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Microstructural and Melting Characteristics of Imitation Cheese Analog

Jae Chul Song and Hyun Jeong Park*

Department of Food and Nutrition, University of Ulsan
**Department of Microbiology, Pusan National University, Pusan*

모방치즈의 조직과 융점특성 연구

송 재 철 · 박 현 정*

울산대학교 식품영양학과 · *부산대학교 미생물학과

Abstract

The imitation processed cheese (IPC), formulated with delactosed non fat dry milk (DENFDM) only, showed the smallest melting area. Calcium caseinate sample showed the largest spread. Satistically protein source as a major ingredient for the IPC yielded significantly different melting areas. In a similar fashion, initial melting temperature was markedly and significantly influenced by protein source. In effect of addition of DENFDM on microstructure of IPC analog revealed that as the fraction of DENFDM was decreased, the network was much more uniform and the fat globules were also better dispersed compared to DENFDM cheese analog. Therefore the results of this study help predict that melting and microstructural characteristics are largely but not solely dependent on the protein source. The DENFDM has a potential beneficial effect as a partial replacement of caseinate in the formation of IPC to characteristic close to processed cheese.

Introduction

The quality of the imitation processed cheese (IPC) is depended upon the formulation and manipulation of processing conditions. Based on these studies, Hansen *et al.*[1] has suggested that microstructural and thermomelting properties of IPC are related to the protein matrix formed from strong surface interactions between calcium caseinate particles, generated by the influence of changing the dielectric constant of the solvent mixture.

The presence of caseinates in IPC mainly affect the physical properties of the product, including shred, melt slice, texture and stretch characteristics unique to the IPC.[2] Melting and textural characteristics are important parameters which might command quality of IPC products, since poor meltability and texture appears to be a serious problem associated with such product.[3] The structural skeleton of cheese is comprised of an intense network of protein fibers, which are cross-linked and bound at various sites.[4]

The thermomeltability and microstructure of IPC were identified to be related to protein matrix,[1] the protein-protein and protein-lipid interactions,[5] extent of proteolysis,[6] swelling behavior and hydration[5] and emulsifying salts.[7]

This study has been concerned with the possibility of delactosed non fat dry milk (DENFDM) formation into conventional IPC. In the IPC manufacture, Non fat dry milk (NFDM) is not interchangeable with caseinate which is characterized by high protein content, low lactose content and unique functional properties.[8] From this proposed study, the importance of DENFDM as a major ingredient for IPC manufacture might be clarified by evaluating the thermomeltability and microstructure of the IPC products.

Materials and Methods

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.

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 with 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.

Formulation of Imitation processed cheese

Twenty-three grams of vegetable oils and 445 *g* water were incorporated to a mixture of emulsifying and buffering agents in the bowl of a dough mixer. A salt-caseinate mixture (1.5 *g* salt and 28 *g* 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.

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.*[9]

Light Microscopy

The Imitation processed cheese analogs for light microscopy (LM) were cut into small cubes and fixed in 10% buffered neutral formali solution for 24 hours at 2°C. The samples were then sectioned to 10-20μm on a freezing microtome (American Optical Co.) and stained with Sudan IV or oil red for fat stain and methylene blue for protein stain. The samples were examined under a Leitz Dialux Microscope equipped with a bright field condenser.

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.[10]

Results

Thermomeltability

In order to assess melting characteristics, including melting area and melting temperature, IPC on laboratory scale was prepared and cut into uniformly sized blocks. The melting area with Tukey's studentized range test and statistical analysis were shown in Table 1 and Table 2 respectively depending upon formulation. When Tukey's test (Table 1) was employed on the different IPC samples, the melting area obtained at the seven different formulation could be grouped into five classes. Therefore the test

Table 1. Comparison of melting area of various IPC analogs

Sample No.	Products	Melting area (cm²/g sample)		
		Exp. I	Exp. II	Mean
1	Ca-caseinate/DENFDM (1:1)	1.71	1.71	1.71_d*
2	Ca-caseinate/DENFDM (2:1)	3.08	3.08	3.08^d
3	DENFDM only	0.65	0.65	0.65^e
4	Ca-caseinate only	4.62	4.60	4.61_a
5	Ca-caseinate/Na-caseinate (1:1)	3.72	3.82	3.77^b
6	Ca-caseinate/NA-caseinate/ DENFDM (1:1:1)	2.95	2.91	2.93^c
7.	Commercial processed cheese (control)	1.73	1.75	1.74^d

*Mean with the same letter are not significantly different α-level = 0.05, DF = 7, MSE = 0.0037

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

Source	DF	SS	MS	F	PR>F	$F_{0.05}$	$F_{0.01}$
Model	6	22.14	3.690	895.92*	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 2) indicated that protein source as a major ingredient for IPC yielded significantly different melting areas. The IPC, formulated with DENFDM only, showed the smallest area, while calcium caseinate sample showed the largest spread.

In a similar fashion, the range of melting temperature was observed. The melting temperature was classified into two groups: (a) the 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 with Tukey's test is shown in Table 3 and the statistical treatment in Table 4. Initial melting temperature was markedly and significantly influenced by protein sources (Table 3 and 4).

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. 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.

Microstructure

The morphology of IPC analogs prepared from different protein sources, including DENFDM, was examined and compared to that of commercial processed cheese as a control. Each microstructural characteristics of IPC were depicted in Fig. 1. Commercial IPC shows uniform distribution of fat globules embedded in a cell like matrix a gelled mass and possibly swollen particles. The fat globules are nonuniform in size. The DENFDM cheese analog showed by LM examination that the product was poorly blended with discrete large particles of DENFDM that did not solubilize. The fat is not emulsified but occupies the spaces between the particles and has speed into the crevices of the particles. In effect of addition of DENFDM on microstructure of IPC analog, combination IPC analogs revealed that as the fraction of DENFDM was decreased the network was much more uniform and the fat globules were also better dispersed compared to the DENFDM analog.

Table 3. Comparison of melting temperatures of various IPC analogs

Sample No.*	Melting temperature (°C)	
	Initial	Complete
1	72.6[b]**	79.5
2	70.4[c]	79.0
3	73.8[a]	79.0
4	65.6[e]	79.0
5	70.4[c]	79.5
6	72.0[b]	79.0
7	68.9[d]	79.0

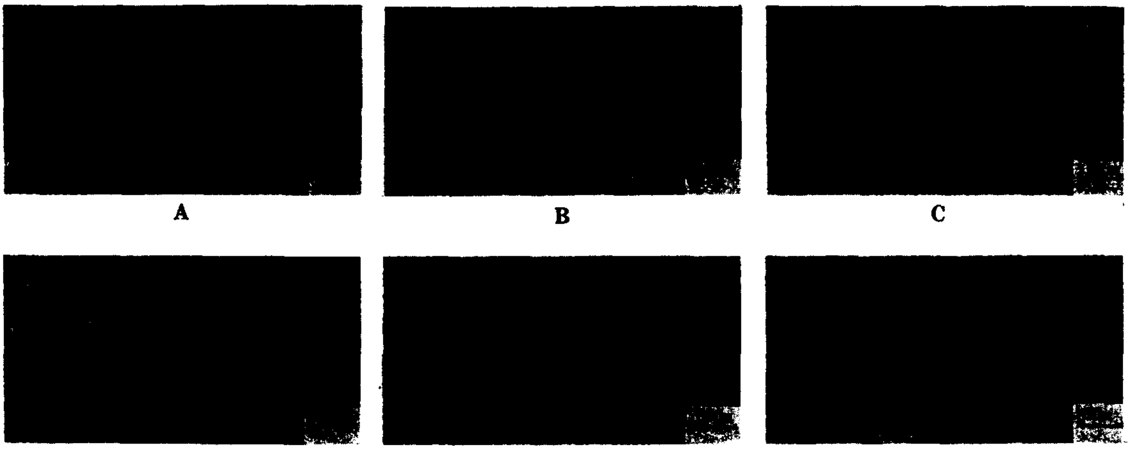
* formulation as same as Table 1

** means with the same letter are not significantly different α-level = 0.05, DF = 7, MSE = 0.0614

Table 4. Analysis of variance: initial melting temperature of various IPC dependend upon a protein source

Source	DF	SS	MS	F	PR>F	$F_{0.05}$	$F_{0.01}$
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



A B C

D E F

G

Fig. 1. Light micrograph of imitation cheese analog prepared from different protein sources

A : Ca-caseinate/DENFDM (1:1) B : Ca-caseinate/DENFDM (2:1)
C : DENFDM only D : Ca-caseinate only
E : Ca-caseinate/Na-caseinate (1:1) F : Ca-/Na-caseinate/DENFDM (1:1:1)
G : Commercial product (control)

Discussion

The uniform melting and unique textural characteristic of imitation processed cheese are desirable properties. On the basis of major observations, these studies have shown quite clearly that the melting and textural characteristics of theese 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 hydrophillic 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.[11] In addition DENFDM protein may not completely from 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 emulsifying properties,[5,8] Chakraborty[8] 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 textural characteristics. However, calcium caseinate, compared to sodium caseinate, showed lower solubility due to large particle size and strong interaction of aggregates promoted by the cross linking of divalent cations.[1]

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 that the effect of sodium caseinate was not significant. Results showed a potential for the use of blends of DENFDM with calcium caseinate and/or sodium caseinate for duplicating commercial processed cheese.

요 약

탈유당 탈지분유만으로 조제한 모방치－즈는 칼슘카제인 단백질로 만든 제품에 비하여 용융면적이 현저히 감소하였으며 단백질원이 용융면적을 변화시키는 주요한 요인이라는 사실이 통계학적으로 규명되었다. 비슷한 결과로 용융온도도 사용된 단백질원에 따라 현저한 차이를 나타내었다. 모방치－즈제품의 미시적 조직검경에서 탈유당 탈지분유의 첨가량을 감소시키면 치－즈제품의 조직은 보다 균일하고 지방구의 분산정도도 탈유당

탈지분유 단독 사용시보다 양호하여 치-즈제품의 주원료인 대체 단백질원으로 탈유당 탈지분유의 부분사용이 가능하였다.

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