0.32	35.14	35.46	6.48
March	9	0.89	34.06	34.94	6.43
April	25	1.08	34.38	35.46	6.49
May	18	0.54	34.61	35.15	6.67
June	19	0.97	34.47	35.45	6.58
July	22	0.23	34.41	34.64	6.61
August	41	0.63	34.60	35.23	6.65
September	38	0.93	34.39	35.33	6.46
October	44	0.59	34.73	35.32	6.49
November	35	0.53	34.84	35.37	6.34
December	38	0.84	34.47	35.32	6.55
Jan.-April	90	0.76	34.43	35.20	6.52
May-July	59	0.56	34.49	35.06	6.62
Aug.-Dec.	196	0.70	34.61	35.31	6.50

and after storage, and lower scores are usually associated with lower score losses. The average score losses for the three months of May, June and July are shown to be 0.74 compared with 1.28 for the fall months of August to December and 1.44 for the winter and early spring months of January to April. The severest winter weather in the State of Washington usually occurs in January and February. The highest scores after storage also were received by the May, June and July samples, averaging 36.46 compared with 36.07 for the later months and 36.46, a full point less, for the earlier months of the year. These results are considered significant, because of the considerable number of samples studied and because ordinarily high score losses during storage are associated with high original scores.

Of interest in this connection is the fact that the average pH values of the May, June and July samples were slightly lower than those for the samples of the earlier and later months of the year. The number of yeasts and molds per ml. and the curd content of the samples were similar for these three seasons of the year. Thus the results do not point toward superior sanitary quality of the May, June and July samples. They suggest a strong similarity with the observations of Hileman and Courtney (54) who conclude that bitter flavors and lipase content are at a minimum in New York cream during the months of June and July when bacterial counts are usually high. They cite the advance of the lactation cycle as one of the factors which increase lipase secretion.

The results of this study also appear to support the findings

of Tracy, Ramsey and Ruehe (128) who found that biological activity in cream, as induced by incubation at room temperature for 1-3 days and as evidenced by high bacterial counts, improved the quality of butter when metal salts were present. It is the author's judgment that metal salts would be present in considerable amounts in many samples of commercial butter today and that Washington butter would not be exceptional in that respect. Certainly it seems that some anti-catalytic agents may be active in the cream and butter produced during the early summer months. Such anti-catalytic effects may not only be associated with the stage of lactation and the activity of bacteria in producing hydrogen and consuming oxygen, but increased amounts of carotene, lecithin and curd protein in milk and cream have been suggested in the literature as possible anti-oxygens. The results of this investigation merely tend to increase the speculative interest in the presence of such anti-catalytic factors. Curd content of the butter studied was not affected by the season.

A few other observations of interest may be gleaned from table 29. For instance, it will be noticed that the average initial score of the fall samples was higher than that for the early summer samples and that the winter and early spring samples scored lowest. These results, no doubt, reflect to a certain extent the sanitary conditions on the farm in the production of milk and cream during these seasons of the year. The fall months with their cool temperatures and usual dry weather should be favorable to the production of butter with the least amount of contamination. The winter and early spring months

with their usual wet conditions are most inducive to bacterial contamination. In addition, more of the cows will be in the latter stages of their lactation period which, no doubt, would tend to lower the flavor score of the milk and cream produced at that time.

In the case of type II butter, season seems to exert a similar influence on the average loss of score during storage as with type I butter. Here too, the lowest average loss in score was recorded for the samples received in the months of May, June, and July. The differences, due to season, were not as pronounced with this type of butter as with type I butter. The average scores after storage were not quite as high for the early summer samples as for the fall samples. Fresh butter scores averaged lowest in the early summer months compared with the other months of the year, although the pH values of the fresh butter averaged highest. With these samples considerable neutralizing probably was necessary in the early summer months which would tend to increase the pH value. These relationships in type II butter are naturally much more complex than in type I butter and, for that reason, fewer conclusions can be drawn from the results obtained with them. For the type I samples this study seems to justify the conclusion that keeping quality was slightly superior during the months of May to July inclusive compared with the rest of the year.

DISCUSSION OF RESULTS

An increase in temperature accelerates most chemical reactions. If flavor deterioration in salted butter were brought about by purely chemical changes alone, the same type of deterioration should occur at a high temperature as at a low temperature, but within a shorter period of time. If bacteria or bacterial enzymes are also involved, an increase in temperature may change the nature of deterioration as well as its speed. Since for the butter samples studied, odor and flavor scores after storage for 1 week at 21°C., showed only a general correlation with the scores after 1 month at 0-5°C., and since individual samples often kept differently at the two temperatures, it would seem that the deterioration of commercial salted butter at 21°C. and at 0-5°C. is not due to purely chemical factors alone. Although the keeping quality of salted butter, when held in a closed bottle for 1 week at 21°C., did not always give an accurate indication of the keeping quality for 1 month at 0-5°C., the bottle test appeared to have some value in the case of butter scoring 35 or more in flavor when fresh. The flavor score after 1 week at 21°C. agreed to within 0.5 points with the flavor score after 1 month at 0-5°C. in 71.4 per cent of 84 such samples examined. The bottle test appears to be of little value in connection with butter scoring less than 35 in flavor when fresh. It is possible, however, that its value would be increased when used to indicate the keeping quality of butter held for a longer period of time. The odor alone perceived in butter after 1 week at 21°C. gave little indication

of the keeping quality for 1 month at 0-5°C.

The mere number of total bacteria found in salted butter can hardly be expected to give a clue to the extent of deterioration, which the butter will undergo during storage at 0-5°C. because many inert and harmless types of organisms may predominate in the flora of high count butter. Consequently, the lack of a perfect correlation found between total bacterial counts and keeping quality in individual samples of salted butter is not surprising. With butter of type I, there was, however, a general trend toward improved keeping qulity with decreasing total bacterial counts in the fresh butter, in the fresh butter serum and especially in the butter after storage. It seems, therefore, that in this type of butter, bacteria are an important factor in deterioration. This conclusion is not justified in the case of type II butter. The bacterial count of the butter or the butter serum after 1 week at 21°C. showed no correlation with the keeping quality of either type of butter held for 1 month at 0-5°C., indicating that bacterial development at 21°C. does not parallel that at 0-5°C.

The number of proteolytic and lipolytic organisms found in the samples of salted butter was small, which is in harmony with the findings of other investigators (112) (52) (62). The keeping quality of type I butter, however, averaged lower for the samples showing increasing numbers of proteolytic bacteria during storage than for those with decreasing numbers. Counts of 1000 or more per ml. in the fresh, and especially in the stored samples, were also associated with lower keeping quality of this type of butter than counts of less than 1000 per ml. No such trend

was noticeable for type II butter. No lipolytic bacteria were found in a great majority of the salted butter samples examined. Type I butter, however, averaged highest in keeping quality, when it contained less than 100 lipolytic bacteria per ml., which were decreasing during storage, and when no such organisms were detected. The number of lipolytic organisms found bore no relationship to the changes in the acid values of the butter and butterfat during storage.

The study of the number of yeasts and molds in the butter used in this investigation suggested that either these organisms, organisms associated with them, or their enzymes, had some influence on the keeping quality of the butter at 0-5°C. and especially again of type I butter. The fact that a high salt concentration improved the keeping quality of samples high in yeasts and molds, and did not cause an improvement when these organisms were present in small numbers, further points to the biological nature of the causative factors involved in the deterioration of type I butter. The observation that the presence of a limited number of yeasts and molds (50-99 per ml.) was associated with high keeping quality, is interesting and is similar to the findings of Thomson (127). It may be harmonized with the beneficial results obtained by Tracy, Ramsey, and Ruehe (128) in combating tallowy flavors in cream and butter by incubating the cream for a limited period of time at room temperature before cooling it down.

Since the results indicated that the yeast and mold counts generally reflected the extent of total microbial contamination in butter made without butter culture, and since the keeping quality of low count butter was

improved by high temperature pasteurization, it seems probable that enzymes surviving pasteurization at 65.6°C. for 30 minutes were involved in the deterioration of type I butter. These enzymes, however, proved to be less destructive to the average keeping quality of the butter than a high microbial contamination as indicated by yeast and mold counts of 100 or more per ml. The fact that the higher pasteurization temperatures did not improve the keeping quality of high count butter may possibly be due to counteractive effects produced by microorganisms on the activity of oxidizing enzymes. High salt concentrations seemed to retard both bacterial and enzymatic activity, but was most effective against bacterial action.

The normal range of pH values for type I butter was found to be 6.0-6.8, which is slightly higher than the range found by Hunziker and Cordes (57). The fact that for type I butter a higher quality when fresh and after 1 month at 0-5°C. tended to be associated with the higher pH values in the fresh butter would seem to justify butter dealers to prefer a high pH (up to 6.6-6.89) in such butter, if the butter is to be held for a considerable time at temperatures just above the freezing point of water.

In the case of type II butter, definitely reduced keeping quality seemed to be associated with pH values below 6.0 and above 6.8. Accurate neutralization procedures in connection with the manufacture of such butter, therefore, appears to be very desirable. The best average keeping quality for 1 months at 0-5°C. seemed to be associated with the samples showing pH values of 6.0-6.29. Since, however, the optimum pH appeared

to be higher for butter to be held for 1 month at 0-5°C. than for fresh butter, it may be that the longer this type of butter is to be held the higher should be its pH value when fresh. These observations should be very useful to the butter dealer.

Although the changes in pH during storage seemed to be somewhat related to the keeping quality of butter, they were so slight that they do not lend themselves as an aid in predicting keeping quality. Slatter (115) reported similarly small changes in the pH of salted butter during storage.

On the basis of further results obtained, a butter dealer looking for sweet cream butter with high keeping quality for 1 month at 0-5°C., would desire a rather high salt in serum concentration in butter of a low pH (less than 6.4), because a low pH value, may perhaps rightfully suggest to him a butter high in biological factors which would be capable of bringing about deterioration. In butter with a pH value of 6.6 or more, the average keeping quality was not improved but seemed to be slightly lowered by increasing salt concentrations.

Since the pH of the phenolphthalein endpoint in acid titration seemed to be raised by the presence of oleic acid and alcohol and lowered by the presence of lactic acid and salt, the acid values of rancid butter and those determined in an alcoholic mixture would be higher than those determined on the same butter when fresh and in an aqueous mixture, and the acid values of butter high in salt and acid would be lower than those of unsalted, low acid butter. Thus the acid values of all types of butter would not be absolutely comparable.

The acid values alone as determined in this study seemed to be of

only slight value in predicting the keeping quality of butter. However, the increase in butter acidity and butterfat acidity during 1 week at 21°C. and especially the increase in the acid ratio (butterfat acidity: butter acidity) appeared to be useful aids in the prediction of keeping quality in butter. High increases in the acid values and in the acid ratios during storage for 1 week at 21°C. were in a large majority of the cases associated with low keeping quality for 1 month at 0-5°C.

Since the highest flavor scores in type I and type II butter, when fresh, were usually associated with the lowest average acid values of both butter and butterfat, it seems that high acid values are indicative of low quality in fresh butter. This statement did not hold true for type III butter.

The percentage of curd in butter as determined by the Kohman method of butter analysis seemed to offer no aid in the prediction of keeping quality whatsoever.

The investigation revealed some justification for the well known preference of butter dealers for June butter for storage purposes. Although it seems that certain factors, perhaps in the nature of anti-oxygens, are at work in early summer butter, the nature of these factors was not studied and suggests an interesting field for further investigation.

SUMMARY AND CONCLUSIONS

Various factors, which might have a bearing upon the general trend of keeping quality in salted butter when stored for 1 month at 0-5°C., were studied over a period of about 3½ years involving approximately 650 samples of butter. The samples were received at monthly intervals from a group of Washington creameries, scored by the same judges and analyzed for chemical composition and bacterial content by standard methods. They were classified into 3 types: Type I butter made without butter culture from cream not neutralized, type II made without butter culture from neutralized cream and type III made with butter culture from neutralized cream. The results and the conclusions drawn from them may be summarized as follows:

The odor, which had developed in 67 samples of butter after storage for 1 week at 21°C., could not be correlated with keeping quality for 1 month at 0-5°C.

Complete flavor and odor scores placed on 101 samples of butter after 1 week at 21°C. did not check in every case with the flavor scores of the same samples after storage for 1 month at 0-5°C. However, the average flavor score after storage for 1 week at 21°C. checked within 0.02 points with the average flavor score after 1 month at 0-5°C. in the case of the butter scoring 35 or more in flavor when fresh and in 71.4 per cent of the individual samples the two scores showed agreement within 0.5 point. For butter scoring less than 35 in flavor when fresh the percentage of agree-

ment was only 41.2 per cent. Individual differences between the two scores ranged from +1.5 points to -1.5 points, but considering the samples of all butter which lost one or more points during storage for 1 month at 0-5°C., it was found that the score losses under the two conditions of storage agreed within 0.5 points in 61.1 per cent of the type I samples, in 72.7 per cent of the type II samples, and in 66.7 per cent of the type III samples. Since no fixed relationship was detected between the course of deterioration occurring in the butter under the two conditions of storage, it was concluded that biological factors as well as chemical factors are involved in the flavor deterioration of salted butter.

Although total bacterial counts were found to be of little value in predicting the keeping quality of individual samples of butter when held for 1 month at 0-5°C., it was shown that for butter of type I, the average keeping quality for 1 month at 0-5°C. improved as the total counts of the fresh butter and especially of the stored butter decreased. No such correlation was found for type II butter. At 21°C. bacterial counts had usually increased markedly after 1 week, indicating that the common salt concentrations of 10-14 per cent salt in the serum were not sufficient to inhibit bacterial growth in the butter at room temperature. However, the counts after storage for 1 week at 21°C. had no relationship to keeping quality at 0-5°C. with any butter.

Proteolytic bacteria were found in small numbers in both type I and type II butter. The number usually decreased during storage for 1 month at 0-5°C. and, although at 21°C. increases occurred more frequently,

they were usually not very large. However, proteolytic counts of 1000 or over in type I butter, when fresh and after storage, were associated with a lower average keeping quality than counts of less than 1000 and the samples showing increases in the count during storage averaged lower in keeping quality than samples with decreasing counts. These relationships did not hold true for type II butter.

Lipolytic bacteria were found in only a small percentage of the samples of salted butter examined. The samples in which no lipolytic bacteria were found, and those which contained less than 100 per ml. and in which the number was decreasing during storage, showed a higher keeping quality than those which contained 100 or more organisms of this type and those in which the count was increasing. Again this relationship did not exist in type II butter. The number of lipolytic organisms showed no relationship to either the acid values of the butter and butterfat before or after storage.

Yeast and mold counts on 554 samples of butter were studied. With 54 samples, for which total bacteria counts were also obtained, it was noticed that with groups of increasing yeast and mold counts the median total bacterial count also increased and the average pH of the fresh butter decreased. With type I butter, the highest keeping quality resulted when the number of yeasts and molds in the fresh butter was between 50 and 99 per ml. Keeping quality decreased on the average as the yeast and mold count increased or decreased from this range. It is hypothesized that in the samples with counts of 100 per ml. or over, deterioration was due, at least in part, to biological factors, while a

count of 50-99 yeasts and molds per ml. may indicate an optimum amount of biological activity, which is insufficient itself to cause chemical decomposition, but sufficient to check oxidative processes in the butter by reducing the available supply of free oxygen. This theory seems to be supported by the fact that salt, which is known to have a restraining action on bacterial activity, reduced the average keeping quality of those samples containing the optimum number of yeasts and molds, but improved the average keeping quality for the other groups of samples containing higher or lower numbers of yeasts and molds. There was no definite relationship between yeast and mold count and keeping quality in type II butter.

Type I butter, with less than 30 yeasts and molds per ml. and pasteurized by the flash method at 81.1-85°C., kept better than such butter having a similar yeast and mold content but made from cream pasteurized at temperatures of 62.8-65.6°C. for 20-30 minutes. It is concluded from this observation that certain enzymes, harmful to the keeping quality of the butter, survive pasteurization at the lower temperatures. Type I butter, containing 100 or more yeasts and molds per ml. and made from flash pasteurized cream, did not keep as well as the two last mentioned classes of butter, which might indicate that the presence of the microorganisms in those numbers was more destructive to the keeping quality of the butter than the enzymes surviving pasteurization at 65.6°C. for 20-30 minutes. When the number of yeasts and molds in the butter exceeded 100 per ml. and the lower pasteurization temperatures were used on the cream, the keeping quality of the butter

was slightly higher than for the butter of a similar yeasts and molds count made from flash pasteurized cream. This may possibly indicate that the activity of microorganisms and enzymes may be to a certain extent counter-active on the keeping quality of the butter. The best keeping quality resulted when the butter contained from 50 to 99 yeasts and molds per ml. regardless of pasteurization temperature. Salt seemed to exert a greater restraining power upon the deteriorative action of microorganisms than upon purely chemical changes and the activity of the enzymes supposedly surviving 65.6°C. for 20-30 minutes.

A low pH within the limited range of pH values in type I butter seemed to accelerate chemical deterioration, but retarded enzymatic action and slightly retarded deterioration by microorganisms. A low pH and a high salt concentration combined had no appreciable effect on purely chemical changes, but retarded the deteriorative action of both enzymes and microorganisms in type I butter.

From the results obtained, it seems that for highest keeping quality, type I butter should be reasonably low in bacterial content, high in pH, and made from cream pasteurized at the higher temperatures. A high salt concentration is apparently not necessary for the keeping quality of such butter, but should be of advantage in butter high in microorganisms.

Of 221 samples of type I butter, only five had pH values of less than 6.0 and the maximum pH found was 6.85. The range of pH values for 389 samples of type II butter was 5.3-7.8 and for 41 samples of type III butter 5.45-7.1. The average pH values for these types of butter were 6.45,

6.53, and 6.36 respectively. Of the type I with pH values above 6.0 a total of 44 per cent ran between pH 6.4 and 6.59 and 85 per cent above pH 6.3. Of the type II samples, 14 per cent had a pH of 7.0 or over and 6 per cent fell below pH 6.0.

In the case of type I butter, there seemed to be a general trend toward improved fresh quality as well as keeping quality with increasing pH values of the fresh samples. Keeping quality was considerably reduced by pH values below 6.3. For the neutralized cream butter, neither fresh quality nor keeping quality varied greatly when the pH values of the fresh butter fell within the range, which was found to be normal for type I butter, namely, pH 6.0-6.8. Higher and lower pH values gave less favorable results. Although a decrease as well as a large increase in pH value during storage was usually associated with reduced keeping quality of type I butter, the changes in pH were slight and within the range of possible experimental errors. The change in pH both after 1 month at 0-5°C. and after 1 week at 21°C. is, therefore, considered of little value for predicting the keeping quality of butter.

The lower the pH value of type I butter the more markedly was its keeping quality improved by an increased concentration of salt. When the pH values of such butter were 6.6 or higher, the average keeping quality was actually somewhat decreased by a higher salt concentration, thus suggesting that a low pH value in type I butter may be largely indicative of a high degree of microbial contamination in the cream before pasteurization. If this supposition is correct, then a high salt concentration reduced the keeping quality of the butter of a high pH (low microbial

content) probably either by restraining the action of the limited number of useful microorganisms present or by accelerating purely chemical changes or both. The pH value did not appear to have any bearing on the curd content of type I butter.

Considering all samples of type I butter, an increase in salt content, regardless of other factors, effected a progressive improvement in the average keeping quality of the butter when held for 1 month at 0-5°C., thus pointing toward a considerable importance of biological factors in the deterioration of such butter at 0-5°C.

The acid content, calculated as lactic acid, and as determined in this investigation for 28 samples of type I butter with pH values above 6.0 was 0.07-0.13 per cent when fresh, 0.078-0.131 per cent after 1 month at 0-5°C. It averaged 0.096 per cent when fresh, 0.109 per cent after 1 week at 21°C. and 0.103 per cent after 1 month at 0-5°C. For 51 samples of type II butter these averages were 0.122, 0.140 and 0.132 per cent respectively.

High acid values of butter and butterfat before and after storage showed a slight tendency toward reduced keeping quality. High increases in the acid values after storage at 21°C. and 0-5°C. did show a fairly close correlation with reduced keeping quality of type I and type II butter, but especially for type I butter.

An increase in the acid ratio (fat acidity:butter acidity) during 1 week at 21°C. and during 1 month at 0-5°C. seemed to be very closely related to poor keeping quality, especially in the case of type I butter. The average acid ratios were higher after 1 month at 0-5°C. than after 1

week at 21°C.

The acid values of fresh butter and fresh butterfat were more closely related to the quality of the butter when fresh than to keeping quality at 0-5°C. For all butter of type I and II, the average acid values of the fresh butter as well as of the butterfat increased as the fresh scores decreased. This was not true for the few samples of neutralized butter containing butter culture.

The normal variations in the curd content of type I butter seems to have no apparent effect on keeping quality for 1 month at 0-5°C. nor on the pH value of the butter.

Butter of type I made in May, June and July, averaged higher in keeping quality when held 1 month at 0-5°C. than such butter made during the other months of the year, even though the average pH value was lower in the early summer months and though the median yeast and mold counts, the average percentages of curd and the average fresh scores were similar. With the type II butter the results are less conclusive, although, for this type of butter too, the average loss in score during storage was lowest for the May, June and July samples. These results support the theory that certain anticatalytic agents are particularly active in milk, cream and butter during the early summer months. The nature of these factors were not studied, but they may be linked up with the stage of lactation of the cows, the carotene or lecithin content of the milk or the nature of the bacterial flora during that season of the year. The curd content of the butter was not affected by the season of the year.

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A P P E N D I X

Table I

The odor of salted butter held in a closed bottle for 1 week at 21°C. as related to the keeping quality of such butter when held for 1 month at 0-5°C.

Sample number	Odor after 1 week at 21°C.	Loss in score during 1 month at 0-5°C.	Score of the butter after 1 month at 0-5°C.
I Butter made without butter culture from cream not neutralized			
Je 44	Good	0	38.0
Je 194	"	0.5	37.5
My 164	"	1.0	36.0
My 124	"	1.5	35.5
Ap 84	"	0.5	36.0
Ap 184	"	2.5	34.0
My 184	"	0.5	35.5
Ap 174	"	2.0	34.0
Ap 234	Fair	2.5	35.5
Ap 224	"	2.0	35.5
My 204	"	0.5	36.5
Je 144	"	0	37.0
Je 34	"	0.5	36.0
Je 134	"	-0.5	36.5
Ap 44	"	-0.5	36.0
My 194	Poor	1.5	36.0
Je 204	"	0.5	37.0
Je 154	"	0	36.5
My 14	Bad	0	37.0
II Butter made without butter culture from neutralized cream			
Je 14	Good	0.5	36.5
My 74	"	0	36.0
My 34	"	1.5	34.5
Ap 114	"	1.5	34.5
My 154	"	-0.25	36.0
Ap 144	"	1.0	34.5
My 104	"	1.0	34.5
Ap 14	"	0	35.0
Ap 54	"	0	35.0
Ap 244	Fair	3.0	34.0
Je 94	"	0	36.0
Ap 134	"	1.0	35.0
My 94	"	1.0	35.0
Je 124	"	2.0	34.0
Ap 34	"	0.5	35.0
Je 184	"	0.5	35.0
Je 214	"	0.5	35.0
Ap 74	"	1.0	34.5

Table I (Cont'd)

Sample number	Odor after 1 week at 21°C.	Loss in score during 1 month at 0-5°C.	Score of the butter after 1 month at 0-5°C.
Ap 104	Fair	1.5	34.0
Ap 24	"	0	35.0
Ap 204	"	0.5	34.5
My 174	"	0	34.0
Je 104	"	0.5	34.0
Ap 124	"	-0.5	34.5
My 214	"	0	34.0
Je 84	Poor	0	37.0
Je 114	"	1.0	34.5
My 44	"	1.5	34.5
My 234	"	1.5	34.5
My 114	"	2.0	34.0
Je 74	"	-1.0	36.5
My 144	"	1.0	34.5
Je 164	"	0.5	34.5
Je 174	"	0	34.5
Ap 64	"	0	34.0
My 134	Bad	1.5	33.5
Ap 214	"	2.0	35.0
My 64	"	1.0	35.5
My 224	"	0	35.0
Je 54	"	1.0	33.0
III Butter made with butter culture from neutralized cream			
Je 24	Good	1.0	34.0
My 84	Fair	0.5	36.0
My 24	"	0.5	34.5
My 54	"	0.5	34.5
Je 64	"	0.5	34.0
Ap 164	Poor	3.5	33.0
Ap 94	"	1.0	35.0
Ap 154	Bad	2.0	32.5

Table II

The number of total and proteolytic bacteria in salted butter and its serum as related to the keeping quality of such butter when held for 1 month at 0-5°C.

Sample number	Score loss during 1 month at 0-5°C.	Score after 1 month at 0-5°C.	Number of bacteria per ml. of butter: total* when fresh	total* after 1 month at 0-5°C.	total* after 1 week at 21°C.	proteolytic** when fresh	proteolytic** after 1 month at 0-5°C.	proteolytic** after 1 week at 21°C.	Number of bacteria per ml. of serum: total* when fresh	total* after 1 week at 21°C.	proteolytic*** when fresh	proteolytic*** after 1 week at 21°C.
I Butter samples made without butter culture from cream not neutralized												
Au 84	-0.5	35.0	1,800	--	7,340	300	--	<1,000	--	--	--	--
Ja 27	-0.5	38.0	40	116	--	4,500	1,500	--	194	--	10,500	--
Ja 17	0	38.0	4	9	--	850	650	--	56	--	6,000	--
Ja107	0	38.0	2	1	--	400	50	--	4,500	--	150,000	--
Au 24	0	36.0	1	2	--	<100	<100	--	21	340	<1,000	<1,000
N 124	0.5	35.5	28	15	1,150	5,200	2,300	240,000	124	7,500	31,000	5,000
D 134	1.0	35.0	42	15	580	1,000	2,000	55,000	390	1,210	16,000	10,000
D 124	1.0	36.5	27	26	1,040	1,000	500	10,000	350	11,000	10,000	--
O 14	1.0	36.0	18	12	7,000	2,000	200	<1,000	49	6,800	2,000	<1,000
Au154	1.0	35.0	10	21	1,300	4,400	1,700	3,000	370	8,500	23,000	15,000
D 94	1.0	36.0	6	13	236	400	800	2,000	205	64,000	9,000	<1,000
D 84	1.5	33.5	1,550	143	1,020	2,800	<100	<1,000	7,500	8,500	2,500	20,000
Au204	1.5	36.5	58	--	--	9,500	--	--	128	154	11,000	<1,000
N 94	1.5	35.5	26	17	5,200	<100	<100	<1,000	430	95,000	5,000	40,000
Au194	1.5	36.0	8	--	--	100	--	--	--	--	--	--
O 54	2.0	35.5	770	1,050	52,000	35,000	6,000	--	8,500	40,000	350,000	1,100,000
S 44	2.0	35.5	44	51	218	3,000	2,500	<1,000	162	3,200	4,000	<1,000
O 74	2.0	35.0	20	20,000	35,000	2,000	5,100	12,000	--	--	--	--
Au254	2.0	35.0	7	--	13	200	--	<1,000	--	--	--	--
D 154	2.0	36.0	6	32	196	200	400	5,000	216	310,000	5,000	<1,000
Au234	2.5	34.0	360	--	510	400	--	2,000	--	--	--	--
N 174	2.5	35.0	37	23	730	3,100	200	--	450	4,900	40,000	50,000
Au124	2.5	34.5	2	2	1	100	200	<1,000	17	140	<1,000	<1,000

Table II (cont'd.)

Sample number	Score loss during 1 month at 0-5°C.	Score after 1 month at 0-5°C.	Number of bacteria per ml. of butter: total* when fresh	total* after 1 month at 0-5°C.	total* after 1 week at 21°C.	proteolytic** when fresh	proteolytic** after 1 month at 0-5°C.	proteolytic** after 1 week at 21°C.	Number of bacteria per ml. of serum: total* when fresh	total* after 1 week at 21°C.	proteolytic*** when fresh	proteolytic*** after 1 week at 21°C.
S 14	3.5	34.5	34	220	3,000	200	1,000	1,000	127	7,150	<1,000	<1,000
II Butter samples made without butter culture from neutralized cream												
Au 74	-0.5	34.5	1,160	--	--	1,000	--	--	11,000	47,000	<1,000	<1,000
Ja 37	-0.5	36.0	675	620	--	80,000	10,000	--	2,350	--	450,000	--
Au164	-0.25	34.2	1,140	430	525	253,000	23,000	95,000	--	--	--	--
Au284	-0.25	35.2	420	--	--	1,000	--	--	850	760	<1,000	<1,000
Au134	0	34.0	420	--	3,400	138,000	--	12,000	--	--	--	--
N 234	0	35.0	320	492	85,500	12,400	13,400	940,000	1,410	90,000	52,000	40,000
Ja207	0	36.0	232	--	--	2,000	--	--	780	--	70,000	--
Au214	0	35.0	43	--	--	<100	--	--	--	--	--	--
O 64	0	35.0	41	8	15,000	3,200	200	<1,000	320	2,700	8,000	15,000
Au 34	0.25	34.2	153	115	1,240	900	<100	<1,000	530	1,400	<1,000	<1,000
Au244	0.25	34.2	110	54	85	300	<100	<1,000	225	950	<1,000	<1,000
Au304	0.25	34.7	53	--	2,800	300	--	<1,000	900	690	--	<1,000
Au184	0.25	34.2	24	35	--	1,500	200	--	--	--	--	--
Au224	0.5	35.0	2,320	530	375	200	1,200	<1,000	12,400	18,500	<1,000	<1,000
D 114	0.5	34.0	1,740	210	1,100	3,100	1,500	50,000	15,500	58,000	30,000	800,000
N 44	0.5	34.5	83	12	8,400	6,800	1,000	32,000	550	8,400	10,000	10,000
Au 44	0.5	35.0	80	60	--	1,200	300	--	--	--	--	--
Ja137	0.5	34.5	17	12	--	4,000	200	--	46	--	7,000	--
O 34	0.5	35.5	18	1,200	25,000	2,000	11,000	--	390	6,000	21,000	<1,000
S 34	1.0	33.5	750	350	18,000	1,300	1,000	<1,000	3,000	17,000	5,000	<1,000
Ja137	1.0	36.0	163	--	--	5,000	--	--	790	--	195,000	--
Au 14	1.0	33.0	124	--	620	3,500	--	12,000	--	--	--	--
O 24	1.0	34.5	45	200	19,000	1,000	100	--	107	1,450	<1,000	<1,000

Table II (cont'd.)

Sample number	Score loss during 1 month at 0-5°C.	Score after 1 month at 0-5°C.	Number of bacteria per ml. of butter: total* when fresh	total* after 1 month at 0-5°C.	total* after 1 week at 21°C.	proteolytic** when fresh	proteolytic** after 1 month at 0-5°C.	proteolytic** after 1 week at 21°C.	Number of bacteria per ml. of serum: total* when fresh	total* after 1 week at 21°C.	proteolytic*** when fresh	proteolytic*** after 1 week at 21°C.
Au104	1.5	33.5	164	--	--	5,300	--	--	--	--	--	--
O 44	1.5	35.0	61	76	28,500	4,100	3,600	<1,000	4,500	3,500	15,000	7,000
Au 94	1.5	33.0	7	--	540	2,400	--	<1,000	--	--	--	--
Au264	1.5	34.5	3	17	--	1,500	600	--	640	7,000	<1,000	<1,000
Au114	2.0	34.0	122	--	--	25,100	--	--	--	--	--	--
Au294	2.25	32.2	230	340	950	4,600	2,100	4,000	4,600	6,300	45,000	15,000
S 24	2.5	34.0	46	215	24,000	400	300	<1,000	274	10,500	3,000	<1,000
Au174	3.0	33.0	16	--	156	2,000	--	3,000	--	--	--	--

* Number reported as thousands.

** The dilutions when fresh and after 1 month at 0-5°C. were 1:100 to 1:10,000; after 1 week at 21°C. they were 1:1,000 to 1:100,000.

*** The dilutions were 1:1,000 to 1:100,000.

Table III

The number of lipolytic bacteria in salted butter as related to the keeping quality of such butter when held for 1 month at 0-5°C.

Sample number	Number of lipolytic bacteria per ml. of butter* when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	Score loss during 1 month at 0-5°C.	Score after 1 month at 0-5°C.	Acid value of butter when fresh	Acid value of butter increase during 1 month at 0-5°C.	Acid value of butterfat when fresh	Acid value of butterfat increase during 1 month at 0-5°C.	Acid ratio when fresh	Acid ratio increase during 1 month at 0-5°C.
I Butter made without butter culture from cream not neutralized											
N 174	100	1500	0	2.5	35.0	4.65	0.90	3.5	0.4	70.9	- 4.3
O 54	750	900	100	2.0	35.5	5.00	0.05	2.8	1.6	56.0	35.1
N 184	0	600	0	1.0	35.5	5.45	0.50	4.6	-0.6	84.4	-17.2
My124	0	145	—	1.5	35.5	4.0	0.50	4.0	0	100.0	-11.1
N 94	300	10	—	1.5	35.5	4.25	0.50	3.05	0.75	71.8	8.2
Ap184	0	50	0	2.5	34.0	6.5	-1.5	5.5	-2.0	84.6	-14.6
Jy 64	0	10	—	2.5	35.5	5.5	0	4.5	—	81.8	—
My164	0	5	—	1.0	36.0	4.0	0.50	3.5	0	87.5	- 9.7
N 124	50	0	0	0.5	35.5	5.35	0	3.5	-0.05	65.4	- 0.9
My184	30	0	—	0.5	35.5	4.0	0	4.0	0	100.0	0
Ap 84	5	0	0	0.5	36.0	4.5	1.50	4.0	0.5	88.9	-15.9
Ap224	0	0	0	2.0	35.5	5.5	0.50	5.0	0.5	90.9	0.7
My 14	0	—	0	0	37.0	3.0	1.50	3.0	0	100.0	-33.3
My194	0	—	0	1.5	36.0	4.0	0.50	3.0	1.0	75.0	13.9
Je 44	0	—	0	0	38.0	4.0	0	2.5	1.5	62.5	37.5
Je144	0	—	0	0	37.0	4.0	1.00	4.0	0.5	100.0	-10.0
Je194	0	—	0	0.5	37.5	4.5	0.80	3.0	1.5	66.7	23.3
Jy 44	0	—	0	3.0	35.0	4.5	1.50	4.0	—	88.9	—
Jy184	0	—	0	3.0	34.5	5.0	0	4.0	—	80.0	—
D 124	0	0	0	1.0	36.5	4.1	1.00	3.8	0.05	92.7	-17.3
Ap 44	0	0	0	-0.5	36.0	4.0	0	3.5	0	87.5	0
Ap174	0	0	0	2.0	34.0	7.5	-2.5	6.5	-1.5	86.7	13.3
Ap234	0	0	0	2.5	35.5	4.0	1.0	4.0	1.0	88.9	2.1

Table III (cont'd.)

Sample number	Number of lipolytic bacteria per ml. of butter* when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	Score loss during 1 month at 0-5°C.	Score after 1 month at 0-5°C.	Acid value of butter when fresh	Acid value of butter increase during 1 month at 0-5°C.	Acid value of butterfat when fresh	Acid value of butterfat increase during 1 month at 0-5°C.	Acid ratio when fresh	Acid ratio increase during 1 month at 0-5°C.
My204	0	0	--	0.5	36.5	4.0	1.0	2.5	0.5	62.5	- 2.5
Je 34	0	0	--	0.5	36.0	5.5	1.0	3.0	3.0	54.5	37.8
Je134	0	0	--	-0.5	36.5	5.0	0	4.0	1.0	80.0	20.0
Je154	0	0	--	0	36.5	4.0	0.5	3.0	1.0	76.0	13.9
Je204	0	0	--	0.5	37.0	4.0	1.0	2.5	1.5	62.5	17.5
Jy 34	0	0	--	2.0	36.0	4.5	--	4.0	--	88.9	--
Jy164	0	0	--	2.5	35.5	4.5	1.0	4.5	--	100.0	--
Jy194	0	0	--	3.0	35.0	5.5	-0.5	4.5	--	81.8	--
O 14	0	0	0	1.0	36.0	4.4	0.1	2.9	0.8	65.9	16.3
O 74	0	0	0	2.0	35.0	5.6	0.65	2.9	2.80	51.8	39.4
O 94	0	0	0	1.0	35.5	5.1	0.2	2.6	1.7	50.9	30.2
D 84	0	0	0	1.5	33.5	9.45	-0.05	6.4	0.85	67.7	9.4
D 94	0	0	0	1.0	36.0	6.2	-0.55	4.45	0.50	71.8	15.8
D 134	0	0	0	1.0	35.0	7.2	0.1	6.3	-0.10	87.5	- 2.6
D 154	0	0	0	2.0	36.0	6.8	0.05	5.0	0.8	73.5	11.1
II Butter made without butter culture from neutralized cream											
Je124	110	1250	--	2.0	34.0	6.0	0	4.5	1.0	75.0	16.7
Jy 94	30	900	--	-0.5	35.5	5.0	3.5	4.0	--	80.0	--
Jy114	0	2500	--	1.5	34.0	5.5	2.0	4.5	--	81.8	--
O 44	0	300	0	1.5	35.0	5.3	0.5	3.4	2.35	64.1	35.0
N 24	0	300	0	0.5	35.0	7.4	0.7	5.7	0.75	77.0	2.6
N 44	0	800	0	0.5	34.5	4.6	3.45	4.7	0	102.1	-45.8
O 24	0	100	0	1.0	34.5	7.7	-0.8	5.6	0.45	72.7	14.9
Ap 14	100	90	20	0	35.0	6.5	1.0	4.5	0.5	69.2	- 2.6
Ap 34	485	115	0	0.5	35.0	6.5	0.5	6.0	0	92.3	- 6.6

Table III (cont'd.)

Sample number	Number of lipolytic bacteria per ml. of butter* when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	Score loss during 1 month at 0-5°C.	Score after 1 month at 0-5°C.	Acid value of butter when fresh	Acid value of butter increase during 1 month at 0-5°C.	Acid value of butterfat when fresh	Acid value of butterfat increase during 1 month at 0-5°C.	Acid ratio when fresh	Acid ratio increase during 1 month at 0-5°C.
Ap 74	115	75	750	1.0	34.5	7.0	0	6.0	-1.5	85.7	-21.5
Ap104	1600	150	0	1.5	34.0	6.0	2.0	5.0	1.0	83.3	- 8.3
Je 14	150	0	--	0.5	36.5	4.0	1.0	3.0	1.5	75.0	15.0
Jy 24	300	0	--	2.0	33.5	5.0	0.5	4.5	--	90.0	--
Jy 74	1000	100	--	1.5	34.5	5.0	1.0	4.5	--	90.0	--
Je 54	0	10	--	1.0	33.0	5.5	0.5	4.00	1.5	72.7	18.9
Ap124	0	0	15	-0.5	34.5	6.0	0.5	5.00	0	83.3	- 6.4
Ap134	0	0	13	1.0	35.0	5.5	2.0	4.00	0.5	72.7	-12.7
My 94	0	25	--	1.0	35.0	6.0	0	4.00	0.5	66.7	8.3
My144	0	40	--	1.0	34.5	6.0	0.5	3.50	1.0	58.3	10.9
Ap144	75	0	0	1.0	34.5	6.5	3.5	5.5	-0.5	84.6	-34.6
Ap214	15	0	0	2.0	35.0	5.5	1.50	5.0	0.5	90.9	-12.4
My154	20	0	--	-0.25	36.0	4.5	0	4.0	-0.5	88.9	-11.0
My174	80	0	--	0	34.0	6.0	0	5.0	0.5	83.3	- 8.3
M 234	50	0	0	0	35.0	7.35	0.75	4.95	0.05	87.4	- 5.7
My224	40	0	--	0	35.0	5.0	0	4.0	0	80.0	0
My234	17	0	--	1.5	34.5	5.5	0	4.5	0	81.8	0
My214	70	0	--	0	34.0	4.5	0.5	4.5	0	100.0	-10.0
Ap 24	0	0	0	0	35.0	6.0	1.0	4.5	0	75.0	-10.7
Ap 54	0	0	0	0	35.0	7.5	1.0	6.0	-1.0	80.0	-21.2
Ap 64	0	0	0	0	34.0	7.0	1.5	5.5	-1.0	78.5	-25.6
Ap114	0	0	0	1.5	34.5	4.5	1.5	3.5	1.0	77.8	- 2.8
Ap204	0	0	0	0.5	34.5	6.0	2.0	5.0	0	83.3	-20.8
Ap244	0	0	0	3.0	34.0	6.0	1.0	4.5	0.5	75.0	- 5.6
My 34	0	0	--	1.5	34.5	4.0	1.0	3.0	0	75.0	-15.0
My 44	0	0	--	1.5	34.5	6.0	0	4.5	0	75.0	0
My 64	0	0	--	1.0	35.5	5.0	0	3.5	0	70.0	0

Table III (cont'd.)

Sample number	Number of lipolytic bacteria per ml. of butter* when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	Score loss during 1 month at 0-5°C.	Score after 1 month at 0-5°C.	Acid value of butter when fresh	Acid value of butter increase during 1 month at 0-5°C.	Acid value of butterfat when fresh	Acid value of butterfat increase during 1 month at 0-5°C.	Acid ratio when fresh	Acid ratio increase during 1 month at 0-5°C.
My104	0	0	--	1.0	34.5	5.5	0	4.0	0	72.7	0
My114	0	0	--	2.0	34.0	4.0	0.5	3.5	0.5	87.5	1.3
My134	0	0	--	1.5	33.5	5.0	0	3.0	0	60.0	0
Je 74	0	0	--	-1.0	36.5	5.0	0	4.0	1.0	80.0	20.0
Je 84	0	0	--	0	37.0	5.0	1.0	3.5	2.0	70.0	21.6
Je 94	0	0	--	0	36.0	5.0	0.5	3.0	2.5	60.0	40.0
Je104	0	0	--	0.5	34.0	4.5	1.0	2.5	2.5	55.5	35.4
Je114	0	0	--	1.0	34.5	6.0	0.5	3.5	2.5	58.3	34.0
Je164	0	0	--	0.5	34.5	5.5	1.0	4.0	1.5	72.7	11.9
Je174	0	0	--	0	34.5	7.0	0.5	4.5	2.5	64.2	29.1
Je184	0	0	--	0.5	35.0	5.0	0.5	2.5	2.5	50.0	40.9
Je214	0	0	--	0.5	35.0	4.5	1.0	3.5	1.0	77.8	4.0
Jy 14	0	0	--	2.0	35.5	4.5	2.5	4.5	--	100.0	--
Jy104	0	0	--	1.0	34.5	5.0	3.5	4.5	--	90	--
Jy124	0	0	--	1.5	34.5	4.5	1.0	4.0	--	88.9	--
Jy144	0	0	--	1.0	34.0	5.0	3.0	4.5	--	90.0	--
Jy154	0	0	--	0	34.5	5.0	3.0	5.0	--	100.0	--
Jy174	0	0	--	1.0	35.0	5.0	1.5	4.5	--	90.0	--
Jy214	0	0	--	2.0	34.0	5.0	1.5	4.5	--	90.0	--
Jy224	0	0	--	3.0	33.0	5.0	1.0	4.5	--	90.0	--
Jy234	0	0	--	0.5	35.0	10.0	2.25	5.5	--	55.0	--
O 34	0	0	0	0.5	35.5	5.0	0.65	3.0	2.65	60.0	36.5
O 64	0	0	0	0	35.0	7.15	0.7	3.5	1.35	48.9	12.9
O 104	0	0	0	-0.5	35.5	6.1	-0.4	2.75	2.25	45.1	42.6
N 54	0	0	0	0.5	34.5	6.95	0	4.2	0.15	60.4	2.2
D 114	0	0	0	0.5	34.0	8.2	0.05	6.15	0.90	75.0	10.4

* All counts of 0 denote counts of less than 10 per ml.

Table IV

The number of yeasts and molds in fresh salted butter as related to the number of total bacteria and to the pH of such butter

Butter made without butter culture from cream not neutralized and from neutralized cream

Sample number	Number of yeasts and molds per ml. of fresh butter*	Number of total bacteria per ml. of fresh butter	pH of fresh butter
Au204	0	58,000	6.6
Au154	0	9,800	6.6
D154	0	6,500	6.6
D94	0	6,300	6.8
Ja17	0	4,200	6.3
Au124	0	500	6.6
034	5	16,000	6.5
Au94	5	6,600	7.2
S44	10	44,000	6.4
Ja107	10	1,650	6.3
D114	10	1,740,000	6.4
N44	15	83,000	6.4
Au194	15	7,600	6.4
N124	20	28,400	6.3
014	20	18,500	6.5
Ja137	20	17,000	6.3
Au164	25	1,140,000	7.3
Au264	25	3,300	6.7
D134	30	42,000	6.5
Ja37	30	675,000	6.0
Au34	30	153,000	6.9
N94	35	26,200	6.3
064	40	41,000	6.4
074	40	20,400	6.5
Au184	50	24,500	6.5
Au234	65	420,000	6.6
Au114	65	122,000	6.6
024	75	45,000	6.4
S14	100	34,000	6.2
Au44	105	80,000	6.4
D124	115	27,000	6.7
Au244	140	110,000	6.9
Au214	150	43,000	6.0
Au174	150	16,500	6.7
N174	160	37,000	6.4

Table IV (cont'd)

Sample number	Number of yeasts and molds per ml. of fresh butter*	Number of total bacteria per ml. of fresh butter	pH of fresh butter
Ja27	200	40,500	6.6
Au294	210	230,000	6.5
Au74	215	1,160,000	6.6
Au104	230	164,000	6.6
Ja187	230	163,500	6.2
S34	250	730,000	6.0
D84	260	1,550,000	5.5
Au254	270	6,700	6.6
Au24	315	1,500	6.0
Au14	340	124,000	6.4
Au84	365	1,800,000	6.8
Au224	365	2,320,000	6.6
Au304	470	53,000	7.2
N254	540	320,000	6.6
Au134	675	420,000	7.1
Au234	920	360,000	6.4
054	3,510	770,000	6.5
S24	4,550	46,000	6.0
044	8,200	61,000	6.4

*All counts of 0 denote counts of less than 10

Table V

Individual data on all samples of butter used in this investigation

Sample number	pH of butter		Churning cream		Butter		Score of butter			Fresh butter	
	when fresh	after 1 month at 0-5°C.	% acid before neutralizing	pasteurizing temperature °C.	% salt in serum**	% curd	when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	number of yeasts per ml.***	number of molds per ml.***
I Butter made without butter culture from cream not neutralized											
N 45	5.5	(5.6)*	0.22	66	12.8	0.61	37.0	37.0	36.0	5	10
D 84	5.5	—	—	66	10.6	0.39	35.0	35.5	34.5	250	10
Jul65	5.78	(5.80)	—	66	12.8	0.34	35.0	35.5	35.0	30	20
Au135	5.8	5.56	—	68	10.0	0.7	38.0	36.5	—	1,495	15
Au225	5.8	—	—	66	12.0	0.95	36.5	35.0	36.5	100	50
Jy 73	6.0	6.30	—	66	14.2	0.7	37.0	37.5	—	35	20
N 43	6.0	6.20	0.14	66	12.9	0.68	37.5	36.5	—	0	10
Au 24	6.0	—	0.15	68	13.3	1.10	36.0	36.0	—	45	270
O 134	6.0	—	—	68	9.7	0.96	38.0	36.0	35.5	10,000	0
Mh105	6.0	—	—	66	11.5	0.85	38.0	35.0	—	1,400	0
My 15	6.05	5.80	0.21	—	—	0.4	—	—	—	860	45
Jy 53	6.1	6.35	—	68	12.7	1.0	38.0	37.0	—	0	0
S 223	6.1	6.15	—	68	11.8	0.8	36.0	37.0	—	400	50
Je 84	6.1	5.50	0.20	66	12.0	0.54	35.25	33.5	—	965	0
S 54	6.1	—	—	66	10.2	0.76	37.0	35.0	—	30	0
Mh 95	6.1	—	—	66	11.3	0.75	35.5	35.0	—	1,200	40
Ap 65	6.1	—	—	66	13.8	0.75	37.0	34.0	—	2,200	10
Jy 85	6.1	(6.16)	—	66	12.7	0.86	37.5	36.0	37.0	0	0
Au 53	6.15	5.85	0.16	66	10.9	1.0	38.0	32.0	—	15	10
S 93	6.15	6.25	0.16	68	13.4	1.0	38.0	37.0	—	75	50
N 183	6.15	6.20	—	66	14.4	0.93	37.5	37.0	—	185	5
Je 23	6.2	6.25	—	—	—	0.8	—	—	—	280	0
Jy145	6.2	6.35	0.12	66	14.1	0.8	37.0	36.0	—	145	5
F 184	6.2	6.55	—	66	14.0	0.69	37.5	35.5	—	290	0

Table V (cont'd.)

Sample number	pH of butter		Churning cream		Butter		Score of butter			Fresh butter	
	when fresh	after 1 month at 0-5°C.	% acid before neutral-izing	pasteur-izing temper-ature °C.	% salt in se-rum**	% curd	when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	number of yeasts per ml.***	number of molds per ml.***
Je134	6.2	--	0.25	66	8.9	0.79	36.0	36.5	--	1,250	300
S 14	6.2	--	--	82	10.5	0.85	38.0	34.5	--	90	10
S 144	6.2	--	--	68	9.7	0.67	38.0	34.0	--	2,000	0
S 204	6.2	--	--	82	12.3	1.26	36.5	34.5	--	40	0
Ja245	6.2	--	0.27	66	8.2	0.64	35.0	35.0	--	80	5
Je 55	6.2	--	0.18	66	12.4	0.91	37.0	36.0	--	25	0
N 65	6.2	--	--	66	11.0	0.83	37.5	37.0	--	10	10
N 105	6.2	(6.00)	--	68	12.6	0.54	37.5	36.0	36.0	440	15
My193	6.25	6.20	--	--	--	0.70	--	--	--	10	0
Je 33	6.25	6.17	--	--	--	0.70	--	--	--	30	10
Je 93	6.25	6.05	--	--	--	0.55	--	--	--	1,240	20
Au193	6.25	6.10	--	--	10.7	0.6	37.5	37.0	--	305	0
O 223	6.25	6.35	--	--	14.1	0.95	36.0	36.5	--	100	5
N 103	6.25	6.60	--	82	14.0	0.67	36.5	35.5	--	25	10
My 73	6.3	6.05	--	--	--	0.6	--	--	--	1,100	40
Jy183	6.3	6.55	--	68	13.3	0.5	37.0	37.0	--	30	0
S 183	6.3	6.40	0.20	66	10.0	0.6	38.0	34.5	--	180	5
O 63	6.3	6.60	--	82	12.4	0.7	38.0	35.5	--	110	0
Je154	6.3	--	--	66	11.9	0.82	36.5	36.5	--	65	20
S 2'4	6.3	--	--	66	12.7	0.65	37.0	35.0	--	10	5
O 84	6.3	--	0.17	66	12.4	0.98	36.5	35.5	36.0	0	0
N 84	6.3	--	--	66	11.8	0.68	37.0	35.5	36.0	30	0
N 94	6.3	--	--	63	9.5	0.66	37.0	35.5	37.0	35	0
N 124	6.3	--	--	82	13.4	0.80	36.0	35.5	35.5	20	0
N 254	6.3	--	--	68	12.1	0.93	36.5	37.0	36.5	520	10
Ja305	6.3	--	0.20	--	13.4	0.52	36.0	35.0	--	520	10
Je105	6.3	--	--	66	14.0	0.85	37.0	34.5	--	280	10

Table V (cont'd.)

Sample number	pH of butter		Churning cream		Butter		Score of butter			Fresh butter	
	when fresh	after 1 month at 0-5°C.	% acid before neutralizing	pasteurizing temperature °C.	% salt in serum**	% curd	when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	number of yeasts per ml.***	number of molds per ml.***
O 25	6.3	--	--	--	11.0	0.58	37.0	36.5	--	120	110
Au235	6.3	--	--	--	11.1	0.51	38.0	--	--	50	50
S 35	6.3	--	--	--	12.3	1.25	37.5	36.5	--	0	5
D 105	6.3	--	0.24	63	9.2	0.34	36.0	36.0	--	80	10
My 93	6.35	6.7	--	--	--	0.8	--	--	--	20	10
S 53	6.35	6.58	0.16	82	13.3	1.0	36.0	37.0	--	150	0
S 63	6.35	6.73	0.14	66	12.8	0.5	37.0	37.0	--	10	0
S 153	6.35	6.48	0.12	66	14.5	0.8	38.0	36.0	--	1,000	0
O 53	6.35	--	--	82	15.2	0.7	37.5	36.5	--	5	0
N 13	6.35	6.45	--	68	12.7	0.93	37.5	35.0	--	5	15
D 73	6.35	6.10	--	66	13.5	1.02	38.0	34.0	--	15	0
F 54	6.35	6.75	--	68	13.0	0.66	36.5	36.0	--	0	0
My124	6.35	6.2	--	--	13.7	0.82	37.0	35.5	--	10	115
My184	6.35	6.05	0.17	66	12.1	0.86	36.0	35.5	--	7,200	10
Jy133	6.4	6.55	--	--	14.2	0.6	37.5	36.0	--	115	0
Au 63	6.4	6.42	0.14	66	14.2	0.9	38.0	37.0	--	5	5
Au145	6.4	6.25	0.16	66	13.9	0.4	38.0	38.0	--	60	5
F 114	6.4	6.25	--	66	13.7	0.35	36.0	36.0	--	0	0
Ap 44	6.4	6.6	--	66	14.2	0.98	35.5	36.0	--	125	0
Ap174	6.4	6.8	0.16	66	13.5	0.7	36.0	34.0	--	0	0
Je234	6.4	--	--	66	10.5	0.61	38.0	38.0	--	--	--
Au194	6.4	--	--	66	11.8	0.56	37.5	36.0	--	10	5
Au234	6.4	--	--	82	10.6	0.49	36.5	34.0	--	920	0
S 44	6.4	--	--	63	8.8	0.9	37.5	35.5	--	10	0
S 134	6.4	--	--	66	11.3	0.64	38.0	35.0	--	7,000	20
S 284	6.4	--	--	82	9.1	0.17	37.5	35.0	--	0	5
N 64	6.4	--	--	66	11.2	0.60	37.5	36.0	--	0	0

Table V (cont'd.)

Sample number	pH of butter		Churning cream		Butter		Score of butter			Fresh butter	
	when fresh	after 1 month at 0-5°C.	% acid before neutralizing	pasteurizing temperature °C.	% salt in serum**	% curd	when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	number of yeasts per ml.***	number of molds per ml.***
N 174	6.4	--	--	82	11.4	0.65	37.5	35.0	35.0	130	30
N 244	6.4	--	--	82	14.0	0.56	37.0	37.0	36.5	210	0
Mh135	6.4	--	--	66	13.1	0.49	37.5	36.5	--	10	0
Ap195	6.4	--	--	--	12.3	0.95	37.5	38.0	--	10	10
My 25	6.4	--	--	66	12.1	0.75	36.5	36.5	--	480	20
My135	6.4	--	--	66	12.1	1.18	37.5	36.0	--	10	10
Je 25	6.4	--	--	66	10.4	0.91	36.0	34.5	--	120	0
Au 55	6.4	--	--	68	10.2	0.76	38.0	37.5	--	300	0
Au 85	6.4	--	0.15	82	12.2	0.78	38.0	38.0	37.0	80	15
Au115	6.4	--	--	66	11.7	0.83	38.0	37.5	--	0	20
S 195	6.4	--	--	66	12.1	0.60	37.5	37.0	--	800	65
Au205	6.4	--	--	66	11.8	0.91	38.0	37.0	--	50	40
S 15	6.4	--	--	--	11.1	0.80	37.0	36.5	--	45	5
O 65	6.4	--	--	66	13.1	0.89	38.0	36.5	--	15	10
O 215	6.4	--	--	--	13.0	0.68	38.0	36.5	--	10	10
Ja136	6.4	--	--	68	13.1	0.95	37.0	35.0	--	900	0
D 126	6.44	(6.05)	0.18	66	12.5	0.7	36.0	35.5	36.5	30	0
My163	6.45	6.45	--	--	--	0.8	--	--	--	10	10
Ja103	6.45	6.40	--	--	--	0.7	--	--	--	60	30
Jy 43	6.45	6.55	--	--	11.3	0.9	38.0	37.0	--	75	15
Jy163	6.45	6.52	--	66	12.8	0.8	37.0	38.0	--	15	10
Au203	6.45	6.30	--	82	15.4	0.7	38.0	36.5	--	25	5
S 143	6.45	6.55	--	82	12.4	0.7	38.0	36.0	--	15	15
O 23	6.45	6.55	--	--	14.7	0.65	37.0	35.5	--	65	0
O 173	6.45	6.40	0.15	63	10.9	0.8	37.0	36.0	--	15	5
D 143	6.45	6.50	0.15	66	12.2	1.01	37.5	34.75	--	5	0
Ja 34	6.45	6.30	--	66	13.3	0.65	35.0	35.0	--	175	5

Table V (cont'd.)

Sample number	pH of butter		Churning cream		Butter		Score of butter			Fresh butter	
	when fresh	after 1 month at 0-5°C.	% acid before neutralizing	pasteurizing temperature °C.	% salt in serum**	% curd	when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	number of yeasts per ml.***	number of molds per ml.***
My164	6.45	6.35	--	--	11.3	0.5	37.0	36.0	--	70	5
Je 34	6.45	--	0.15	82	12.2	0.65	36.5	36.0	--	0	20
Je144	6.45	--	--	82	11.5	0.79	37.0	37.0	--	25	10
Je204	6.45	--	0.13	66	10.8	0.35	37.5	37.0	--	10	10
Ja 15	6.46	--	--	68	10.2	0.54	37.0	36.5	--	5	5
Jy105	6.45	(6.5)	--	--	10.1	0.89	38.0	36.5	37.0	1,800	0
Jy125	6.46	(6.35)	0.16	82	11.7	0.37	37.5	36.5	36.0	10	25
Jy145	6.46	(6.45)	--	66	10.8	0.89	37.5	36.0	36.0	120	10
N 86	6.47	--	--	--	10.8	0.70	38.0	37.0	--	0	0
My103	6.5	6.35	--	--	--	1.2	--	--	--	30	15
Je223	6.5	6.55	--	--	--	0.7	--	--	--	10	5
Au 93	6.5	6.35	--	82	12.0	0.5	38.0	36.5	--	80	15
Au213	6.5	6.40	--	82	12.3	0.5	38.0	37.0	--	265	140
Ja 54	6.5	6.10	--	82	10.7	0.65	37.0	34.0	--	1,645	0
Ja134	6.5	6.30	0.15	66	11.0	1.04	35.75	35.5	--	5	0
F 34	6.5	6.45	--	66	10.8	0.59	37.0	37.0	--	110	5
F 44	6.5	6.90	--	66	11.6	0.71	38.0	37.0	--	15	0
F 74	6.5	6.45	--	82	11.1	0.95	37.0	36.5	--	30	0
Ap184	6.5	6.65	--	82	11.3	0.45	36.5	34.0	--	155	0
My204	6.5	6.3	--	66	11.6	0.94	37.0	36.5	--	35	0
O 14	6.5	--	--	66	12.1	0.81	37.0	36.0	36.5	10	10
O 54	6.5	--	--	82	7.2	0.74	37.5	35.5	34.5	3,500	10
O 74	6.5	--	--	66	10.9	0.98	37.0	35.0	35.0	20	20
O 154	6.5	--	--	63	9.7	0.75	38.0	35.5	35.0	0	0
O 184	6.5	--	--	66	11.0	0.58	38.0	36.0	36.0	10,000	0
N 184	6.5	--	--	66	11.3	0.53	36.5	35.5	34.0	10	5
D 14	6.5	--	--	68	11.2	0.50	36.5	35.0	36.0	320	80

Table V (cont'd.)

Sample number	pH of butter		Churning cream		Butter		Score of butter			Fresh butter	
	when fresh	after 1 month at 0-5°C.	% acid before neutralizing	pasteurizing temperature °C.	% salt in serum**	% curd	when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	number of yeasts per ml.***	number of molds per ml.***
D 154	6.5	--	--	66	10.2	0.89	36.0	35.0	36.0	20	10
Ja 95	6.5	--	0.20	66	12.1	0.90	36.0	34.0	--	700	400
Mh 65	6.5	--	--	--	12.8	0.70	38.0	34.5	--	180	30
Mh 75	6.5	--	--	66	11.7	0.25	37.0	35.0	--	0	20
Mh155	6.5	--	--	--	10.6	0.71	37.5	36.5	--	0	0
Ap 25	6.5	--	--	82	13.0	0.25	37.5	37.0	--	35	10
Ap155	6.5	--	--	66	10.6	1.00	38.0	35.0	--	10	100
My 35	6.5	--	0.16	82	12.1	0.15	38.0	35.5	--	60	10
My 45	6.5	--	--	66	10.7	0.20	36.5	36.0	--	50	20
My 55	6.5	--	0.16	82	12.0	1.96	37.5	37.0	--	10	10
Je 85	6.5	--	0.18	82	11.7	0.93	38.0	35.5	--	10	0
Je165	6.5	--	--	82	11.8	0.90	38.0	36.0	--	40	5
Je175	6.5	--	0.12	66	11.6	0.74	38.0	36.0	--	5	0
Jy 35	6.5	(6.42)	0.15	82	11.3	0.88	38.0	37.0	38.0	0	5
D 235	6.5	--	0.18	66	13.2	0.65	36.5	36.0	--	45	10
Au185	6.5	--	--	82	9.7	0.70	38.0	34.0	--	800	0
O 75	6.5	(6.39)	--	66	14.3	0.57	35.0	33.5	33.0	420	100
N 226	6.50	--	--	82	11.7	0.90	36.0	36.0	--	900	0
N 156	6.52	--	--	66	13.7	1.00	38.0	37.5	--	40	0
N 76	6.53	--	--	82	14.5	0.60	38.0	36.5	--	5	0
N 106	6.53	--	--	63	9.2	0.90	37.5	36.0	--	110	120
N 136	6.53	--	--	66	12.5	0.50	38.0	37.5	--	30	0
N 186	6.53	--	--	82	10.7	0.80	38.0	37.0	--	15	0
Je213	6.55	6.43	--	--	--	0.60	--	--	--	35	0
Je253	6.55	6.45	--	--	--	0.90	--	--	--	0	0
Jy113	6.55	6.35	--	82	15.3	0.80	37.0	37.0	--	5	10
Au173	6.56	6.40	--	63	12.6	0.50	38.0	37.0	--	15	0

Table V (cont'd.)

Sample number	pH of butter		Churning cream		Butter		Score of butter			Fresh butter	
	when fresh	after 1 month at 0-5°C.	% acid before neutralizing	pasteurizing temperature °C.	% salt in serum**	% curd	when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	number of yeasts per ml.***	number of molds per ml.***
S 108	6.55	6.60	0.12	82	9.0	0.95	38.0	37.0	—	2,250	140
D 133	6.55	6.60	—	82	10.4	0.48	37.5	35.0	—	105	5
D 173	6.55	6.40	—	—	11.5	0.91	37.0	34.0	—	2,830	90
Ja104	6.55	6.30	0.20	66	8.0	0.66	35.25	34.5	—	585	5
Ap224	6.55	6.55	0.15	82	10.6	0.50	37.50	35.5	—	130	0
Je 44	6.55	—	—	82	9.9	0.53	38.00	36.0	—	20	25
Je194	6.55	—	—	—	9.4	0.47	38.00	37.5	—	60	5
O 155	6.55	—	—	66	11.4	0.87	38.00	36.5	—	15	0
D 75	6.55	—	—	88	13.7	0.57	37.00	36.5	—	100	10
D 16	6.55	—	—	66	12.1	0.90	37.50	38.0	—	1,400	15
My135	6.6	6.30	0.26	—	—	0.40	—	—	—	75	0
Je243	6.6	5.30	—	—	—	0.70	—	—	—	590	10
O 83	6.6	6.55	—	82	13.1	0.70	37.00	36.0	—	25	0
Ja164	6.6	6.50	—	82	11.6	0.80	36.50	36.75	—	50	0
Au124	6.6	—	—	82	12.7	0.59	37.00	34.50	—	0	0
Au154	6.6	—	0.17	66	10.4	0.53	36.00	35.00	—	0	0
Au204	6.6	—	—	63	11.2	0.60	38.00	36.50	—	0	0
Au254	6.6	—	0.15	66	10.8	0.74	37.00	35.00	—	10	260
O 124	6.6	—	—	66	14.2	0.68	37.50	35.00	34.5	460	15
D 154	6.6	—	—	66	10.8	0.52	38.0	36.00	37.0	0	0
D 204	6.6	—	—	82	12.7	0.90	37.0	36.5	37.0	25	0
D 265	6.6	—	—	66	9.5	0.80	37.5	37.0	—	25	5
Ja 45	6.6	—	—	—	10.1	0.58	36.0	36.0	—	0	5
Ja 75	6.6	—	—	66	10.7	0.88	36.5	36.0	—	5	0
N 26	6.6	—	—	66	11.2	0.60	37.5	35.5	—	15	0
D 106	6.6	(6.16)	—	82	11.2	1.10	38.0	37.0	35.5	5	10
D 156	6.6	(6.38)	—	82	10.5	0.90	38.0	36.0	36.0	15	0

Table V (cont'd.)

Sample number	pH of butter		Churning cream		Butter		Score of butter			Fresh butter	
	when fresh	after 1 month at 0-5°C.	% acid before neutralizing	pasteurizing temperature °C.	% salt in serum**	% curd	when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	number of yeasts per ml.***	number of molds per ml.***
D 65	6.6	--	0.16	82	11.1	0.86	37.5	37.0	--	30	5
Mh175	6.6	--	--	66	10.6	1.02	37.5	37.0	--	10	10
D 35	6.6	--	0.16	82	12.2	0.97	37.0	37.0	--	10	0
Ap 55	6.6	--	--	82	13.3	0.7	37.5	36.5	--	50	10
N 145	6.6	(6.47)	--	66	12.3	1.11	38.0	38.0	35.0	60	20
My 65	6.6	--	0.12	66	11.3	0.53	38.0	37.0	--	10	10
S 125	6.6	--	0.15	66	11.7	0.45	38.0	36.5	--	10	5
Au 45	6.6	--	--	66	11.2	0.83	37.0	37.0	--	250	40
S 45	6.6	--	0.15	82	12.4	0.41	38.0	37.0	--	0	5
N 135	6.6	--	--	66	10.2	0.84	38.0	37.5	--	170	15
O 145	6.6	--	--	85	12.6	0.56	37.5	37.0	--	10	10
O 195	6.6	--	0.16	66	11.1	0.72	38.0	37.0	--	0	15
O 235	6.6	--	--	--	10.1	0.79	37.5	36.0	--	180	0
D 216	6.63	--	--	--	13.0	1.10	38.0	36.5	--	25	0
D 93	6.65	6.55	0.15	82	12.7	0.67	37.5	35.5	--	15	0
Jy175	6.66	(6.67)	0.16	63	9.8	0.99	36.5	36.5	36.5	5	25
My143	6.7	6.50	0.12	66	--	1.1	--	--	--	1,050	10
D 43	6.7	6.45	--	--	12.6	0.74	37.0	35.5	--	60	10
D 183	6.7	6.60	--	63	11.0	0.76	36.0	36.0	--	30	0
F 84	6.7	6.70	0.15	82	12.9	0.74	34.0	34.5	--	5	0
F 144	6.7	6.55	--	82	12.2	0.84	37.0	36.5	--	145	0
Ap 84	6.7	6.65	--	82	11.7	0.76	36.5	36.0	--	5	5
My194	6.7	6.45	--	66	10.9	0.68	37.5	36.0	--	40	10
Ja226	6.7	--	0.16	82	12.3	0.55	38.0	34.5	--	150	30
D 124	6.7	--	--	82	11.1	0.93	37.5	36.5	37.5	115	0
Ja236	6.7	--	--	66	11.5	1.06	38.0	34.0	--	15	0
Ja 55	6.7	--	0.14	66	11.6	1.05	38.0	36.5	--	0	0

Table V (cont'd.)

Sample number	pH of butter		Churning cream		Butter		Score of butter			Fresh butter	
	when fresh	after 1 month at 0-5°C.	% acid before neutralising	pasteurising temperature °C.	% salt in serum**	% curd	when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	number of yeasts per ml.***	number of molds per ml.***
Ja 65	6.7	--	--	63	11.3	0.75	38.0	37.0	--	400	0
Ja175	6.7	--	--	--	12.1	0.64	36.0	35.5	--	5	0
Ja156	6.7	--	--	63	11.5	0.33	38.0	34.5	--	0	0
Ja185	6.7	--	0.11	82	11.9	1.22	37.5	36.0	--	170	0
N 85	6.7	--	0.16	82	10.8	0.60	38.0	37.5	--	0	0
O 83	6.7	(6.65)	--	68	10.8	0.5	37.5	36.0	--	140	0
D 155	6.7	--	--	66	10.9	0.97	37.5	36.5	--	5	0
Ja 46	6.7	--	--	82	11.5	0.72	37.0	34.5	--	10	0
Ja 86	6.7	--	--	66	9.5	0.8	37.5	37.0	--	5	0
D 86	6.72	(6.64)	0.15	66	11.6	0.40	38.0	36.5	37.0	20	0
My 14	6.75	6.5	--	82	9.5	0.82	37.0	37.0	--	0	10
Ja 14	6.8	6.45	0.15	82	12.4	0.65	38.0	36.5	--	20	0
Au 84	6.8	--	--	68	9.8	0.76	34.5	35.0	--	360	5
D 94	6.8	--	--	66	10.3	0.98	37.0	36.0	35.0	0	0
D 104	6.8	--	--	66	12.0	0.82	38.0	37.5	36.5	75	0
D 194	6.8	--	--	63	11.1	0.50	38.0	37.0	37.0	0	0
Ja 85	6.8	--	0.15	82	12.2	0.22	37.5	36.0	--	40	10
N 205	6.8	(6.65)	0.15	82	11.3	0.67	38.0	37.0	36.0	15	5
D 195	6.8	--	--	66	11.5	0.79	38.0	37.0	--	45	40
Ja196	6.8	--	--	68	11.6	0.86	38.0	34.5	--	0	5
Ap234	6.85	6.55	--	68	10.5	0.6	38.0	35.5	--	5	0
Ap105	6.85	--	--	66	11.5	1.1	37.5	36.5	--	80	20
II Butter made without butter culture from neutralized cream											
My203	5.3	5.65	--	66	--	1.2	--	--	--	180	15
S 43	5.4	5.45	0.36	63	11.7	0.8	34.5	33.0	--	350	140
O 203	5.55	5.15	0.45	--	11.3	0.7	32.0	32.0	--	240	40

Table V (cont'd.)

Sample number	pH of butter		Churning cream		Butter		Score of butter			Fresh butter	
	when fresh	after 1 month at 0-5°C.	% acid before neutralizing	pasteurizing temperature °C.	% salt in serum**	% curd	when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	number of yeasts per ml.***	number of molds per ml.***
M 264	5.6	--	--	71	6.1	0.48	36.0	35.5	--	60	10
O 205	5.6	--	0.5	71	6.9	0.56	34.5	34.0	--	10	10
S 163	5.75	5.80	0.36	66	13.5	0.9	35.0	35.0	--	60	0
S 264	5.8	--	--	63	13.7	0.65	37.0	35.0	--	5,000	40
Ja155	5.8	--	0.5	66	11.4	0.75	35.0	34.0	--	380	15
Ja216	5.8	--	0.42	66	12.7	0.74	36.0	34.5	--	30	0
S 33	5.85	5.92	--	66	11.4	1.0	36.0	36.5	--	300	0
M 73	5.85	5.80	0.45	66	10.6	1.39	36.0	34.0	--	1,185	35
D 123	5.85	6.00	0.38	66	12.0	0.64	36.0	34.0	--	170	5
F 174	5.85	6.7	0.37	76	13.0	0.43	36.0	35.5	--	35	0
Ap244	5.85	5.8	0.32	68	10.7	0.51	37.0	34.0	--	90	0
My213	5.9	5.90	0.45	79	--	0.55	--	--	--	145	10
Au314	5.9	--	--	68	--	0.51	36.0	35.0	--	--	--
Mh 85	5.9	--	--	68	10.5	0.71	34.5	34.0	--	900	30
Mh125	5.9	--	--	66	9.3	0.46	35.0	33.5	--	20	0
Je135	5.9	--	0.55	66	8.3	0.71	35.0	34.5	--	1,200	80
Je155	5.9	--	--	66	10.2	0.59	36.5	35.0	--	350	0
D 275	5.9	--	0.47	71	14.2	0.42	35.0	34.5	--	40	30
M 83	5.95	6.0	0.56	66	13.4	0.58	35.0	34.5	--	85	10
Ap 14	5.95	6.0	0.58	68	10.3	0.6	35.0	35.0	--	205	160
My 63	6.0	6.55	--	70	--	1.0	--	--	--	120	20
S 123	6.0	6.04	0.61	71	14.4	0.4	35.5	34.0	--	5	0
S 243	6.0	6.08	0.56	68	13.1	0.7	36.0	35.0	--	15	15
O 43	6.0	5.95	0.50	66	13.7	0.7	34.0	34.0	--	155	15
O 73	6.0	5.90	--	66	12.0	0.8	35.0	35.0	--	10	55
F 14	6.0	6.55	0.36	85	10.8	0.69	36.0	36.0	--	45	5
Ap 54	6.0	5.8	0.33	68	8.9	0.19	35.0	35.0	35.5	2,800	135

Table V (cont'd.)

Sample number	pH of butter		Churning cream		Butter		Score of butter			Fresh butter	
	when fresh	after 1 month at 0-5°C.	% acid before neutralizing	pasteurizing temperature °C.	% salt in serum**	% curd	when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	number of yeasts per ml.***	number of molds per ml.***
S 214	6.0	--	--	70	10.2	0.55	35.5	32.5	--	35	5
O 174	6.0	--	--	66	14.0	0.57	35.5	35.0	34.0	40	10
Je 75	6.0	--	0.47	66	14.6	1.08	35.0	35.0	--	25	0
Jy135	6.0	(6.1)	0.72	--	11.2	0.75	35.0	34.5	34.0	1,250	10
Je 83	6.05	5.83	0.65	66	--	0.8	--	--	--	3,500	240
Je153	6.05	6.1	0.49	67	11.9	0.7	35.0	35.0	--	130	35
Au 23	6.05	6.15	0.57	66	14.2	0.9	36.0	35.5	--	125	0
Au 83	6.05	--	0.52	68	12.2	0.6	35.0	--	--	150	5
O 93	6.05	6.10	0.58	71	13.8	0.9	36.0	35.0	--	50	0
O 143	6.05	5.65	0.36	71	11.7	0.9	35.5	33.0	--	335	10
Jy193	6.1	6.20	0.62	77	13.9	0.4	34.0	34.0	--	40	10
N 33	6.1	6.35	0.65	66	11.3	0.7	35.0	34.0	--	135	65
N 53	6.1	6.30	--	68	14.0	0.32	36.0	33.5	--	0	20
Je 94	6.1	--	0.46	68	11.5	0.81	36.0	36.0	--	5	0
S 84	6.1	--	--	71	10.1	0.29	34.5	34.0	--	900	10
D 244	6.1	--	--	85	10.3	0.58	35.5	34.5	35.0	150	0
Mh 15	6.1	--	--	71	10.1	0.52	35.0	35.5	--	30	20
Mh115	6.1	--	--	66	13.0	0.23	33.5	32.0	--	7,500	80
Ap135	6.1	--	--	--	11.5	0.65	36.0	33.0	--	20	20
Ap165	6.1	--	--	66	9.2	0.55	37.0	35.0	--	1,800	70
O 85	6.1	--	0.45	66	12.8	0.29	35.0	35.0	--	1,500	80
N 165	6.1	--	0.37	68	14.1	0.60	36.0	35.5	--	5	5
N 195	6.1	--	0.28	68	10.3	0.54	36.0	36.0	--	10	5
Ja266	6.1	--	0.45	66	11.4	0.64	35.0	34.5	--	23	0
Jy123	6.15	6.1	--	66	11.7	0.7	35.0	35.0	--	420	0
S 193	6.15	6.25	0.52	66	13.4	0.7	36.0	35.0	--	1,200	120
O 113	6.15	6.15	0.63	66	10.2	0.9	35.5	34.0	--	0	0

Table V (cont'd.)

Sample number	pH of butter		Churning cream		Butter		Score of butter			Fresh butter	
	when fresh	after 1 month at 0-5°C.	% acid before neutralising	pasteurising temperature °C.	% salt in serum**	% curd	when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	number of yeasts per ml.***	number of molds per ml.***
N 133	6.15	5.95	0.46	66	9.6	0.76	35.0	34.0	--	220	0
Je124	6.15	--	--	71	8.8	0.58	36.0	34.0	--	3,200	750
My 83	6.2	6.10	0.56	66	--	0.4	--	--	--	400	10
My173	6.2	6.10	0.44	63	--	0.7	--	--	--	1,300	70
Je 53	6.2	6.10	0.46	66	--	0.6	--	--	--	1,040	15
S 13	6.2	6.20	0.45	66	13.3	0.6	35.0	35.0	--	3,500	20
S 23	6.2	6.40	0.65	85	11.9	0.4	35.0	34.0	--	95	5
O 253	6.2	6.25	0.26	66	9.6	0.7	35.0	34.0	--	0	5
Ap 24	6.2	6.2	0.36	66	12.1	1.44	35.0	35.0	--	530	25
My 44	6.2	5.8	0.4	66	13.4	0.73	36.0	34.5	--	15	0
S 114	6.2	--	0.6	82	10.5	1.02	35.0	34.0	--	20	0
O 144	6.2	--	--	68	9.9	0.69	37.5	36.0	36.0	0	25
O 254	6.2	--	--	71	7.7	0.66	36.5	34.0	--	--	--
N 24	6.2	--	--	71	12.3	0.90	36.5	35.0	34.5	160	10
N 74	6.2	--	--	71	9.3	0.59	35.0	34.5	34.0	5	0
N 164	6.2	--	--	--	10.5	0.48	35.0	35.5	--	4,000	40
Mh 25	6.2	--	--	66	13.0	0.68	36.0	35.0	--	60	20
Ja 35	6.2	--	--	66	10.8	0.51	36.0	34.5	--	45	0
My 15	6.2	--	0.56	68	12.6	0.67	34.5	35.0	--	80	20
Jy115	6.2	(6.1)	0.36	66	10.6	0.40	34.5	35.0	35.5	0	0
Au 25	6.2	--	0.3	66	10.8	0.47	37.0	36.5	36.5	2,200	0
D 135	6.2	--	0.54	68	10.9	0.46	35.0	35.0	--	90	15
Au 75	6.2	--	0.65	71	8.8	0.85	36.5	36.0	34.5	550	15
N 75	6.2	--	0.35	70	13.0	0.18	36.0	36.0	--	35	0
Au245	6.2	--	0.57	68	9.9	0.83	35.0	33.5	34.5	8,000	40
S 155	6.2	--	0.62	--	12.7	0.53	36.0	35.0	--	320	60
S 205	6.2	--	0.48	66	15.1	0.55	36.0	36.5	--	15	5

Table V (cont'd.)

Sample number	pH of butter		Churning cream		Butter		Score of butter			Fresh butter	
	when fresh	after 1 month at 0-5°C.	% acid before neutralizing	pasteurizing temperature °C.	% salt in serum**	% curd	when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	number of yeasts per ml.***	number of molds per ml.***
Ja206	6.2	--	0.46	71	13.3	0.59	35.0	34.5	--	90	5
O 55	6.2	--	0.26	66	11.5	0.52	35.5	35.0	--	15	10
O 105	6.2	--	--	--	13.1	1.01	36.0	34.5	--	260	10
My233	6.25	6.25	0.55	66	--	0.75	--	--	--	435	5
O 193	6.25	6.25	--	82	12.2	0.6	34.0	35.0	--	10	0
N 193	6.25	6.30	0.26	66	13.3	0.84	36.0	36.0	--	--	--
Ja204	6.25	6.05	0.29	68	13.4	1.00	34.5	34.5	--	70	5
F 94	6.25	6.65	0.40	68	10.6	0.72	34.0	34.0	--	75	5
My 64	6.25	6.0	--	--	7.8	0.75	36.5	35.5	--	130	0
Je 84	6.25	--	0.25	66	10.1	0.59	37.0	37.0	--	90	5
Je164	6.25	--	--	--	14.8	0.95	35.0	34.5	--	0	10
Ap 75	6.25	--	--	66	15.1	0.45	34.0	33.0	--	10	5
Jy 15	6.25	(6.15)	0.67	66	11.6	0.59	34.5	34.5	34.5	1,800	20
My 43	6.3	6.15	0.34	63	--	0.7	--	--	--	600	200
Jy253	6.3	6.45	0.22	67	12.8	0.9	--	37.0	--	--	--
S 113	6.3	6.35	0.42	67	10.9	0.9	37.0	35.0	--	0	0
S 173	6.3	6.50	0.57	--	12.8	0.7	35.5	34.0	--	55	5
O 163	6.3	6.10	0.65	71	12.4	0.6	36.0	36.0	--	20	0
N 113	6.3	6.15	0.50	66	9.0	0.47	35.5	34.0	--	65	40
Ja 44	6.3	6.20	0.48	85	11.7	0.7	35.0	35.5	--	45	0
Ja174	6.3	6.10	0.34	66	14.8	0.6	34.25	34.0	--	0	5
F 164	6.3	6.55	0.50	85	11.5	0.64	35.0	35.0	--	45	0
My104	6.3	5.75	0.35	66	10.9	0.81	35.5	34.5	--	5	20
My174	6.3	6.40	--	68	13.8	0.6	34.0	34.0	--	720	25
S 104	6.3	--	0.22	68	12.1	0.42	36.5	34.0	--	70	0
S 174	6.3	--	0.53	70	11.2	0.60	36.0	35.0	--	35	15
O 164	6.3	--	--	--	12.2	0.66	35.0	34.5	--	1,500	20

Table V (cont'd.)

Sample number	pH of butter		Churning cream		Butter		Score of butter			Fresh butter	
	when fresh	after 1 month at 0-5°C.	% acid before neutralizing	pasteurizing temperature °C.	% salt in serum**	% curd	when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	number of yeasts per ml.***	number of molds per ml.***
O 214	6.3	--	--	67	10.1	0.50	36.0	35.0	34.5	2,200	140
O 224	6.3	--	--	--	9.7	0.61	36.0	34.5	34.5	14,000	0
N 14	6.3	--	--	68	10.5	1.02	36.5	36.0	35.5	0	230
N 214	6.3	--	--	66	12.9	0.39	34.0	34.5	35.0	1,000	200
D 184	6.3	--	--	66	14.2	1.07	35.5	35.0	35.0	65	15
Ja115	6.3	--	0.38	70	13.2	0.76	35.0	33.5	--	0	5
S 175	6.3	--	--	85	9.6	0.56	36.0	35.0	--	145	15
Ja195	6.3	--	0.28	68	10.7	0.78	37.0	34.5	--	1,900	20
Au135	6.3	--	--	--	11.4	1.03	35.5	34.0	--	3,500	40
N 155	6.3	--	0.34	66	13.3	0.96	35.0	34.0	--	10	0
D 45	6.3	--	--	--	17.1	0.42	36.0	35.5	--	30	5
D 55	6.3	--	0.54	71	13.1	0.39	34.5	34.0	--	165	5
D 255	6.3	--	0.21	68	13.0	0.82	36.0	35.5	--	200	10
Ja276	6.3	--	0.55	66	13.2	0.58	35.0	34.5	--	70	10
My 23	6.35	6.55	--	71	--	0.5	--	--	--	2,200	40
Je183	6.35	5.90	0.55	83	--	0.55	--	--	--	50	10
Au 43	6.35	6.05	0.50	71	9.0	0.7	36.0	37.0	--	135	0
Au163	6.35	6.35	0.68	77	13.3	0.6	33.0	34.0	--	50	0
D 103	6.35	6.25	0.47	66	13.4	0.48	36.0	34.25	--	5	0
Ja154	6.35	6.70	0.41	71	9.8	0.5	34.25	34.0	--	0	0
F 194	6.35	6.35	0.40	66	15.2	0.2	35.5	35.5	--	40	0
Ap204	6.35	6.20	0.60	85	9.6	0.45	35.0	34.5	--	170	10
Ap 85	6.35	--	--	66	12.6	0.40	37.0	35.5	--	800	20
My113	6.4	6.25	0.57	83	--	0.95	--	--	--	20	15
My223	6.4	6.45	0.55	66	--	0.8	--	--	--	320	15
Je 43	6.4	6.65	0.45	66	--	0.6	--	--	--	85	0
Je 63	6.4	6.12	0.63	77	--	0.45	--	--	--	60	5

Table V (cont'd.)

Sample number	pH of butter		Churning cream		Butter		Score of butter			Fresh butter	
	when fresh	after 1 month at 0-5°C.	% acid before neutralizing	pasteurizing temperature °C.	% salt in serum**	% curd	when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	number of yeasts per ml.***	number of molds per ml.***
Je 73	6.4	6.20	0.33	66	--	0.7	--	--	--	170	0
Jy 33	6.4	6.45	0.50	71	13.8	0.8	34.0	34.0	--	80	50
Au 73	6.4	--	0.60	68	11.9	0.6	35.0	--	--	200	35
Au123	6.4	6.25	0.55	66	13.4	0.6	35.0	35.0	--	40	0
Au153	6.4	6.20	--	--	13.0	0.5	35.0	33.0	--	105	30
Au183	6.4	6.20	0.55	83	11.4	0.5	37.0	35.5	--	20	0
D 203	6.4	6.25	0.55	65	12.7	0.33	35.0	33.5	--	1,195	20
Ja 74	6.4	6.15	--	68	12.6	0.52	34.5	34.0	--	150	25
My114	6.4	6.2	0.3	66	9.6	0.74	36.0	34.0	--	10	10
My134	6.4	6.25	--	--	10.2	0.52	35.0	33.5	--	60	15
Je214	6.4	--	--	--	11.9	0.57	35.5	35.0	--	700	10
Au 14	6.4	--	--	--	8.8	0.7	34.0	33.0	--	300	40
Au 44	6.4	--	0.24	66	10.3	0.63	35.5	35.0	--	20	35
Au144	6.4	--	0.6	66	15.2	0.54	34.5	35.0	--	10	30
S 244	6.4	--	--	66	8.6	0.71	36.0	34.5	--	250	0
O 24	6.4	--	--	83	10.3	0.77	35.5	34.5	34.5	65	10
O 44	6.4	--	--	66	9.4	0.18	36.5	35.0	34.5	8,000	200
O 64	6.4	--	--	67	11.9	0.48	35.0	35.0	34.5	30	10
N 44	6.4	--	--	67	14.2	0.45	35.0	34.5	34.5	15	0
N 84	6.4	--	--	64	11.0	0.45	34.5	34.0	33.5	350	15
N 224	6.4	--	0.45	67	9.8	0.40	36.0	36.0	--	350	90
D 34	6.4	--	--	66	9.7	0.39	36.0	34.0	34.0	2,500	20
D 114	6.4	--	--	70	11.2	0.68	34.5	34.0	35.0	10	0
D 174	6.4	--	--	71	9.4	0.49	36.5	35.0	35.5	65	0
D 254	6.4	--	--	71	11.1	0.74	36.0	34.0	35.0	15	0
D 284	6.4	--	--	66	13.6	0.67	35.5	35.0	34.5	15	5
Ja 25	6.4	--	0.3	71	15.3	0.37	35.5	34.5	--	25	5

Table V (cont'd.)

Sample number	pH of butter		Churning cream		Butter		Score of butter			Fresh butter	
	when fresh	after 1 month at 0-5°C.	% acid before neutralizing	pasteurizing temperature °C.	% salt in serum**	% curd	when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	number of yeasts per ml.***	number of molds per ml.***
Jy 25	6.4	(6.35)	0.68	64	12.2	0.67	34.5	35.0	35.5	290	20
O 185	6.4	—	0.55	66	10.4	0.47	36.0	35.0	—	0	0
N 115	6.4	—	0.57	66	13.6	0.65	34.5	34.0	—	150	0
N 185	6.4	—	0.33	68	13.6	1.09	35.5	35.5	—	0	0
Ja 66	6.4	—	—	—	10.3	0.88	35.5	34.5	—	30	0
Je263	6.45	6.15	—	—	—	0.3	—	—	—	1,750	0
Jy205	6.45	6.60	0.34	71	12.9	0.4	36.0	35.0	—	0	50
Jy235	6.45	6.50	0.33	70	16.2	0.2	35.0	35.0	—	150	90
S 133	6.45	6.62	0.48	66	14.2	0.3	36.0	34.0	—	45	0
N 93	6.45	6.75	0.51	68	13.2	0.67	35.0	35.0	—	45	15
F 204	6.45	6.9	0.42	70	10.6	0.20	34.5	35.0	—	140	0
Ap 34	6.45	6.6	—	66	13.8	0.97	35.5	35.0	—	400	50
Ap 74	6.45	6.3	0.37	68	8.7	0.48	35.5	34.5	—	2,100	300
Ap185	6.45	—	—	66	16.0	0.35	35.0	34.5	—	10	10
Jy 55	6.45	(6.4)	0.56	85	10.5	0.82	34.0	34.5	33.0	50	0
Je113	6.5	6.05	0.46	63	—	0.65	—	—	—	1,480	150
Je233	6.5	6.40	0.56	66	—	0.5	—	—	—	680	5
Jy103	6.5	6.05	0.48	82	11.5	0.7	36.0	36.0	—	270	5
Jy243	6.5	6.35	0.60	71	8.6	0.4	35.0	34.0	—	1,200	0
N 123	6.5	6.30	0.6	85	10.6	0.43	34.5	34.5	—	170	0
N 163	6.5	6.40	0.6	75	13.9	0.71	35.0	35.0	—	25	5
D 113	6.5	6.35	0.4	67	11.8	0.92	37.0	35.25	—	15	105
D 163	6.5	6.35	0.4	68	10.3	0.63	34.0	33.75	—	775	80
Ja184	6.5	6.35	0.7	66	8.5	0.63	34.5	33.0	—	60	30
F 234	6.5	6.5	0.56	68	9.8	0.51	35.5	35.0	—	40	0
Au184	6.5	—	—	68	12.1	0.56	34.5	34.0	—	30	20
Au294	6.5	—	—	66	16.5	0.39	34.0	32.0	—	180	30

Table V (cont'd.)

Sample number	pH of butter		Churning cream		Butter		Score of butter			Fresh butter	
	when fresh	after 1 month at 0-5°C.	% acid before neutralizing	pasteurizing temperature °C.	% salt in serum**	% curd	when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	number of yeasts per ml.***	number of molds per ml.***
S 94	6.5	--	0.45	70	10.1	0.45	33.0	34.0	--	1,200	400
O 34	6.5	--	--	71	7.9	0.91	36.0	35.5	34.5	0	5
N 204	6.5	--	--	85	10.2	0.43	35.5	35.5	35.5	80	70
D 24	6.5	--	0.42	71	11.3	0.95	35.0	35.5	35.0	270	0
D 84	6.5	--	--	66	14.4	0.47	34.5	34.0	35.5	405	20
D 164	6.5	--	--	71	10.4	0.65	35.5	34.0	35.5	45	25
Ja215	6.5	--	0.28	66	15.2	0.68	34.0	34.5	--	50	5
Ja225	6.5	--	--	--	10.9	0.61	35.0	34.5	--	75	10
Ja285	6.5	--	0.42	66	9.9	0.62	36.5	--	--	60	0
Ja295	6.5	--	--	66	11.7	0.57	35.5	35.0	--	80	10
Ap 15	6.5	--	--	66	11.7	0.75	36.0	35.0	--	2,500	30
Ap 35	6.5	--	0.48	77	14.4	0.75	35.5	34.0	--	10	120
Je 65	6.5	--	0.65	71	10.4	0.74	34.5	34.0	--	70	20
Je115	6.5	--	--	77	13.7	0.86	36.0	33.0	--	20	10
Au105	6.5	--	--	--	8.9	0.52	35.5	35.0	--	120	10
Au215	6.5	--	0.59	68	11.1	0.40	35.0	35.0	35.0	1,500	70
O 35	6.5	--	0.54	71	11.1	0.36	36.0	35.0	--	80	0
Ja176	6.5	--	0.55	71	11.9	0.32	36.0	34.5	--	4,500	10
O 165	6.5	--	0.53	85	10.4	0.48	35.0	34.0	--	60	30
N 25	6.5	--	0.52	71	10.5	0.42	35.5	--	--	0	0
D 165	6.5	--	0.50	66	15.0	0.62	34.5	--	--	100	15
D 245	6.5	--	0.45	85	9.6	0.95	35.5	34.5	--	70	0
D 255	6.5	--	0.29	68	13.0	1.01	35.5	35.0	--	10	5
Ja 16	6.5	--	0.40	85	9.9	0.72	34.5	35.0	--	60	0
My 33	6.55	6.75	0.60	74	--	0.7	--	--	--	410	30
Je265	6.55	6.98	--	--	--	0.6	--	--	--	1,250	0
S 253	6.55	6.75	0.75	66	12.0	1.0	34.0	33.5	--	8,000	110

Table V (cont'd.)

Sample number	pH of butter		Churning cream		Butter		Score of butter			Fresh butter	
	when fresh	after 1 month at 0-5°C.	% acid before neutralizing	pasteurizing temperature °C.	% salt in serum**	% curd	when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	number of yeasts per ml.***	number of molds per ml.***
N 153	6.55	6.50	0.52	71	13.9	0-63	36.0	36.0	--	65	0
D 23	6.55	6.40	0.3	66	12.3	0.83	36.0	33.75	--	70	5
D 83	6.55	6.30	0.61	66	12.9	0.79	35.0	33.75	--	85	30
Ja 64	6.55	5.9	0.65	66	11.6	0.5	34.0	34.0	--	440	5
Ja 94	6.55	6.25	0.26	74	14.1	0.4	34.5	34.0	--	20	0
Ja194	6.55	6.25	0.4	66	11.4	0.7	36.0	35.0	--	0	0
Ap 64	6.55	6.6	0.68	68	8.9	0.82	34.0	34.0	--	20	10
Ap104	6.55	6.35	--	--	6.9	0.37	35.5	34.0	--	625	15
My224	6.55	6.30	0.67	72	7.4	0.45	35.0	35.0	--	235	0
Je133	6.6	6.25	0.55	67	--	0.65	--	--	--	475	15
F 154	6.6	6.75	0.49	71	13.1	0.66	35.0	35.0	--	190	5
F 244	6.6	6.9	0.18	67	12.3	0.57	38.0	36.0	--	5	5
Je144	6.6	--	0.72	82	11.5	0.66	35.5	34.5	--	4,000	30
Au234	6.6	--	--	--	12.9	0.79	35.0	35.0	--	40	25
Au 74	6.6	--	0.70	71	10.7	0.39	34.0	34.5	--	200	15
Au104	6.6	--	--	--	11.5	0.62	35.0	33.5	--	210	20
Au224	6.6	--	0.36	66	15.0	0.70	35.5	35.0	--	365	0
Au114	6.6	--	--	--	11.9	0.44	36.0	34.0	--	55	10
S 64	6.6	--	0.51	85	12.3	0.46	35.0	34.0	--	30	30
S 154	6.6	--	0.35	71	11.7	0.60	36.5	34.5	--	40	0
Ja116	6.6	--	0.38	66	14.8	0.74	35.0	34.0	--	70	20
N 154	6.6	--	0.58	71	8.1	0.29	35.0	35.0	34.0	18,000	0
Ja106	6.6	--	--	68	1.22	0.50	36.5	36.0	--	30	30
N 194	6.6	--	--	71	10.0	0.66	35.5	35.5	34.5	400	20
Ja 96	6.6	--	--	--	12.9	0.65	35.5	35.0	--	10	0
N 234	6.6	--	--	66	12.8	0.46	35.0	35.0	35.0	450	90
D 215	6.6	--	0.25	66	13.0	0.77	36.0	36.0	--	620	10

Table V (cont'd.)

Sample number	pH of butter		Churning cream		Butter		Score of butter			Fresh butter	
	when fresh	after 1 month at 0-5°C.	% acid before neutralizing	pasteurizing temperature °C.	% salt in serum**	% curd	when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	number of yeasts per ml.***	number of molds per ml.***
D 64	6.6	--	--	71	10.7	0.70	36.0	37.0	37.0	11,700	10
Ja 36	6.6	--	--	63	11.8	0.69	35.0	34.0	--	140	10
D 234	6.6	--	--	64	10.7	0.61	35.0	34.0	35.5	175	0
Mh185	6.6	--	--	--	10.6	0.79	34.5	35.5	--	70	10
Je 35	6.6	--	0.50	85	10.3	0.62	35.5	33.5	--	1,260	0
Au 65	6.6	--	--	--	12.8	0.63	34.0	34.5	--	380	30
Au 95	6.6	--	--	66	13.8	0.78	35.0	35.5	35.5	90	20
S 225	6.6	--	0.58	71	10.3	0.61	35.5	35.0	--	290	20
Au165	6.6	--	--	77	13.2	0.30	34.5	34.5	--	30	10
S 215	6.6	--	0.7	66	10.3	0.55	34.5	34.0	--	20	0
Jy 83	6.6	--	0.67	68	13.9	0.30	35.0	--	--	75	50
Au 33	6.6	6.47	0.48	66	12.9	0.60	36.5	36.0	--	5	10
O 45	6.6	--	0.55	66	14.5	0.30	34.0	34.5	--	10	10
N 15	6.6	--	--	66	11.7	0.62	35.0	33.5	--	210	0
N 55	6.65	--	0.45	85	9.9	0.86	34.5	34.5	--	5	5
S 203	6.65	--	--	--	12.8	0.30	35.5	--	--	0	0
O 103	6.65	6.50	0.58	66	12.8	0.60	35.5	34.5	--	20	5
D 63	6.65	6.60	--	68	9.1	0.54	35.5	34.5	--	70	5
F 64	6.65	6.70	0.54	71	11.4	0.73	35.5	34.0	--	70	50
Ap124	6.65	6.50	0.48	70	14.5	0.36	34.0	34.5	--	20	5
My234	6.65	6.65	0.6	71	6.7	0.64	36.0	34.5	--	295	15
Je184	6.65	--	0.58	68	12.7	0.60	35.5	35.0	--	600	30
Ap254	6.7	6.50	--	--	8.1	0.82	34.5	34.0	--	1,040	40
O 233	6.7	6.70	0.50	66	10.3	0.7	35.0	35.0	--	20	0
O 263	6.7	6.60	0.42	66	11.1	0.7	34.0	35.0	--	5	0
D 33	6.7	6.65	--	--	10.2	1.04	36.0	34.0	--	260	0
My 94	6.7	6.4	0.51	71	10.3	0.69	36.0	35.0	--	65	10

Table V (cont'd.)

Sample number	pH of butter		Churning cream		Butter		Score of butter			Fresh butter	
	when fresh	after 1 month at 0-5°C.	% acid before neutralizing	pasteurizing temperature °C.	% salt in serum**	% curd	when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	number of yeasts per ml.***	number of molds per ml.***
Je224	6.7	--	0.59	75	10.2	0.26	37.0	35.5	--	--	--
Au174	6.7	--	0.56	68	9.6	0.34	36.0	33.0	--	50	--
Au244	6.7	--	0.45	68	10.8	0.69	34.5	34.0	--	20	--
O 114	6.7	--	--	66	14.1	0.51	35.5	35.0	34.5	0	10
D 214	6.7	--	0.24	68	11.9	0.48	36.5	36.5	36.5	0	0
Ja105	6.7	--	0.35	63	12.3	0.42	35.0	35.0	--	30	0
Ja205	6.7	--	0.35	71	11.1	0.82	36.0	35.0	--	30	5
Mh145	6.7	--	--	73	11.2	0.29	34.5	34.5	--	1,200	80
S 55	6.7	--	0.70	63	8.6	0.68	35.0	34.5	--	450	80
O 255	6.7	--	0.42	--	--	0.5	37.0	36.0	--	200	10
Je173	6.75	6.70	0.38	68	--	0.8	--	--	--	110	15
Je203	6.75	6.60	0.70	66	--	0.8	--	--	--	30	10
Jy 63	6.75	6.85	0.50	66	15.6	1.0	35.0	34.0	--	25	5
Jy173	6.75	6.92	0.58	66	15.6	0.7	34.0	34.0	--	475	285
O 13	6.75	6.70	0.51	67	13.1	0.7	37.0	35.0	--	0	5
O 183	6.75	6.65	0.69	66	11.3	0.8	36.5	35.5	--	5	5
Ja114	6.75	6.80	0.50	68	10.8	0.54	35.0	34.75	--	7,450	5
Ap214	6.75	6.6	0.38	66	9.5	0.64	37.0	35.0	--	120	0
My144	6.75	6.4	--	66	9.2	0.49	35.5	34.5	--	210	20
O 123	6.8	6.45	0.45	75	12.8	0.8	35.0	36.0	--	5	0
O 213	6.8	6.80	0.70	66	8.3	0.8	34.0	34.0	--	190	0
D 193	6.8	6.70	0.55	71	11.4	0.84	35.0	33.25	--	480	5
F 134	6.8	6.35	0.67	66	8.7	0.55	34.5	34.5	--	175	0
Ap144	6.8	6.75	0.34	68	11.3	1.15	35.5	34.5	--	0	0
S 164	6.8	--	--	68	10.9	0.79	34.5	34.0	--	1,700	30
S 254	6.8	--	--	71	11.6	0.59	35.0	34.5	--	1,200	600
Ja125	6.8	--	--	--	11.2	0.54	35.5	34.5	--	1,500	10

Table V (cont'd.)

Sample number	pH of butter		Churning cream		Butter		Score of butter			Fresh butter	
	when fresh	after 1 month at 0-5°C.	% acid before neutral-izing	pasteur-izing temper-ature °C.	% salt in se-rum**	% curd	when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	number of yeasts per ml.***	number of molds per ml.***
Ja235	6.8	--	0.34	66	12.0	0.56	35.0	35.0	--	10	15
Ja255	6.8	--	0.46	73	12.9	0.84	34.5	33.0	--	20	10
My 85	6.8	--	0.68	71	12.7	0.79	34.5	35.0	--	2,200	400
S 85	6.8	--	--	--	9.9	0.43	34.0	32.5	--	750	20
My153	6.85	6.55	0.68	77	--	1.0	--	--	--	90	10
My183	6.85	6.90	0.50	66	--	0.8	--	--	--	110	5
Je143	6.85	--	0.74	--	--	0.6	--	--	--	30	0
Ja124	6.85	6.35	--	--	12.1	0.5	34.0	33.25	--	40	0
Ja144	6.85	6.30	--	67	9.5	0.65	34.5	33.0	--	560	20
My154	6.85	6.8	0.32	68	12.4	0.79	35.75	36.0	--	0	20
My214	6.85	6.5	--	--	10.1	0.51	34.0	34.0	--	430	5
Jy 93	6.9	--	0.69	67	1.29	0.6	34.0	--	--	40	55
Au 13	6.9	6.92	0.58	66	15.8	0.6	35.0	35.0	--	880	75
Au103	6.9	6.75	--	--	9.5	0.9	34.0	34.0	--	1,760	65
O 133	6.9	6.80	0.55	66	18.1	0.6	35.0	34.0	--	10	0
F 224	6.9	6.85	0.30	66	14.4	0.73	35.5	35.0	--	45	0
Je174	6.9	--	--	--	11.4	0.41	34.5	34.5	--	600	0
Ap114	6.9	6.8	0.58	68	13.5	0.40	36.0	34.5	--	15	0
Au 34	6.9	--	0.68	66	10.8	0.78	34.5	34.25	--	30	0
N 104	6.9	--	--	63	10.8	0.90	37.5	37.0	37.0	15	0
Ja135	6.9	--	0.32	66	10.6	0.73	35.5	33.0	--	340	10
Mh205	6.9	--	--	--	11.8	0.54	35.0	33.0	--	40	20
Ap115	6.9	--	--	--	10.0	0.80	35.5	33.0	--	90	25
Ap175	6.9	--	0.47	66	12.3	0.75	35.5	34.0	--	430	20
My125	6.9	--	0.51	66	12.2	1.48	34.5	35.0	--	3,300	40
Je125	6.9	--	0.60	66	13.0	0.85	35.0	34.0	--	450	30
S 235	6.9	--	0.64	68	9.2	0.50	35.0	35.0	--	800	0

Table V (cont'd.)

Sample number	pH of butter		Churning cream		Butter		Score of butter			Fresh butter	
	when fresh	after 1 month at 0-5°C.	% acid before neutralizing	pasteurizing temperature °C.	% salt in serum**	% curd	when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	number of yeasts per ml.***	number of molds per ml.***
O 125	6.9	--	0.61	68	9.8	1.65	36.0	35.0	--	5	0
D 95	6.9	--	0.35	68	13.8	0.76	35.5	35.0	--	25	0
D 145	6.9	--	0.33	67	12.7	0.87	35.5	34.0	--	25	5
Je 13	6.95	6.65	0.50	66	--	0.70	--	--	--	350	15
Je153	6.95	--	0.69	67	--	0.4	--	--	--	205	5
Jy 13	7.0	6.85	0.77	66	11.4	0.8	34.5	34.0	--	120	5
Au243	7.0	6.90	0.70	66	13.8	0.5	35.0	34.0	--	15	10
S 83	7.0	6.92	0.55	66	9.9	0.7	35.0	35.0	--	570	10
S 263	7.0	--	0.70	70	10.3	0.3	37.0	--	--	3,150	10
D 153	7.0	6.80	0.54	71	12.4	0.38	33.0	32.5	--	105	0
Ap134	7.0	6.85	0.58	66	12.6	0.70	36.0	35.0	--	770	65
O 104	7.0	--	--	66	12.0	0.67	35.0	35.5	35.0	375	0
D 74	7.0	--	--	63	10.8	0.38	33.5	34.0	35.0	65	0
D 144	7.0	--	--	71	13.6	0.76	35.5	34.5	35.0	160	0
Ja145	7.0	--	--	72	12.0	0.42	35.0	34.0	--	320	5
S 145	7.0	--	--	--	12.9	0.42	35.5	35.5	--	85	0
Jy155	7.0	(7.00)	0.61	66	10.9	0.72	34.0	33.5	34.5	400	80
S 85	7.0	--	0.75	66	12.7	0.41	34.0	--	--	390	10
Ja166	7.0	--	0.55	66	13.2	0.74	35.5	35.0	--	10	25
My123	7.05	7.35	0.60	66	--	1.00	--	--	--	1,450	300
Jy 23	7.05	7.05	0.65	66	16.2	0.60	34.0	34.0	--	180	0
Jy213	7.1	7.20	0.73	66	14.6	0.6	34.0	33.0	--	10	10
Au113	7.1	6.90	0.44	66	12.4	0.4	37.0	36.5	--	60	0
Au233	7.1	6.85	0.75	66	7.9	0.5	36.5	34.0	--	150	40
O 243	7.1	6.90	0.57	68	8.2	0.75	35.0	35.0	--	445	0
My 34	7.1	7.3	--	77	12.1	0.93	36.0	34.5	--	0	20
Au134	7.1	--	--	--	9.8	0.71	34.0	34.0	--	540	135

Table V (cont'd.)

Sample number	pH of butter		Churning cream		Butter		Score of butter			Fresh butter	
	when fresh	after 1 month at 0-5°C.	% acid before neutralizing	pasteurizing temperature °C.	% salt in serum**	% curd	when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	number of yeasts per ml.***	number of molds per ml.***
Ap 45	7.15	--	--	66	12.1	0.75	34.5	34.0	--	60	10
Jy 75	7.15	(7.0)	--	67	13.3	1.04	34.5	34.5	35.0	110	0
Ja256	7.2	--	0.48	73	11.1	0.66	35.5	35.0	--	420	20
D 53	7.2	7.10	0.66	71	12.2	0.68	33.0	33.5	--	270	20
Au 94	7.2	--	0.70	66	13.8	0.60	34.5	33.0	--	0	5
Au214	7.2	--	--	73	14.5	0.48	35.0	35.0	--	140	10
O 115	7.2	--	0.46	77	15.7	0.30	36.0	35.0	--	0	0
My 75	7.2	--	0.59	66	12.8	0.61	34.0	35.0	--	720	10
S 185	7.2	--	0.63	71	12.1	0.69	36.0	35.5	--	400	20
Ja 24	7.3	7.15	0.65	71	10.1	0.95	34.25	34.0	--	30	5
S 25	7.3	--	--	71	10.5	0.78	35.0	34.0	--	500	20
Au164	7.3	--	0.60	64	13.4	0.62	34.0	34.0	--	20	5
Ja 76	7.3	--	0.49	66	11.3	0.89	35.5	35.5	--	60	0
Jy223	7.35	7.20	--	--	8.7	1.00	35.0	35.0	--	140	160
O 163	7.35	7.45	0.60	63	11.9	0.30	34.0	33.5	--	380	0
M 143	7.35	7.40	0.70	71	12.8	0.57	34.5	32.5	--	140	0
Jy 95	7.35	--	0.60	70	10.9	0.78	34.5	33.5	35.0	0	0
F 214	7.4	7.4	--	71	13.8	0.56	36.0	35.5	--	20	0
Au 35	7.4	--	--	71	8.8	0.61	36.0	35.0	33.5	1,100	15
Je163	7.45	7.22	0.70	66	--	0.7	--	--	--	85	0
O 95	7.5	--	0.48	66	11.6	0.86	34.5	35.0	--	130	250
O 194	7.5	--	--	71	12.5	0.72	35.5	35.0	34.5	180	0
S 135	7.5	--	--	77	13.3	1.20	34.0	34.5	--	5	0
Mh 35	7.5	--	--	72	9.6	0.43	36.5	35.5	--	160	20
Je 15	7.5	--	--	--	11.4	1.47	35.5	33.0	--	3,500	10
Jy263	7.5	7.37	0.58	--	--	0.70	--	33.0	--	--	--
Je273	7.55	7.28	0.65	66	--	0.9	--	--	--	35	10

Table V (cont'd.)

Sample number	pH of butter		Churning cream		Butter		Score of butter			Fresh butter	
	when fresh	after 1 month at 0-5°C.	% acid before neutral-izing	pasteur-izing temper-ature °C.	% salt in se-rum**	% curd	when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	number of yeasts per ml.***	number of molds per ml.***
Je 54	7.55	--	--	--	7.9	0.96	34.0	33.0	--	80	15
Jel04	7.6	--	0.75	71	12.8	0.86	34.5	34.0	--	55	15
Aul45	7.6	--	0.60	66	12.2	0.65	35.0	34.5	36.0	0	30
D 185	7.6	--	0.48	66	11.0	1.28	35.0	34.0	--	255	45
Ky105	7.7	--	0.60	71	10.6	0.78	34.0	33.5	--	60	10
S 95	7.8	--	0.47	66	11.6	0.78	35.0	33.0	--	580	40
III Butter made with butter culture from neutralized cream											
F 24	5.45	6.35	0.43	64	11.7	0.46	34.5	33.5	--	360	40
Je 95	5.5	--	--	63	10.2	0.81	34.0	--	--	170	0
Apl54	5.55	5.6	--	64	14.9	0.13	34.5	32.5	--	160	75
N 114	5.6	--	--	68	9.8	0.55	34.0	34.5	35.0	12,000	400
Jy 45	5.95	--	--	--	5.5	0.49	34.0	34.5	35.5	45	70
S 115	6.0	--	--	--	7.2	0.59	37.5	37.5	--	2,200	200
Apl64	6.1	6.25	0.42	66	9.7	0.49	36.5	33.0	--	3,000	0
Au 54	6.1	--	0.60	66	10.2	0.79	34.5	35.0	--	6,000	20
D 224	6.1	--	--	68	9.4	0.22	36.0	35.0	34.5	445	20
S 75	6.1	--	0.60	71	11.8	0.69	35.0	34.0	--	80	40
Jel23	6.15	6.15	0.34	67	13.5	0.6	--	--	--	0	60
S 194	6.2	--	--	--	10.6	0.52	34.5	33.5	--	450	10
Au 15	6.2	--	0.49	66	8.9	0.58	36.5	36.0	36.5	10	10
Aul75	6.2	--	0.46	71	12.0	0.70	33.5	34.0	35.0	190	15
O 15	6.2	--	0.55	71	12.1	0.55	34.5	34.0	--	50	50
N 23	6.25	6.30	0.67	66	10.5	0.59	35.5	34.0	--	475	45
My 24	6.25	6.15	0.48	66	9.3	0.55	35.0	34.5	--	12,000	40
Mhl95	6.3	--	--	71	9.9	0.69	34.0	34.5	--	90	10
Jel45	6.3	--	0.48	71	12.0	0.69	36.0	34.5	--	20	0

Table V (cont'd.)

Sample number	pH of butter		Churning cream		Butter		Score of butter			Fresh butter	
	when fresh	after 1 month at 0-5°C.	% acid before neutralizing	pasteurizing temperature °C.	% salt in serum**	% curd	when fresh	after 1 month at 0-5°C.	after 1 week at 21°C.	number of yeasts per ml.***	number of molds per ml.***
Au255	6.3	--	0.52	63	8.1	0.47	33.5	33.0	33.0	2,000	30
O 155	6.3	--	0.56	66	10.6	0.49	37.0	36.5	--	10	70
M 175	6.3	--	0.57	71	10.8	0.35	35.5	34.5	--	50	0
Ap 94	6.4	6.20	0.35	71	10.4	0.49	36.0	35.0	--	200	5
My 84	6.45	6.25	0.66	71	9.2	0.54	36.5	36.0	--	65	10
S 213	6.5	6.55	0.67	63	9.7	0.7	35.0	35.0	--	350	150
O 234	6.5	--	--	71	8.8	0.72	35.5	35.0	34.5	125	15
Je 24	6.55	--	0.61	71	9.1	0.52	35.0	34.0	--	40	15
Ja 26	6.6	--	0.50	66	10.0	0.60	35.0	33.5	--	180	50
Je 64	6.65	--	0.56	66	8.0	0.52	34.5	34.0	--	380	50
D 205	6.7	--	0.26	66	10.5	0.45	37.0	36.5	--	5	25
O 94	6.7	--	--	66	10.8	0.94	34.5	33.5	35.0	190	65
D 175	6.8	--	0.50	66	12.8	0.43	35.0	35.0	--	45	0
Je193	6.85	6.70	0.60	66	11.9	0.7	--	--	--	4,000	30
Ap 95	6.85	--	--	71	10.5	0.7	34.5	34.5	--	115	20
Au274	6.9	--	0.58	71	13.3	0.3	35.0	35.0	--	220	5
Ja275	6.9	--	0.46	71	11.5	0.61	35.5	34.0	--	220	20
Jy 65	6.9	(6.85)	0.60	71	13.2	0.63	35.5	34.5	33.5	10	0
D 44	7.0	--	--	71	10.8	0.66	35.5	35.0	35.0	475	15
My155	7.0	--	0.65	71	8.2	1.20	34.5	35.0	--	80	10
My 54	7.1	6.8	--	64	14.1	0.41	35.0	34.5	--	16	10

* Figures in parenthesis are pH values after 1 week at 21°C. instead of 1 month at 0-5°C.

** % salt in serum = 100 x % salt: (100 - % fat).

*** Counts of 0 denote counts of less than 10.

Table VI

The acid value of butter and butterfat as related to the keeping quality of salted butter when held for 1 month at 0-5°C.

Sample number	After 1 month at 0-5°C. loss in score	score	pH of fresh butter	Acid value of butter when fresh	after 1 week at 21°C.	after 1 month at 0-5°C.	Acid value of fat when fresh	after 1 week at 21°C.	after 1 month at 0-5°C.	Acid ratio when fresh	after 1 week at 21°C.	after 1 month at 0-5°C.
I Butter made without butter culture from cream not neutralized												
0124	2.5	35.0	6.6	5.70	6.80	6.25	4.30	5.60	5.30	75.4	82.4	84.8
0154	2.5	35.5	6.5	4.50	4.15	4.40	2.90	3.60	3.95	64.4	86.7	89.8
N174	2.5	35.0	6.4	4.65	5.25	5.55	3.30	3.40	3.70	71.0	64.8	66.7
054	2.0	35.5	6.5	5.0	7.10	5.05	2.80	4.50	4.60	56.0	63.4	91.1
074	2.0	35.0	6.5	5.60	7.10	6.25	2.90	4.10	5.70	51.8	57.7	91.2
0134	2.0	36.0	6.0	5.90	7.20	6.55	3.30	4.05	5.10	55.9	56.3	77.9
0184	2.0	36.0	6.5	5.15	6.85	5.45	3.60	4.80	3.05	69.9	70.1	56.0
0204	2.0	36.0	6.4	4.80	5.25	5.20	2.10	4.35	4.50	43.8	82.9	86.5
D154	2.0	36.0	6.6	6.80	6.85	6.85	5.00	5.80	5.80	73.5	84.7	84.7
N34	1.5	35.5	6.3	5.30	5.80	6.00	3.50	3.75	3.75	66.0	64.8	62.5
N64	1.5	36.0	6.4	5.35	6.10	5.50	3.15	3.15	3.30	58.9	51.6	60.0
N94	1.5	35.5	6.3	4.25	4.55	4.75	3.05	3.00	3.80	71.8	65.9	80.0
D14	1.5	35.0	6.5	6.50	7.80	6.90	4.65	5.80	5.55	71.5	74.4	80.4
D84	1.5	33.5	5.5	9.45	11.30	9.40	6.40	8.45	7.25	67.7	74.8	77.1
Au225	1.5	35.0	5.8	7.70	9.30	-	4.00	4.50	-	51.9	48.4	-
014	1.0	36.0	6.5	4.40	4.00	4.50	2.90	3.65	3.70	65.9	91.3	82.2
084	1.0	35.5	6.3	5.10	5.90	5.30	2.60	3.30	4.30	51.0	55.9	81.1
N184	1.0	35.5	6.5	5.45	6.05	5.95	4.60	3.75	4.00	84.4	62.0	67.2
D124	1.0	36.5	6.7	4.10	5.55	5.10	3.80	3.80	3.85	92.7	68.5	75.5
D134	1.0	35.0	6.5	7.20	7.50	7.30	6.30	6.40	6.20	87.5	85.3	84.9
D194	1.0	37.0	6.8	5.05	5.75	5.65	4.05	4.00	4.15	80.2	69.6	73.5
N124	0.5	35.5	6.3	5.35	5.80	5.35	3.50	3.00	3.45	65.4	51.7	64.5
D94	0.5	36.5	6.8	6.20	6.80	5.65	4.45	4.80	4.95	71.8	70.6	87.6
D104	0.5	37.5	6.8	7.15	8.05	6.70	4.85	5.90	5.70	67.8	73.3	85.1

Table VI (Cont'd)

Sample number	After 1 month at 0-5°C.			Acid value of butter			Acid value of fat			Acid ratio		
	loss in score	score	pH of fresh butter	when fresh	after 1 week at 21°C.	after 1 month at 0-5°C.	when fresh	after 1 week at 21°C.	after 1 month at 0-5°C.	when fresh	after 1 week at 21°C.	after 1 month at 0-5°C.
D204	0.5	36.5	6.6	5.30	6.10	5.55	4.05	4.25	4.20	76.4	69.7	75.7
N244	0	37.0	6.4	4.40	4.75	5.00	3.40	3.50	2.85	77.3	73.7	57.0
Au85	0	36.0	6.4	3.90	4.10	-	2.80	2.50	-	71.8	61.0	-
N254	-0.5	37.0	6.3	6.10	6.60	6.60	4.50	4.20	4.00	73.8	63.6	60.6
II Butter made without butter culture from neutralized cream												
D34	2.0	34.0	6.4	8.70	10.80	8.85	6.75	8.10	6.75	77.6	75.0	76.3
D254	2.0	34.0	6.4	8.80	9.50	7.75	7.05	8.30	7.30	80.1	87.4	94.2
044	1.5	35.0	6.4	5.30	8.10	5.80	3.40	5.00	5.75	64.2	61.7	99.1
0144	1.5	36.0	6.2	5.45	6.00	6.00	3.50	5.15	4.90	64.2	85.8	81.7
0244	1.5	34.5	6.3	8.25	8.65	7.65	5.60	5.95	5.55	67.9	68.8	72.8
D164	1.5	34.0	6.5	8.05	8.85	7.95	5.55	6.20	5.95	68.9	70.1	74.8
D174	1.5	35.0	6.4	7.70	8.40	6.75	6.00	6.70	5.75	77.9	79.8	85.2
Au75	1.5	35.0	6.2	6.80	8.70	-	4.20	4.50	-	61.8	51.7	-
Au245	1.5	33.5	6.2	6.50	7.50	-	4.60	6.10	-	70.8	81.3	-
024	1.0	34.5	6.4	7.70	7.50	6.90	5.60	6.70	6.05	72.7	89.3	87.7
0214	1.0	35.0	6.3	6.00	7.00	5.30	3.80	5.50	4.60	63.3	78.6	86.8
D144	1.0	34.5	7.0	6.60	11.50	7.55	5.20	11.25	6.65	78.8	97.8	88.1
D234	1.0	34.0	6.6	7.10	8.65	7.85	5.95	7.10	6.20	83.8	82.1	79.0
D244	1.0	34.5	6.1	8.15	10.20	8.90	6.30	8.95	7.35	77.3	87.7	82.6
Au35	1.0	35.0	7.4	4.00	4.40	-	3.00	2.80	-	75.0	63.6	-
034	0.5	35.5	6.5	5.00	6.45	5.85	3.00	5.25	5.65	60.0	81.4	96.6
0114	0.5	35.0	6.7	6.20	6.90	5.95	2.90	3.80	4.10	46.8	55.1	68.9
0164	0.5	34.5	6.3	9.90	10.10	9.80	6.70	6.85	6.75	67.7	67.8	68.9
0174	0.5	35.0	6.0	7.10	8.00	7.55	3.40	4.45	4.05	47.9	55.6	53.6

Table VI (Cont'd)

Sample number	After 1 month at 0-5°C.			Acid value of butter			Acid value of fat			Acid ratio		
	loss in score	score	pH of fresh butter	when fresh	after 1 week at 21°C.	after 1 month at 0-5°C.	when fresh	after 1 week at 21°C.	after 1 month at 0-5°C.	when fresh	after 1 week at 21°C.	after 1 month at 0-5°C.
0194	0.5	35.0	7.5	4.25	4.60	4.60	2.35	3.60	3.85	55.3	78.3	83.7
0244	0.5	34.0	6.5	6.80	7.00	7.30	3.25	4.20	4.50	47.8	60.0	61.6
N14	0.5	36.0	6.3	6.10	6.70	6.35	4.45	4.30	4.85	73.0	64.2	76.4
N24	0.5	35.0	6.2	7.40	7.30	8.10	5.70	5.70	6.45	77.0	78.1	79.6
N44	0.5	34.5	6.4	4.60	7.75	8.05	4.70	4.85	4.70	102.2	62.6	58.4
N54	0.5	34.5	6.1	6.95	7.60	6.95	4.20	4.90	4.55	60.4	64.5	62.6
N74	0.5	34.5	6.2	6.05	6.95	7.65	4.60	4.30	4.10	76.0	61.9	53.6
N104	0.5	37.0	6.9	4.55	6.25	5.30	3.20	3.75	3.50	70.3	60.0	66.0
N134	0.5	34.5	7.0	5.85	6.40	6.65	3.55	3.60	3.75	60.7	56.3	56.4
N144	0.5	35.0	6.0	5.45	6.35	5.65	3.80	3.20	4.75	69.7	50.4	84.1
D114	0.5	34.0	6.4	8.20	9.25	8.25	6.15	7.60	7.05	75.0	82.2	85.5
D184	0.5	35.0	6.3	8.25	9.30	8.40	6.25	8.25	7.00	75.8	88.7	83.3
D264	0.5	35.0	6.4	6.40	7.40	6.65	5.05	5.90	5.45	78.9	79.7	82.0
Au25	0.5	36.5	6.2	5.80	4.60	-	2.40	3.50	-	41.4	76.1	-
Au145	0.5	34.5	7.6	5.50	6.20	-	2.10	3.60	-	38.2	58.1	-
064	0	35.0	6.4	7.15	7.75	7.85	3.50	4.80	4.85	49.0	61.9	61.8
N84	0	34.5	6.4	6.40	8.50	7.45	4.70	6.40	5.80	73.4	75.3	77.9
N154	0	35.0	6.6	7.20	9.55	8.10	4.80	6.60	4.80	66.7	69.1	59.3
N194	0	35.5	6.6	6.35	8.80	7.35	5.00	7.10	5.15	78.7	80.7	70.1
N204	0	35.5	6.5	6.80	8.30	8.00	5.60	5.70	6.30	82.4	68.7	78.8
N224	0	36.0	6.4	6.25	7.75	6.90	4.45	4.60	4.90	71.2	59.4	71.0
N234	0	35.0	6.6	7.35	8.60	8.10	4.95	5.25	5.00	67.3	61.0	61.7
D54	0	34.5	6.5	9.85	9.65	8.95	7.15	9.50	8.45	72.6	98.4	94.4
D214	0	36.5	6.7	5.45	6.55	6.10	4.45	4.85	4.80	81.7	74.0	78.7
Au215	0	35.0	6.5	5.20	6.10	-	3.70	4.40	-	71.2	72.1	-
0104	-0.5	35.5	7.0	6.10	6.20	5.70	2.75	4.60	5.00	45.1	74.2	87.7
N164	-0.5	35.5	6.2	8.85	9.05	8.90	5.10	5.50	6.10	57.6	60.8	68.5
N214	-0.5	34.5	6.3	7.65	8.30	8.55	4.65	5.35	4.90	60.8	64.5	57.3

Table VI (Cont'd)

Sample number	After 1 month at 0-5°C.			Acid value of butter			Acid value of fat			Acid ratio		
	loss in score	score	pH of fresh butter	when fresh	after 1 week at 21°C.	after 1 month at 0-5°C.	when fresh	after 1 week at 21°C.	after 1 month at 0-5°C.	when fresh	after 1 week at 21°C.	after 1 month at 0-5°C.
D24	-0.5	35.5	6.5	8.80	9.80	8.60	7.10	7.00	6.85	80.7	71.4	79.7
D74	-0.5	34.0	7.0	6.80	6.85	6.35	4.75	5.50	5.30	69.9	80.3	83.5
Au95	-0.5	35.5	6.6	5.70	6.10	-	3.80	4.20	-	66.7	68.9	-
D64	-1.0	37.0	6.6	7.80	8.60	8.85	5.70	6.60	6.20	73.1	76.7	70.10
III	Butter made with butter culture from neutralized cream											
094	1.0	33.5	6.7	7.70	10.00	8.00	5.10	9.60	7.45	66.2	96.0	93.1
D224	1.0	35.0	6.1	8.90	11.00	9.30	9.00	10.10	8.75	101.1	91.8	94.1
0234	0.5	35.0	6.5	8.20	8.75	8.50	4.90	5.65	6.40	59.8	64.6	75.3
D44	0.5	35.0	7.0	8.90	9.40	9.05	6.00	7.70	6.55	67.4	81.9	72.4
Au15	0.5	36.0	6.2	7.30	8.40	-	4.10	4.30	-	56.2	51.2	-
Au255	0.5	33.0	6.3	6.30	6.80	-	5.40	6.20	-	85.7	76.5	-
N114	-0.5	34.5	5.6	7.85	9.25	8.10	4.50	5.20	5.45	57.3	56.2	67.30
Au175	-0.5	34.0	6.2	6.10	6.60	-	3.90	3.60	-	63.9	54.5	-