

## A Study on Thermomeltability of Imitation Processed Cheese Products

Song, Jae-Chul

Dept. of Food and Nutrition

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### 〈Abstract〉

The imitation processed cheese, formulated with delactosed non fat dry milk (DENFDM) only, showed the smallest melting area, while calcium caseinate sample showed the largest spread. Statistically protein source as a major ingredient for the imitation processed cheese yielded significantly different melting areas. In a similar fashion, initial melting temperature was markedly and significantly influenced by protein source. Therefore the results of this study help predict that melting characteristics is largely but not solely dependent on the protein solubility, since the presence of denatured whey protein in DENFDM may exert a detrimental effect on meltability.

### 모방치-즈의 Melting 특성에 관한 연구

송 재 철

식품영양학과

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### 〈요 약〉

탈유당 탈지분유만으로 조제한 모방치-즈는 칼슘카제인단백질로 만든 제품에 비하여 용융면적이 현저히 감소하였으며 단백질원이 용융면적을 변화시키는 중요한 요인이라는 사실이 통계학적으로 규명되었다. 비슷한 결과로 용융온도도 사용된 단백질원에 따라 현저한 차이를 나타내었다. 이러한 현상은 탈유당 탈지분유 제조시 생긴 변성 유장단백의 존재에 기인한 것으로 사료된다.

### I. Introduction

The presence of caseinates in imitation cheese mainly affect the physical properties of the product, including shred, melt slice, texture and stretch characteristics unique to the imitation processed cheese. Melting characteristics are important parameters which might command quality of imitation processed cheese

products, since poor meltability appears be a serious problem associated with such products (1). Early research efforts investigated effect of several factors on the meltability of cheese products. The structural skeleton of cheese is comprised of an intense network of protein fibers, which are cross-linked and bound at various sites (2). Keller et al. (3) studied the effect of calcium retention during curd formation on meltability. The thermomeltability of

imitation processed cheese was identified to be related to protein matrix (4), the protein-protein and protein-lipid interactions (5), extent of proteolysis (6), swelling behavior and hydration (5) and emulsifying salts (7).

This study was undertaken to increase the understanding of the manner in which protein source are effective in melting characteristics to examine the usefulness of delactosed non fat dry milk (DFNFDM).

## II. Materials and Methods

### 1. Samples

The spray dried calcium caseinate (MP #113, identified as having "good" functional properties in imitation cheese) examined was manufactured in New Zealand while sodium caseinate was purchased from Matheson Coleman & Bell Inc. for formulation of imitation processed cheese analogs.

### 2. Preparation of DENFDM

Five parts of commercial NFDM was incorporated in 95 parts of 62% methanol solution (grade Technical). The mixture was first agitated by wire whip type agitator (Horbart Model A-200-2 mixer) at room temperature for 2 hours. The first extracts were separated by gravity sedimentation technique at room temperature. For the removal of excess lactose, the extracts were removed which 62% methanol on the ratio of 20:80(w/w) respectively, for 4 hours at room temperature. Portion of each extract was isolated and used for sample after freeze drying.

### 3. Formulation of Imitation Processed Cheese

Twenty-three grams of vegetable oils and 445 grams water were incorporated to a mixture of emulsifying and buffering agents in the bowl of a dough mixer. A salt-caseinate

mixture (1.5 grams salt and 28 grams caseinate or DENFDM) was added to the warm water-fat blend with appropriate mixing. The curd was packaged in aluminum foil and kept in refrigeration at 4–6°C. The cheese samples was cooled down before evaluation of characteristics.

### 4. Melting Characteristics

Prepared cheese samples were cut and shaped into 1 cm diameter which were weighed and placed in a petri dish. The samples were melted in a microwave oven (Sanyo, EM 8600) for 20 seconds at full power (650 watts). The area of the melted curd was measured with a planimeter. Melting area was expressed as area per gram of sample. Melting temperature was measured by modifying method of Catsimpoolas et al. (8).

### 5. Statistical Analysis

The F-test procedure was carried out to analyze by SAS(1982 system). Multiple comparison of means was also performed using Tukey's studentized range test by SAS. The significant difference at 1% and 5% level was obtained from Ott (9).

## III. Results

In order to assess melting characteristics, including melting area and melting temperature, imitation processed cheese on a laboratory scale was prepared and cut into uniformly-sized blocks. The melting area, measured after microwave heating and expressed as centimeter per gram of sample, is shown in Table 1. Significant differences were observed (Table 2) depending upon formulation.

Tukey's studentized range test was conducted in order to determine which pairs of means were significantly different (Table 3). When Tukey's test was employed on the different IPC samples, the melting area obtained at the

**Table 1. Comparison of melting area of various IPC analogs**

| Sample No. | Products                                     | Melting area (cm <sup>2</sup> /g sample) |         |      |
|------------|--|--|---------|------|
|            |  | Exp. I                                   | Exp. II | Mean |
| 1          | Ca-caseinate/DENFDM(1 : 1)                   | 1.71                                     | 1.71    | 1.71 |
| 2          | Ca-caseinate/DENFDM(2 : 1)                   | 3.08                                     | 3.08    | 3.08 |
| 3          | DENFDM only                                  | 0.65                                     | 0.95    | 0.65 |
| 4          | Ca-caseinate only                            | 4.62                                     | 4.60    | 4.61 |
| 5          | Ca-caseinate/Na-caseinate(1 : 1)             | 3.72                                     | 3.82    | 3.77 |
| 6          | Ca-caseinate/Na-caseinate/DENFDM (1 : 1 : 1) | 2.95                                     | 2.91    | 2.93 |
| 7          | Commercial processed cheese(control)         | 1.73                                     | 1.75    | 1.74 |

**Table 2. Analysis of variance: melting area of various IPC depended upon a protein source**

| Source          | DF | SS    | MS    | F       | PR>F   | F <sub>0.05</sub> | F <sub>0.01</sub> |
|-----------------|----|-------|-------|---------|--------|-------------------|-------------------|
| Model           | 6  | 22.14 | 3.690 | 985.92* | 0.0001 | 3.87              | 7.19              |
| Error           | 7  | 0.03  | 0.004 | —       | —      | —                 | —                 |
| Corrected total | 13 | 22.17 | —     | —       | —      | —                 | —                 |

\*Significant at both  $P < 0.05$  and  $P < 0.01$  levels

**Table 3. Tukey's studentized range test: melting area of various IPC depended upon a protein source**

Means with the same letter are not significantly different.

Alpha level = 0.05, DF = 7, MSE = 0.0037

| Grouping | Mean | N | Sample No. * |
|----------|------|---|--------------|
| A        | 4.61 | 2 | 4            |
| B        | 3.77 | 2 | 5            |
| C        | 3.08 | 2 | 2            |
| C        | 2.93 | 2 | 6            |
| D        | 1.74 | 2 | 7            |
| D        | 1.71 | 2 | 1            |
| E        | 0.65 | 2 | 3            |

\*formulation as same as Table 1

seven different formulation could be grouped into five classes. Therefore the test indicated that protein source as a major ingredient for IPC yielded significantly different melting areas.

For purpose of evaluation, the performances were compared with calcium caseinate sample and a commercial processed sample. The imitation processed cheese, formulated with delactosed NFDM only, showed the smallest

melting area, while calcium caseinate sample showed the largest spread. However the formulation of calcium caseinate with DENFDM (1 : 1) was closest to the commercially processed sample and thus suggests a potential beneficial use for the product as a partial replacement for calcium caseinate.

In a similar fashion, the range of melting temperature was observed. The melting temperature was classified into two groups: (a) the

**Table 4 Analysis of variance: initial melting temperature of various IPC depended upon a protein source**

| Source          | DF | SS    | MS    | F       | PR<F   | F <sub>0.05</sub> | F <sub>0.01</sub> |
|-----------------|----|-------|-------|---------|--------|-------------------|-------------------|
| Model           | 6  | 88.54 | 14.75 | 240.24* | 0.0001 | 3.87              | 7.19              |
| Error           | 7  | 0.43  | 0.06  | —       | —      | —                 | —                 |
| Corrected total | 13 | 88.97 | —     | —       | —      | —                 | —                 |

\*significant at both  $P < 0.05$  and  $P < 0.01$  levels

**Table 5. Comparison of melting temperatures of various IPC analogs**

| Sample No.* | Melting temperature (°C) |          |
|-------------|--------------------------|----------|
|             | Initial                  | Complete |
| 1           | 72.6                     | 79.5     |
| 2           | 70.4                     | 79.0     |
| 3           | 73.8                     | 79.0     |
| 4           | 65.4                     | 79.0     |
| 5           | 70.0                     | 79.5     |
| 6           | 72.0                     | 79.0     |
| 7           | 68.8                     | 79.0     |

\*formulation as same as Table 1

**Table 6. Tukey's studentized range test; initial melting temperature of various IPC depended upon a protein source**

Means with the same letter are not significantly different

Alpha level = 0.05, DF = 7, MSE = 0.0614

| Grouping | Mean  | N | Sample No.* |
|----------|-------|---|-------------|
| A        | 73.80 | 2 | 3           |
| B        | 72.60 | 2 | 1           |
| B        | 72.05 | 2 | 6           |
| C        | 70.45 | 2 | 2           |
| C        | 70.40 | 2 | 5           |
| D        | 68.90 | 2 | 7           |
| E        | 65.60 | 2 | 4           |

\*formulation as same as Table 1

initial melting temperature and (b) the temperature for complete melting, defined as the temperature at which the block had undergone 50% change of native shape. The raw data is shown in Table 4 and the statistical treatment in Table 5. Initial melting

temperature was markedly and significantly influenced by protein sources, whereas complete melting temperature was employed (Table 6).

The results indicated that melting temperature of the imitation processed cheese formulated by combination of calcium caseinate and DENFDM was relatively close to the control. This is in agreement with the findings for melting area. However, the calcium caseinate/DENFDM (2:1) was not significantly different from the sample containing calcium caseinate/sodium caseinate (1:1). The observation was made that calcium caseinate/DENFDM (1:1) was very similar to the calcium caseinate/DENFDM/sodium caseinate (1:1:1). Statistically, the desirable protein source for duplication of the commercial sample was identified as blends of calcium caseinate with either sodium caseinate or DENFDM appears to contribute useful functional properties as a caseinate replacement.

## V. Discussion

The uniform melting quality of imitation processed cheese is a desirable property. On the basis of major observations, these studies have shown quite clearly that the melting characteristics of cheese analogs differed significantly for protein source as a major ingredient.

Since lipid-protein interaction (5) is important role in maintaining the structure of cheese matrix, hydrophobic interactions and hydrophilic bonding abilities of caseinate were predicted to be associated to emulsion stability.

However, hydrophobic bonding is not much likely to play a role in stabilizing the interaction of both polar and non-polar lipids with proteins since DENFDM protein was markedly denatured during process and resulted in low solubility. In addition DENFDM protein may not completely form complex with lipid and not completely act as emulsifier by forming a stable coating around fat globules.

In the imitation processed cheese, excess calcium bridging may also inhibit the emulsion properties (5,10). Chakraborty proposed that electrolytes influenced the stability of the calcium caseinate as well as the emulsion system. Calcium caseinate is much more water soluble than DENFDM and forms higher viscous suspensions leading to better emulsion and better melting characteristics. However, calcium caseinate compared to sodium caseinate, showed lower solubility due to large particle size and strong interaction of aggregates promoted by the crosslinking of divalent cations. Theoretically addition of sodium caseinate should exhibit improved thermomeltability because it is more soluble and more emulsifying ability. In this study it is of interest to note that the effect of sodium caseinate was not significant.

The results of this study help predict that melting characteristics are largely but not solely dependent on the solubility since the presence of denatured whey protein in DENFDM may exert a detrimental effect on meltability.

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