FACTORS AFFECTING THE BODY AND TEXTURE OF PROCESSED CHEESE

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Package processed cheese has become a very important product in the cheese industry. The quality of this product may be affected by a number of factors, yet there has been a marked lack of information concerning them in the literature (1, 2, 3 and 4). A study of the patent literature may give an outline of the general procedure that is used and certain of the added constituents, but it does not give any indication of the factors that control quality. Undoubtedly each manufacturer has made numerous practical observations in his plant, but these are not generally available. The experimental work here reported is part of a study undertaken to contribute to our knowledge of this relatively recent product.

The experimental work has concerned itself mainly with the factors that affect the physical properties of processed cheese. The flavor of processed cheese, as in ordinary cheese, is recognized as an important element in its quality, but an experimental study of flavor is of little permanent value because it is largely controlled by the blending of various lots of cheese. Observations on flavor were therefore made only to indicate any changes which may be attributed to the factors under consideration.

A previous paper (2) has reported observations on the body and texture of processed cheese as affected by (1) "emulsifiers," (2) processing temperature, (3) moisture content, (4) reaction, and (5) the age of the cheese used. The present paper gives further observations on these factors and in addition, on the effect of variations in (6) common salt content and (7) casein-to-fat ratio.

The processed cheese that was made to study the above factors was prepared in a small steam jacketed kettle equipped with double action agitators patterned after kettles used commercially. The full capacity of the kettle was sixteen pounds, but in the experimental work only eight pounds were used because this amount was adequate for samples and could be handled more conveniently. To facilitate accurate control of the processing temperature a special thermometer was built into the hollow agitator shaft, the bulb being at right angles to the shaft and revolving in the cheese. (For further details see previous paper).

In a previous paper (2) it had been found that cheese processed below 140°F. is likely to undergo gassy fermentation, that the body of the pro-

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cessed cheese is practically constant when made within the range of 140 to 150°F., and that above 150°F. the body increases rapidly. Further, when the cheese is held in the kettle at 145 to 155°F. there is an increase in the body which is almost proportional to the holding time. Color changes have been noted in cheese processed at higher temperatures (1, 2).

In view of the above observations, the processed cheese in the experiments reported here was made by heating uniformly to 148–150°F., and when this temperature had been reached, drawing the samples from the kettle without delay. All factors were kept as uniform as possible in each case, varying only the particular factor under consideration.

The body of the experimental processed cheese was measured by a mechanical device which determined the crushing strength of an inch cube of the cheese with the force applied being increased at a uniform rate until the inch cube had been crushed to a thickness of half an inch. The results are reported in grams of weight, but since this weight was applied with a mechanical advantage of five, the figures given must be multiplied by five to obtain the actual crushing strength. To minimize the effect of individual differences between cubes, six to ten measurements were made in each case with the cubes cut from duplicate or triplicate samples of cheese. The figures reported are the averages of such measurements. This method of measuring the body eliminates the personal factor and gives results that are easily recorded; the experience with this method indicates that it is more reliable than ordinary personal judgment.

Since texture concerns itself with the finer structure of the cheese for which no physical measurements can be given, observations on this property are recorded in descriptive terms. In this connection the slicing properties as measured on a commercial meat slicer are helpful; the appearance of the cut surface, the thinnest slice that can be cut without breaking, and the tendency of the cheese to cling to the revolving blade, all are indicative of texture.

While the main purpose was to study the body and texture, observations were made on,—

(1) The reaction, both pH and titratable acidity,
(2) The appearance of the tinfoil in which the cheese was enclosed,
(3) The color,
(4) The moisture content, and
(5) the keeping quality.

EXPERIMENTAL RESULTS

There are three salts that are commonly used as the so-called emulsifying agents. These are sodium citrate, di-sodium phosphate and Rochelle salt. No explanation will be attempted of the chemical action of these salts.
They are added to prevent fat separation in processing and to control the body and texture. Even when these salts are used, fat separation may occur in the early stages of heating, but in cases where the finished product will be satisfactory, this free fat must again become an integral part of the mass by the time a temperature of 140°F. has been reached. If the fat separation has been excessive or if the fat is not properly re-incorporated, the finished cheese will have a greasy surface, the texture will tend to be coarse and the body weak. With certain cheese or blends (proper age, acidity, etc.) it is possible to produce satisfactory processed cheese without the use of emulsifying salts, but on a production basis the difficulties of selection are so great, and the supply of cheese that meets this requirement is so restricted that the use of emulsifying salts is a practical necessity. Further, even in cases where emulsifying salts would not be absolutely necessary, their use improves the product. A study of the effect of

![Graph](image-url)
various so-called emulsifying salts in processed cheese is therefore of direct importance.

In accordance with the above, comparisons were made to determine the effect of sodium citrate, di-sodium phosphate and Rochelle salt, individually and in combinations. Graphs I to V inclusive give the results with respect to body.

It will be noted in Graph I that Rochelle salt produced the firmest body, and di-sodium phosphate produced the weakest body, with sodium citrate intermediate, at all percentages tried. This confirms the previous report (2) with respect to sodium citrate and di-sodium phosphate, viz., that the former produces cheese of a firmer body than the latter. This is confirmed further by Graph II. Attention is called to the difference in shapes of the curves for citrate and phosphate in Graphs I and II; these variations are due to the fact that different lots of cheese were used. Variations such as these are encountered throughout the experimental work on processed cheese, and so far they have not been related to any specific property of the cheeses involved. This fact must be kept in mind and conclusions can be drawn only where a certain factor shows a general trend quite consistently.

Graph III shows the body of processed cheese when made with various percentages and combinations of sodium citrate and Rochelle salt. Curve
A connects three points representing 1 and 0%, $\frac{1}{2}$ and $\frac{1}{4}$%, and 0 and 1%, sodium citrate and Rochelle salts respectively; Curve B connects five points representing 2 and 0%, $1\frac{1}{2}$ and $\frac{3}{4}$%, 1 and 1%, $\frac{1}{2}$ and $1\frac{1}{4}$%, and 0 and 2% sodium citrate and Rochelle salts respectively; Curve C connects five points representing 3 and 0%, 2.25 and 0.75%, 1.5 and 1.5%, 0.75 and 2.25%, and 0 and 3% sodium citrate and Rochelle salts respectively. In an entirely similar manner Graph IV shows the body of processed cheese when made with various combinations of di-sodium phosphate and Rochelle salts, and Graph V, when made with various combinations of sodium citrate and di-sodium phosphate. Graphs III and IV show that the general trend is an increase in the firmness of the cheese as Rochelle salt replaces sodium citrate and di-sodium phosphate respectively. Graph V, Curves A and B, in general show the expected effect, viz., a decrease in body as phosphate
replaces citrate. The results in Curve C were unexpected and no explanation is at present available.

The reactions (pH) of the cheese samples concerned in Graphs I to V inclusive are given in each case, to show that the variations in the body are not due to differences in reaction. This becomes more apparent referring to the results in Graph VII.

The texture of the cheese samples in the above experiments showed noticeable differences. The samples containing only sodium citrate were considered to be most satisfactory; the texture was smooth as shown by the sliced surface and by the thinness of the slice that could be cut without breaking. The cheese was not brittle and it contained many small air cells. During the processing of the cheese and discharging from the kettle there
is opportunity for the incorporation of air. Apparently the physical condition which enables the hot cheese mass to retain the air is also conducive to a smooth texture, as it has been observed that the texture is almost invariably coarse when no air cells are present.

The texture of the cheese made with Rochelle salt was not as satisfactory. As the amount of Rochelle salt was increased the cheese becomes slightly brittle and cross-sections showed cracks which indicate that the cheese did not fuse together as the hot, viscous stream flowed into the mold. These cracks occasionally caused trouble in measuring the body of the cheese as the cube would break at one of them, causing a low result. In general the cheese made with Rochelle salt was somewhat mealy and did not slice quite as satisfactorily. A case has been reported (2, 3) where

![Graph V](image-url)
gritty particles resembling broken glass were identified as calcium tartrate crystals. In the present experiments no such defect was observed in any of the cheese made with Rochelle salt. Apparently the crystallization of calcium tartrate in cheese occurs only under special conditions which have not been reproduced.

The texture of cheese made with di-sodium phosphate was less satisfactory than either of the above. The cheese was not brittle but soft and soapy. The slicing property is poorer as the cheese tends to cling to the revolving blade. As with Rochelle salt, cracks due to poor fusion were noted. With the larger amounts of phosphate the tinfoil showed discoloration.

From the results of the studies on these salts it was decided to use 2.0% sodium citrate in subsequent experiments where other factors were being studied unless otherwise indicated.

In the manufacture of processed cheese it is quite a common practice to use about 0.5% common salt in addition to that which is already present in the original cheese. Experiments were undertaken to determine the effect of added sodium chloride alone and in combination with emulsifying salts. In experiments comparing the effects of common salt additions up to 2.0%, it was found in general that the body of the cheese decreased with increased salt content, and fat separation during processing and graininess in the texture of the finished cheese increased. Salt additions in excess of one per cent were distinctly noticeable to the taste. In an experiment where 2.0% common salt and sodium citrate or Rochelle salt were added up to 3%, it was found that these emulsifying salts remedied the defects occasioned by the common salt, and there was a general trend of increased body with increases in the amount of emulsifying salt (Graph VI). The finding that the body of the cheese samples containing Rochelle salt was weaker in most cases than corresponding samples made with sodium citrate.
was unexpected. The only explanation that can at present be suggested is that Rochelle salt was less efficient in overcoming the weakening effect of the salt on the body.

The reaction of the original cheese and of the finished processed cheese is of importance in a number of respects. In commercial processing of cheddar cheese, it is known that the acidity of the cheese used in making the blend cannot be ignored; in this case, however, there is involved not only (1) the direct effect of reaction on the behavior in processing, but also (2) differences in flavor and physical properties resulting from the effect reaction has on the curing processes in the original cheese. The experimental work reported here has concerned itself only with the former of these two points. The direct effect of reaction at the time of processing is important because of its relation to the flavor, keeping quality and physical properties of the finished product, and to the discoloration of the tinfoil, as shown in the previous paper (2).

In order to determine the effect of reaction at the time of processing, experiments were conducted in which a number of samples were prepared
from the same lot of original cheese, processed with 2% sodium citrate and with additions of sodium bicarbonate or hydrochloric acid to produce the desired range in reaction. Curve A in Graph VII reproduces the results of such an experiment reported in a previous paper (2); Curve B gives additional results with a different lot of cheese. In the former the cheese was six months old, while in the latter the cheese was over ten months old at the time of processing; there were undoubtedly other differences in the two lots of cheese, so that an attempt to relate the difference in the curves definitely to the age of the cheese is not justified. The boxed point on each curve represents the reaction of the control sample, i.e., the processed cheese made with 2% sodium citrate, but without either sodium bicarbonate or hydrochloric acid; the reaction of these control samples give further indication of a difference between the two lots of cheese.

The results in Graph VII show that the body of the processed cheese may be influenced to a marked extent by the reaction. Curve A differs from Curve B mainly in that the former shows a pronounced increase in body on the alkaline side of the control sample. Disregarding this difference, the curves show a general similarity in that the maximum body comes within the range of pH 5.6 to 6.1.

The texture of the cheese was found to vary with the reaction. Between the limits of pH 5.7 to 6.3 there was little difference in texture; at greater acidity, the cheese had a grainy appearance, was very brittle, and had an oily surface. At the most acid reaction indicated, the cheese was so soft that body measurements were impossible. With decreasing acidity beyond pH 6.4, the texture became more grainy, the surface of the sample was soapy, and the fat tended to accumulate at the upper surface of the sample. The layer below the fat was very coarse grained as compared with the fine granulations in the sample on the acid side of the above limits in which there was no evidence of fat rising.

A pronounced darkening of the tinfoil was observed in the samples of low acidity. In the most severe cases the darkening penetrated into the cheese to a depth of about a fourth of an inch. The tinfoil used in lining the sample boxes throughout this work was of the same grade as is used commercially.

The moisture content of the cheese is known to affect the body and texture, and was therefore kept as uniform as possible in all the experiments. Results previously reported show that when other factors were kept constant the body of processed cheese varied inversely with the moisture content; with high moisture the body was weak and the texture was somewhat grainy with a tendency for fat separation, while at the other extreme the cheese is very firm, dry and brittle. Numerous instances have been found to show that the amount of moisture present in two samples of cheese may be the same and yet the body will be very different. The most striking
example of this appears in Graph VII in which two successive points (Curve A) differ in body by almost 2,000 grams.

Reference was made to the age of the two lots of cheese used in Graph VII, and while other factors may well be involved in this case, the somewhat weaker body in Curve B is expected on the basis of age. This becomes more apparent from results previously reported (2) where three separate lots of cheese were processed at different ages ranging from 1 day to 9 months. With one exception in the case of cheese three days old, the body of the processed cheese decreased with the age of the cheese from which it was made. The blending of cheese in commercial practice reduces the variations due to age; usually two or three parts of young cheese (1 to 3 months old) to one part of older cheese (8 to 12 months) are used, the proportions being varied according to the flavor desired.

The body of original cheese becomes weaker with increases in the fat content, the moisture content being held constant. This general observation has been verified by Sammis and Germain (5) who found further that the quality of such cheese decreased with increases of the fat content. Some of the cheese which had been made by the above investigators in their experiments, was used in processing experiments in which the object was to compare two commercial forms of sodium citrate (U. S. P. VIII or 2 Na₅C₆H₅O₇·11H₂O and U. S. P. X. or Na₅C₆H₅O₇·2H₂O) and di-sodium phosphate. No appreciable difference was found between the two forms of citrate; the results have been averaged and are given in comparison with di-sodium phosphate in Graph II. The same lot of cheese was not used throughout the experimental work shown in Graph II, but at each percentage of emulsifier studied the cheese used for the phosphate and citrate samples were comparable. Graph II is therefore a fair comparison of the two emulsifiers, but is not to be used to indicate the effect of increasing percentages. For example, the sudden drop in the body at 3% emulsifier was due to the fact that the average age of the cheese was about 9 months as compared with 6½ to 7 months for the others.

While the main object of the experimental work involved in Graph II was as already stated, it was found that when the results were tabulated there was a difference in the body of the processed cheese samples made from each pair of original cheese. When the findings were checked against the more complete record of Sammis and Germain, it was found (as is shown in Table 1) that in each pair of cheeses, the one with the lowest ratio of casein-to-fat produced the weakest body in the processed cheese. This fact that a high fat content weakens the body of processed cheese has been further verified in a study of cheese spreads where it was found that the moisture content of the spreads could be reduced without losing the spreading characteristic if the fat content was increased.
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**TABLE 1**

*The relationship between the casein-to-fat ratio in the milk and the body of the resulting processed cheese using different emulsifying salts*

<table>
<thead>
<tr>
<th>CHEESE NO.</th>
<th>UNPROCESSED CHEESE</th>
<th>MILK</th>
<th>PROCESSED CHEESE</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Per cent moisture</td>
<td>Per cent fat in dry substance</td>
<td>Casein-to-fat ratio</td>
</tr>
<tr>
<td></td>
<td>Sodium citrate</td>
<td>Di-sodium Phosphate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>U.S.P. VIII</td>
<td>U.S.P. X</td>
<td></td>
</tr>
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<td>7</td>
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<td><em>53.70</em></td>
<td><em>0.681</em></td>
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<td>106</td>
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</table>

*These figures taken from data presented by Sammis and Germaine (5).*

**SUMMARY**

From the experimental work described in this paper, a number of conclusions may be drawn:

1. The body and texture of processed cheese are improved by the addition of the salts used as emulsifiers.

2. Sodium citrate gave the most desirable body and texture, Rochelle salt and di-sodium phosphate following in the order named. Defects noted with Rochelle salt were mealiness tending toward graininess and poor fusion of the warm cheese in the molds. Di-sodium phosphate gave a very soft, soapy product that also showed poor fusion.
3. Graininess is associated with lack of air cells in the cheese and is often accompanied by fat separation.

4. The use of one-half of one per cent of sodium chloride is sufficient. More than one per cent is noticeable to the taste and weakens the body of the cheese. The use of the emulsifying agents lessens the body defects caused by the use of sodium chloride.

5. Temperature control is necessary.

6. The reaction of the cheese is important, commercially it is modified by blending. The addition of one per cent of acid or its equivalent of alkali weakens the body of the cheese and produces decided changes in the texture.

7. Between reactions of pH 5.7 and 6.3 the differences in the body and texture are very slight. On either side of this range of reaction defects are noted that become more serious as the difference between the reaction of the sample and the limits set above increases.

8. When all other factors are kept constant the body of processed cheese varies in an inverse ratio with the amount of water that is incorporated in it.

9. The body of the cheese becomes weaker as the age of the cheese used increases. An average age of five to seven months in blending mixtures should give satisfactory results.

10. The casein-to-fat ratio in the milk used for the original cheese has a marked effect upon the body of the processed cheese, the greater the proportion of fat the weaker the body.

In conclusion the authors wish to express their thanks to Chas. Pfizer and Co., Inc., who have sponsored the fellowship under which this work has been done.

REFERENCES


