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THE INFLUENCE OF STARTER ON THE KEEPING QUALITY OF BUTTER

by

J. Kenneth Miss, B. S. (1924)

A Thesis submitted to the Faculty of the South Dakota State College of Agriculture and Mechanic Arts in Partial Fulfillment of the Requirements for the Degree of Master of Science

Brookings, South Dakota, June, 1925
INTRODUCTION

Butter is the most important product of the dairy industry. Therefore, experimental work which indicates how the quality of butter may be improved is of considerable value.

The present methods of handling cream and making butter are largely responsible for the mediocre quality of much of the American butter. The quality of the cream is not in the control of the buttermaker, except as he may improve it through impressing the producers with the importance of producing high grade cream. Manufacturing methods are, however, in the control of the buttermaker, and he should profit by the research work which has been done, and use methods which have indicated their value in improving the quality of the butter.

While some experimental work has been carried on in an effort to improve the quality of butter, the results are, as yet, only indications as to the best methods to use. Much more experimental work will need to be done before the results can be considered conclusive.

OBJECT OF THE EXPERIMENT

This experiment was conducted to obtain data on how the keeping quality of butter is affected by the use of starter.
when either the cream from which the butter is produced is ripened with starter, or when the butter is washed with starter.

THE USE OF STARTER

Before considering the experimental work in regard to the use of starter it will be well to consider the development of some of the present day practices in buttermaking, and to define some of the technical terms which will be used frequently.

The term starter, as it is commonly used, includes a variety of materials, such as buttermilk, sour cream from the previous churning, sour milk and skim milk ripened by spontaneous souring, and sour milk, cream, diluted, condensed milk, or redissolved skim milk powder, ripened by the addition of a pure culture of bacteria which produce lactic acid. When the word starter is used in this thesis, reference is made to a pure, or relatively pure culture of lactic acid producing bacteria.

The widespread use of pure culture starter is largely due to the investigations of Storch (1890). Even since starter has come into prominence there has been no general agreement as to the proper amount of starter to use, nor as to the best method of using the starter. Guthrie (1918) estimates that less than fifty percent of the creameries use starter. He attributes this condition to several things, among them being the indifference
of the buttermaker, the lack of knowledge concerning the propa-
gation of starter, the small amount of cream, irregularchurn-
ing, and difficulty in securing good milk for starter culture.

The main object for using starter, as given by McKay
and Larsen (1922), is to secure the desirable and delicate fla-
vor and aroma which are so characteristic of good butter. While
no doubt all buttermakers have the same object in view, various
methods are used to attain this objective. Formerly it was the
custom to ripen the cream to a high degree of acidity before
churning. Butter thus made might score quite high when fresh,
but deteriorate rapidly if placed in storage.

McKay and Larsen (1922) state that unless market con-
ditions so demand, it is not advisable to ripen cream of about
30 percent fat to over .50 or .55 percent acidity. They also
mention that it is safer to under-ripen slightly than to over-
ripen. Munsiker (1920) suggests that .8 percent of acidity in
the serum of the cream represents the proper degree of acidity.
Bendixen (1925) favors the factor of .65 percent of acidity in
the serum as suggested by Mortensen.

Hammer (1924) in an address to the members of the
National Creamery Buttermakers Association said, "With a defi-
nite appreciation of the relationship between acidity and de-
terioration there has come a change in the ideas with reference
to the methods of using starters. The development of a rather
high acidity no longer appears desirable, except possibly under
very special conditions, and a better plan seems to be to ripen to a much lower acidity than was formerly used. These lower acidities give considerable flavor and aroma development, although undoubtedly less than high ripening, while the butter resulting deteriorates less than that made from the highly ripened cream, but more than than made from sweet cream."

Despite the results of experimental work and the opinions of the leaders in the field of dairy manufacturing, there are men in the dairy industry today who advocate the use of starter in all buttermaking. Sam Haugdahl (1925) states to the effect that the use of starter will not only increase the quality of fresh butter, but will also increase the keeping quality of the butter. In this same article a letter written October 9, 1924 by O. F. Hunsiker is quoted. The major portion of this letter is reproduced here as it sums up quite adequately the facts which one should bear in mind when considering the use of starter, and the keeping quality of butter.

"A good starter is a starter which, under the right temperature conditions, will produce high flavor and low acid. Its proper use means to impart its flavor to the cream and butter without materially raising the acid of the cream.

"At this point it is important to bear in mind that developing flavor in cream means fermentation, and fermentation is a stage of decomposition. Some of the constituents in cream are broken down. Developing flavor in the cream, or cream ripening, represents the early stages of decomposition of some of the
constituents. It so happens that during these early stages of decomposition the flavors produced are desirable but when these changes continue a point is finally reached beyond which the flavors produced are no longer pleasant; they are objectionable. Therefore, if cream is ripened to the point where it has a very high flavor, the critical point may be very closely approached at churning time. While the butter at the churn may be very good, it may not keep well. If decomposition goes further, as it usually will with the age of the butter, off-flavors will be produced and the butter deteriorates rapidly.

Thus we find that deterioration in butter is a combination of bacteriological and chemical actions. The chemical phase is stressed by Dyer (1916) who attributes off-flavors commonly met in cold storage butter to a chemical change expressed thru a slow oxidation progressing in some one or more of the non-fatty substances occurring in the butter, and he furthermore claims that the extent of this chemical change is directly proportional to quantity of acid present in the cream from which the butter was made.

Sommers and Smit (1924) showed that fishy flavor, one of the most objectionable off-flavors found in butter, is produced by chemical action.

Many other similar facts could be presented, but these are sufficient to show that the deterioration of butter is of a complex nature, and that methods which give a high flavor in fresh
butter are likely to produce serious deterioration, if the butter is placed in storage. Our problem is to develop methods by which a high quality of fresh butter can be produced which will not deteriorate rapidly if placed in storage.

Improved methods in the factory, are not, in themselves, sufficient to overcome present difficulties. The cream delivered to the factory must be of a good quality if high quality butter is to be made from it. Just what the term "quality" implies is hard to put into words. However, we may say that a high quality cream is cream which has been so handled as to preserve its natural flavor and aroma, and to keep all undesirable bacteriological and chemical changes at a minimum.

RESUME OF EXPERIMENTAL WORK

Patrick and others (1893) in in comparing sweet cream versus ripened cream butter found that the sweet cream butter suffered less deterioration from keeping than did the ripened cream product, and in some measure acquired the flavor characteristic of the latter.

Gray (1906) showed that butter made from cream received at the creamery sweet and in good condition kept well while stored at --10 F. and at 10 F.; also after removal from storage, giving results wholly satisfactory. Butter made from cream received at the creamery sour and in fair condition kept well while in storage at --10 F. and at 10F., but deteriorated rapidly after removal from storage, giving, on the whole, results which were unsatisfactory.

Rogers and Gray (1909) in studying the influence of acidity
on the flavor of butter concluded that butter made from pasteurized cream with starter added, after the so-called LeClair or Redicott method, retained its fresh flavor better than ripened cream butter, but was not quite equal in keeping quality to that made from sweet pasteurized cream. The LeClair method is the method commonly spoken of as washing butter in starter.

Rogers, Thompson, and Kistheley (1912) found that the change in pasteurized ripened cream butter stored at 0 F. was four times as great as that in the pasteurized sweet cream butter at the same temperature, and the difference at higher temperatures was nearly as great. Even at 20 F. the deterioration of the sweet cream butter was comparatively slight, indicating that this butter would retain its flavor well after removal from storage.

In a preliminary report of a study of ripening cream in the vat versus ripening in storage, the Minnesota Experiment Station (1919) gave the following: "Evidence gained thus far would indicate that there is little, if anything, to be gained by the ripening of the cream itself, in the production of flavor, but rather that the cream following pasteurization should be cooled quickly and churned sweet, and the starter should be added directly to the butter in the churn, thus employing a small amount of starter and using it where it will do the most good. In no case did the addition of starter to butter work injury, and in most cases a direct benefit was noticeable."

The same station (1920) reports that an attempt to study the relation of casein content to the keeping quality of butter was largely vitiated by the fact that experimental lots of butter manufac-
tured according to a method said to give high casein content as the check lots. The method alluded to was probably that of working a small amount of starter into the butter.

Charron (1920) reports an experiment in which fourteen samples of pasteurized cream were churned without starter, and fifteen samples with starter. Competent judges scored the butter at intervals during storage and were unable to detect any superiority of the butter made with starter.

Mortensen (1922) carried on one of the most extensive experiments along this line. In comparing sweet cream butter with ripened cream butter, he found that while fresh the ripened cream butter scored higher in the majority of cases. The reverse was true at the end of nine months storage. When ripened cream butter was compared with butter made from unripened sweet cream to which starter was added, the ripened cream butter scored higher while fresh, but was surpassed by the sweet cream plus starter butter after two months storage, and the difference was more noticeable after nine months storage. The final comparison was between sweet cream butter and butter made from sweet cream with starter added. The latter butter scored highest while fresh, and after two months storage. After nine months storage, the two lots were about equal.

Since this experiment was so extensive, and was conducted by one who is an authority in the field, his conclusions are quoted.

"It would appear from the above experiment that the demand as determined by the scores given by commercial judges, is still for butter made from ripened cream, as it possesses the most characteristic butter flavor. Butter made from ripened cream deteriorates,
however, faster than either butter made from sweet cream, or from sweet cream and starter, but in the above experiments where low ripening was employed, the ripened butter at the end of a two month storage period was about of the same quality as the sweet cream butter and the sweet cream and starter butter. This is of importance inasmuch as butter ordinarily is consumed in considerably less time than two months after reaching the market. If butter is produced for cold storage then sweet cream butter would be the most desirable.

"Unless a creamery has a special demand for sweet cream butter, it would seem the most advantageous to produce butter from cream ripened to a low degree of acidity."

While the cold storage butter contest of the National Creamery Buttermakers Association is conducted for purposes other than studying the keeping quality of butter, the results are interesting from this standpoint. The results of the 1923 contest as reported by the New York Produce Review and American Creamery (1924) are as follows: 122 entries made without starter went into storage with an average score of 92.864, and after four months storage had an average score of 92.448, a loss of .416 points. 90 entries made with starter went into storage with an average score of 93.116, which was .252 points higher than the fresh score of the butter made without starter. The starter made butter came out of storage with an average score of 92.299. The loss during storage was .817 points, or almost twice that of the butter made without starter.

Sorensen (1924) reports the results of the 1924 contest in which the butter remained in storage for six months. Sixty-eight
tubs of starter made butter had an average score of 93.44 when fresh, and lost .54 points during storage, coming out with an average score of 92.90. The sweet cream butter, of which there was forty-eight tubes, went into storage with an average score of 92.51, which was approximately 1 point lower than the score of the ripened cream butter. The sweet cream butter lost .43 points during storage, averaging 92.03 at the end of the period. Only butter made from cream containing .3 of one percent or less of acid was considered as sweet cream butter in this comparison.

EXPERIMENTAL WORK

Period Covered:
The butter used in this experiment was made at intervals during the period from October to March. While this period is enough to partly compensate for seasonal influences, it could not be said to entirely eliminate the possibility of such variations as it did not extend into the summer months. However, it is doubtful whether the seasonal variations in the composition of the butterfat would invalidate this work.

Cream Supply:
The cream used was secured from various sources over the state, and from the regular supply delivered to the State College Creamery. Cream was obtained from these various sources in order that the resulting butter might be comparable to butter produced in the ordinary commercial creameries throughout the state.
Method of Manufacture:

The so-called split batch method was used in this experiment. The entire batch of cream, which usually amounted to about twelve hundred pounds, was mixed together, neutralized, if sour, to about .25 percent acidity, pasteurized at 145 F. for thirty minutes, and then cooled. About two-thirds of the cream was then drawn from the vat, and about 3 to 4 percent of good starter was added to the remainder. The ripening was carried on at 70 F. for about sixteen hours.

The unripened cream was churned in one lot. In some cases half of this butter was removed from the churn as soon as the granules were the size of wheat kernels, and the remainder was washed and worked in the usual way. This gave the control sample to which the specially treated butter was compared. The butter which had been removed was replaced in the churn and washed with about six gallons of water was added.

The ripened cream was in all cases churned as a single batch. By this process three different kinds of butter was made from each batch of cream; the control butter, or butter made without the use of starter, butter made from starter ripened cream, and butter which was washed in starter.

Storage:

During the first part of the experiment twenty-pound tubs were filled with each kind of butter and were stored to test the keeping qualities of the butter. Later ten-pound tubs were used for
storing the samples. All tubes were properly treated to check mold growth.

The butter was stored in a refrigerator room which had an average temperature of about 33°F, and an average relative humidity of 90 percent. As other dairy products were stored in the same room, the temperature was necessarily kept higher than it should be for storage butter. Too, the room was opened frequently which caused the temperature to fluctuate considerably.

Scoring the Butter:

With one exception, which will be noted later, the recorded scorings are the averages of the scores given by Professor C. C. Tolman, and Buttermaker J. J. Connelly. Others, including the author, also made scorings on the most of this butter, but as these scorings were not made in all cases they will not be recorded.

The butter was scored while fresh, usually on the second day after its manufacture, and again at monthly intervals throughout the storage period. The scorings were conducted in such a manner that the judges did not know the identity of the samples being scored. No deductions were made for defects other than those of flavor and aroma.

RESULTS OF EXPERIMENTAL WORK

On the following pages a complete record of the average scores given to the different samples at the various periods of storage is given, as well as tables showing the trend of the scores of
each kind of butter during the storage period. In Table I one will note fluctuations in the scores given to some of the samples which apparently represent faulty scoring. This is not, however, the case, for although butter is scored according to a score card one's opinion of butter is based upon gustatory and olfactory sensations, and it is well known that these sensations are not absolute but variable. By averaging the scores of all the tabs of each kind of butter for each period of storage, as was done for Tables II and III, these minor fluctuations are largely vitiated.

Table I -- AVERAGE SCORES OF BUTTER AT THE VARIOUS PERIODS OF STORAGE

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<td>89.50</td>
<td>88.50</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>R</td>
<td>90.75</td>
<td>90.50</td>
<td>89.25</td>
<td></td>
</tr>
</tbody>
</table>

(1) Butter made without the use of Starter
(2) Butter washed in Starter
(3) Butter from cream ripened with Starter

These scores are estimated from scores of previous and following month. Scorings made on this data were by an outside judge.

Table II shows that the starter made butter had a slightly higher score when fresh than did the butter made without starter. This is in accordance with most of the conclusions and opinions cited in the first part of this paper. However, it will be noted that the difference in score is not only maintained during the four months storage period, but is actually increased. It is possible that deterioration was accelerated.
in the butter made without starter by allowing to lie on a table exposed to the air and to room temperature while the starter-washed-butter was being washed, worked, and packed. This exposure was usually for a period of about fifteen minutes.

Table III shows the losses in score during the various periods of storage. The losses were much the same for all lots of butter during the first three months of storage. During the fourth month the butter made without starter decreased in score more than did the starter-made-butter. The butter made without starter lost 2.69 points during the four months' storage as compared to a loss of 2.10 points in the butter made with starter. There seems to be little difference in the keeping quality of butter made from starter-ripened-cream, and butter which is washed in starter. The former lost more heavily during the second month of storage, while the latter suffered the greater loss during the third month. The loss during four months was the same for both kinds of butter.

Figure I shows a graphic representation of the material in tables II and III.

**Table II — AVERAGE SCORES OF BUTTER**

<table>
<thead>
<tr>
<th>Method of Manufacture</th>
<th>3 days</th>
<th>1 month</th>
<th>2 months</th>
<th>3 months</th>
<th>4 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cream Ripened</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With Starter</td>
<td>91.18</td>
<td>90.73</td>
<td>89.95</td>
<td>89.19</td>
<td>89.08</td>
</tr>
<tr>
<td>Butter Washed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With Starter</td>
<td>91.13</td>
<td>90.58</td>
<td>89.67</td>
<td>89.42</td>
<td>89.03</td>
</tr>
</tbody>
</table>

* Figures in parentheses are the number of tubes of each kind of butter stored.
Table III -- AVERAGE LOSS IN SCORE

<table>
<thead>
<tr>
<th>Method of Manufacture</th>
<th>PERIOD OF STORAGE</th>
<th>1 month</th>
<th>2 months</th>
<th>3 months</th>
<th>4 months</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>(15)x</td>
<td>(15)</td>
<td>(12)</td>
<td>(10)</td>
</tr>
<tr>
<td>No Starter Used</td>
<td></td>
<td>0.57</td>
<td>1.30</td>
<td>1.92</td>
<td>2.69</td>
</tr>
<tr>
<td>Cream Ripened</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With Starter</td>
<td></td>
<td>0.46</td>
<td>1.23</td>
<td>1.99</td>
<td>2.10</td>
</tr>
<tr>
<td>Butter Washed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With Starter</td>
<td></td>
<td>0.55</td>
<td>1.46</td>
<td>1.64</td>
<td>2.10</td>
</tr>
</tbody>
</table>

Figures in parentheses are number of tubs of each kind of butter stored.

PRACTICABILITY OF THE METHODS USED

To make butter without the use of starter is the easiest, and the cheapest. However, the increase in the quality of the butter occasioned by the use of starter will, in most cases, more than offset the additional expense. The method of using starter to be adopted depends upon local and plant conditions. Vat ripening involves the use of much less starter, but requires more vat room, and necessitates holding the cream in the vats over night. Washing with starter requires much more starter, and lengthens the churning process somewhat. In many places the securing of the proper quality of milk necessary for making good starter is quite a problem. The South Dakota Experiment Station showed that milk powder solutions may be successfully used instead of natural milk for starter culture.

CONCLUSIONS

This rather limited experimental data indicates that:

1. The use of good starter, in either ripening the cream
or washing the butter, improves both the quality of the fresh butter, and the keeping quality of the butter.

2. There is little difference between ripening the cream with starter and washing the butter with starter in their effect upon the quality of the butter.

3. Starter improves both the quality of the fresh butter and the keeping quality of the butter sufficiently to justify its use.

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Much credit is due to Professor T. H. Olson and C. G. Totman for their guidance and assistance in planning and carrying on this work. Credit is also due to J. J. Connelly and G. H. Reeden for their assistance in the performance of the experimental work.

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