J. Korean Soc. Food Nutr.
19(6), 571~576(1990)

한국영양식량학회지

A Study on Textural Characteristics of Imitation Proceessed Cheese Formulated by Delactosed Nonfat Dry Milk

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Abstract

This study has been concerned with the possibility of delactosed nonfat dry milk(DENFDM, lactose 4.25%) formation into conventional imitation processed cheese(IPC). The effect of DENFDM was mainly a contribution to fracturability, elasticity and gumminess, while hardness and cohesiveness were decreased. Similarly calcium caseinate and sodium caseinate were contributing to cohesiveness, hardness, elasticity and gumminess. Delactosed NFDM has a potential beneficial effect as a partial replacement of caseinate in the formation of the imitation processed cheese to characteristics close to commercial processed cheese.

Introduction

Casein and caseinate are good sources of food protein of excellent quality and used as major ingredients for imitation dairy product[1,2], inculuding imitation processed cheese(IPC). In this product nonfat dry milk(NFDM) is not interchangeable with caseinates because NFDM contains high content of lactose which is undesirable in substitute cheese manufacture. Since NFDM has only limited application as a replacement for caseinates[3], development of a method for production of delactosed NFDM(DENFDM) was attempted to formulated the imitation processed cheese[4]. The presence of caseinated in the imitation cheese affect the physical properties of the product, incluing shred, meat slice, texture and stretch characteristics unique to the imitation processed cheese.

The structural skeleton of cheese is comprised of an intense network of protein fibers, which are cross-linked and bound at various sites[5]. This study was undertaken to increase the understanding of the manner in which protein sources are effective in texture characteristics to examine the usefulness of delactosed NFDM.

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.

Chemical Analysis

Total nitrogen was determined by the kjeldahl and microkjeldahl method[6] utilizing a digestion mixture of K_2SO_4 and HgO in concentrated sulfuric acid. The fat content was determined by the direct method of ether extract[6]. The phenol-sulfuric acid method by Marier and Boulet[7] for analysis of lactose was utilized. The content of mineral was analyzed by the flame emmission spectroscopy in the Research Extension Analytical Laboratory at OA-

RDC, Wooster, Ohio. The ash content were calculated as percentage of the dry weight after treatment.

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 remixed with 62% methanol in 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 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 alumimum foil and kept in refrigeration at 4~6℃. The cheese samples was cooled down before evaluation of characteristics.

Textural examination by Instron

All samples were equilibrated at 25℃ for 1 hour and cut into cylindrical shapes of 2cm diameter amd 1 cm height prior to test. Textural properties were evaluated using the Instron Universal Testing Instrument(Model 1000) with a load cell range of 0~50kg. The speed of the crosshead was net at 2.0 cm/min. The plunger was initially adjusted to 1.0cm from a flat holding plate and set for maximum deformation of 0.75cm with automatic control for first and second bite. A diagram of a typical compression curve is depicted in Figure 1 identifying each characteristic.

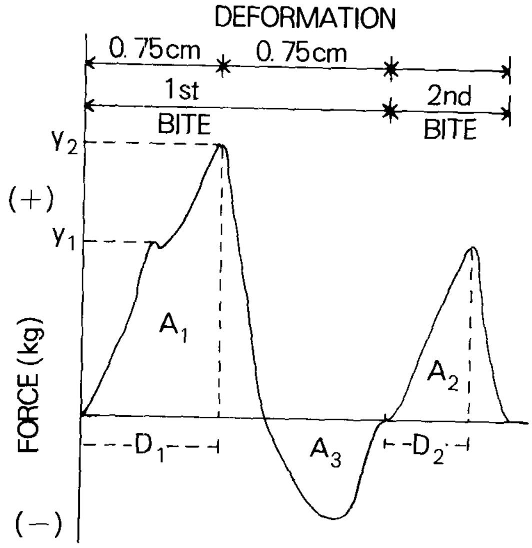

Fig. 1. Typical TPA curve and data obtained from the curve were :
y_1 = fracturability
y_2 = hardness
A_1, A_2, A_3 = areas under the force-deformation curve
$\frac{A_1}{A_2}$ = cohesiveness
A_3 = adhesiveness
$\frac{D_2}{D_1}$ = cohesiveness
(hardness)(cohesiveness) = gumminess
(gumminess)(elasticity) = chewiness

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[8].

Results and Discussion

Analysis of Composition

The composition of DENFDM, commercial casein and NFDM is given in Table 1. The major

Table 1. Chemical analysis of DENFDM

	Commercial caseinate[a]	DENFDM	NFDM
protein(%) (N×6.38)	88.5	78.9	34.58
fat(%)	0.2	0.8	1.02
carbohydrate(%)[b]	–	3.8	51.9
moisture(%)	7.0	4.25	3.35
ash(%)	3.8	9.30	7.87
mineral(mg/g)			
Ca^{++}	13.887	24.241	12.57
phosphorous	6.764	12.779	9.68
K^{+}	0.554	6.172	8.128
Mg^{++}	0.218	1.380	1.100
Na^{+}	0.138	1.67	5.350
Fe^{++}	0.039	0.021	0.032
Zn^{++}	0.041	0.074	0.041
Mn^{++}	0.005	0.001	0.001
Cu^{++}	0.002	0.003	0.004
Ca/Na	100.6	14.5	2.35
Cation divalent / Monovalent	20.5	3.28	1.02

a) from Morr(1982)
b) indicates lactose content

differences in composition between DENFDM and NFDM are in their protein and lactose contents and in their mineral content and composition. Delactosed NFDM is intended as a replacement for calcium caseinate and in this respect the composition of DENFDM approaches that of calcium caseinate with the exception that about 3~4% residual lactose remains along with a greater proportion of milk salts.

The minimum lactose content attainable was found to be about 3.8 % in DENFDM, which is somewhat higher than for commercial, co-precipitated casein(0.2~1.5%)[9].

The quantity of ash was markedly different depending upon the product. DENFDM contained 9.3% ash, whereas commercial casein contained 3.8% ash. The differences in ash content may have an influence on different functional properties depending upon the type of mineral elements. The major differences between DENFDM and commercial casein can be expressed by the ratio of divalent to monovalent cation and in the Ca/Na ratio. The data for DENFDM revealed on intermediate position in these ratios and a tendency for a preferential extraction of monovalent cations over divalent species.

Textural Profile Analysis

In order to evaluate textural characteristics of IPC analogs, an instron universal testing machine was used. Analysis of variance by SAS showed that the textural measures for the seven samples was correlated with protein source(Table 2).

Table 3 illustrates another approach to identify the effect of protein source on the textural characteristics. Since the F values were significantly different, Tukey's studentized range test was applied and the results may be explained as follows :

Table 2. F value of instron of IPC

	Fracturability	Hardness	Cohesiveness	Adhesiveness	Elasticity	Gumminess	Chewiness
DF	6	6	6	6	6	6	6
Error	7	7	7	7	7	7	
Corrected total	13	13	13	13	13	13	13
F	58010.83*	19.25*	10.66*	3249*	352.33*	1381.93*	2.10
$F_{0.05}$	3.87	3.87	3.87	3.87	3.87	3.87	3.87
$F_{0.01}$	7.19	7.19	7.19	7.19	7.19	7.19	7.19

*Significant at both 0.01 and 0.05 levels

Table 3. Instron evaluation of IPC analogs made with different protein sources[p)]

Sample No.[q)]	Fracturability (kg)	Hardness (kg)	Cohesiveness	Adhesiveness (kg-cm)	Elasticity	Gumminess (kg)	Chewiness (kg-cm)
1	NA[r)]	6.85^{ab}	0.30^{ab}	NA	0.60^{a}	1.95^{a}	1.19^{a}
2	1.53	3.84^{bc}	0.12^{c}	NA	0.35^{d}	0.51^{d}	0.93^{a}
3	0.75	1.91^{c}	0.20^{bc}	NA	0.29^{e}	0.57^{d}	0.17^{a}
4	NA	2.73^{c}	0.38^{a}	NA	0.44^{c}	1.02^{c}	0.46^{a}
5	2.90	8.25^{a}	0.19^{bc}	NA	0.48^{c}	1.67^{b}	0.78^{a}
6	NA	4.05^{bc}	0.25^{abc}	NA	0.53^{b}	0.94^{c}	0.49^{a}
7	NA	1.15^{c}	0.17^{bc}	0.57^{a}	0.17^{f}	0.39^{e}	0.03^{a}

p) each value is a mean(n=2). Means in the same column with different letters are significantly different in a confidence of 0.95

q) 1 : calcium caseinate/DENFDM=2 : 1
2 : calcium caseinate/DENFDM/caseinate=1 : 1 : 1
3 : DENFDM only
4 : calcium caseinate only
5 : calcium caseinate/sodium caseinate=1 : 1
7 : control(commercil processed cheese)

r) not applicable

a) Fracturability : Examination of the data showed that samples containing DENFDM exhibited fracturability at application of low force. Calcium caseinate/sodium caseinate(1 : 1) was shown to produce the highest value for the force required to fracture. When DENFDM was incorporated in blends with calcium caseinate and sodium caseinate(1 : 1 : 1), the samples fractured more readily. These results suggest that DENFDM does not engage in strong interactions and thus produces a weaker structual matrix. Some samples did not fracture under the test conditions used and are represented by NA(not applicable).

b) Hardness : Application fo Tukey's range test showed complex groupings for measurements of hardness. However, it is very clear that most of the experimental IPC analogs exhibited greater hardness than the commercial control sample. The samples containing either calcium caseinate or DENFDM alone were not significantly different from the control. When sodium caseinate was added the hardness increased to high values, however the incorporation of DENFDM in such mixtures had a moderating influence. It would appear that DENFDM causes a weakening of the cheese matrix an effect which may be related to its solvation characteristics. It was shown previously that DENFDM delayed the gelatinization of starch[5] : in this experiment, it appears that DENFDM also interferes with the water absorption of sodium caseinate.

c) Cohesiveness : Calcium caseinate was shown to produce the highest values for cohesiveness when it was used singly. In contrast, when DENFDM was used as a single ingredient, cohesiveness was very low. However, blends containing DENFDM produced cohesiveness values not significantly different from the control.

d) Adhesiveness : This parameter relates to the capacity of the components of the broken cheese to stick together and to the probe. Only the control was demonstrated to possess measurable adhesiveness. DENFDM and others were not adhesive at all.

e) Elasticity : Imitation processed cheese analogs were grouped into six classes. The results showed significant differencess for all the samples with the exception that calcium caseinate and its blend with sodium caseinate were similar. The commercial sample was least elastic and of the experimental samples the DENFDM ingredient produced the closest agreement with the control sample.

f) Gumminess : Tukey's range test showed five different groups depending upon formulation. Gumminess was pronounced in all samples containing calcium caseinate. Delactosed NFDM increased gumminess compared with the control but not as much as did the calcium caseinate samples.

g) Chewiness : This parameter is derived as the product between gumminess and elasticity. Tukey's range test demonstrated that all samples belonged in just one identical group. The experimental error for this set of measurements was very large and thus made it impossible to determine conclusively whether or not this characteristic is related to protein source.

Table 4 shows the main trends of protein source on IPC texture and has been compiled from the statistical analysis. It appears that DENFDM has properties which are separate from those associated with caseinates. The product decreases and cohesiveness, and increases the fracturability. It is of interest that sodium caseinate has a pronounced effect on hardness, possibly associated with strong gelling tendencies. This effect may be compensated for by the use of DENFDM.

The textural properties of natural cheese has been shown to be closely correlated with the chemical composition of the cheese in the solid state. Therefore, it is not surprising to note the same effect with the IPC analogs which were formulated by DENFDM and others. At this time, it is not known whether the textural changes are caused by the processing conditions, subtle changes in the manner in which protein interact with other components or a combination of the two.

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Table 4. Main trends of protein source on IPC texture

	Fracturability	Hardness	Cohesiveness	Adhesiveness	Elasticity	Gumminess	Chewiness
DENFDM	↑	↓	↓	–	↑	↑	–
Calcium caseinate	–	–	↑	–	↑	↑	–
Sodium caseinate	–	↑	–	–	↑	↑	–

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(Received October 23, 1990)

탈유당 탈지분유를 이용한 모방치즈의 조직특성에 관한 연구

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요 약

본 연구는 카제인 원료 대체를 위해 탈유당 탈지분유를 모방치즈에 사용하였을 때 야기되는 조직특성의 변화를 관찰하였다. 카제인 원료 대신 탈유당 탈지분유를 일부 대체 사용한 결과 fracturability, elasticity, gumminess성질은 향상하였으나 hardness와 cohesiveness 성질은 감소하였다. 비슷한 결과로 calcium caseinate와 sodium caseinate를 원료로 모방치즈를 만들었을 때 탈유당 탈지분유를 사용한 모방치즈와 비슷한 조직특성을 나타내었다. 따라서 탈유당 탈지분유를 카제인 원료대신 일부 모방치즈에 대체 사용할 수 있음을 확인하였다.