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PROCESSED CHEESES MADE WITH AND WITHOUT PEPTIZATION
Submicroscopic structure and thermodynamic characteristics

B. Schäffer[1], *S. Szakály*[1], *D. Lőrinczy*[2*] *and B. Schäffer*[2]

[1]Hungarian Dairy Research Institute, H-7624 Pécs, Szigeti str. 12, Hungary
[2]Biophysical Department, Faculty of Medicine, University of Pécs, H-7624 Pécs, Szigeti str. 12, Hungary

Abstract

The osteoporosis is regarded as a widespread disease all over the world. In the prevention therapy of this disease there is a primary role of the daily calcium intake with the proper Ca:P ratio (1:1–1:2). The primary source of Ca for people the dairy products are implied, from which only the processed cheeses have inadequate ratio of Ca:P. In cheeses processed without peptization developed in the Hungarian Dairy Research Institute (HDRI) the Ca:P ratio meets the requirements (1.5:1), moreover these products can be enriched with Ca.

In this study we used both processing technologies. The electronmicroscopic photographs demonstrate the differences clearly. The traditionally processed cheese (with peptization) has a ‘spongy’ structure well known from literature, while a space-net can be seen resulting from the casein-filamentous hydrocolloid interaction in the structure of heat-treated cheese without peptization. DSC curves are the same in the temperature range 0–40°C, showing endotherm melting process in two well-distinguished temperature interval (0–20 and 22–40°C). They are different in the temperature interval 40–100°C: in the case of processed cheese with peptization the gel-sol transformation gives a higher endotherm peak in a narrow temperature range, while for heat-treated cheese without peptization this temperature range is wider with a lower endotherm peak.

Both electronmicroscopic and DSC investigations have proved that contrary to the traditionally processed cheese where the structure is formed by the linked peptized protein, in the heat- processed cheese without peptization the frame-forming element is the huge hydrocolloid molecule interacted with the protein. The enthalpy change is substantially lower at the disintegration of the latter structure.

Keywords: DSC, ELMI, heat-treated cheese, osteoporosis, peptization

Introduction

Since 1990 the per capita consumption of total milk and milk products has continuously decreased. This firstly concerns the calcium supply of the Hungarian population which is shown in Table 1 [1]. The data of Table 1 show that the daily calcium

* Author for correspondence: Phone: (36) 72-536-260; Fax: (36) 72-536-261,
E-mail: denes.lorinczy@aok.pte.hu

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Akadémiai Kiadó, Budapest
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consumption decreased from the deemed minimum 800 mg/day in the year of 1990 to below of 700 mg/day level. It means that the Ca:P ratio further decreased below the concerned optimum 1:1 ratio. This progression can explain the subsequent expand of osteoporosis.

Table 1 Characteristic values of the food origin calcium (Ca) and phosphorous (P) consumption of the Hungarian population in 1990 and 1995

Characteristisc of consumption	Consumption			
	1990		1995	
	Ca	P	Ca	P
Yearly total/mg	306 101	561 019	249 802	466 972
Daily mean/mg	839	1537	684	1279
Comparative index	100	100	82	83
Ca:P index	1:1.83		1:1.87	

The calcium and phosphorus content of some foods and their ratio are shown in Table 2. It is obvious from data of Table 2 that primarily the dairy products contain enough calcium because their Ca:P ratio is also over 1:1. The exceptions are the quarg with its low calcium content and the processed cheeses with their high phosphorus content because of the added melting salts.

Table 2 Ca- and P-content and their ratio in different foods

Foods	Ca-content/mg 100 g^{-1}	Pa-content/mg 100 g^{-1}	Ca:P ratio
Cow's milk	120	70	1.71
Cheeses	180–850	100–550	2.00–1.43
Quargs	63–90	180–200	0.50–0.32
Processed cheeses	400–500	900–1000	0.53–0.42
Fruits	9–968	2–800	9.50–0.17
Vegetables	7–133	20–160	1.87–0.12
Egg	42	240	0.18
Meats	5–30	120–350	0.12–0.03
Chitterlings	13–18	284–380	0.06–0.04

For the sake of decreasing the phosphorus content of processed cheeses, the Hungarian Dairy Research Institute had developed a process [2], in which the traditional peptization does not take place, so the cheeses can be heat-processed without adding phosphate salts [3]. The main goal of this study is to investigate the microstructure and thermal stability of this kind of cheeses.

Materials and methods

Same composition raw material, containing cheese, cream and butter, was used in the experiment. The raw material was divided into two parts, the first half was melted traditionally with 2% melting salt (mixture of ortho- and polyphosphates), the other half was heat-processed with the new technology by adding 2% stabilizer (a mixture of plant origin hydrocolloids). The main steps of the process are shown in Fig. 1 [4, 5].

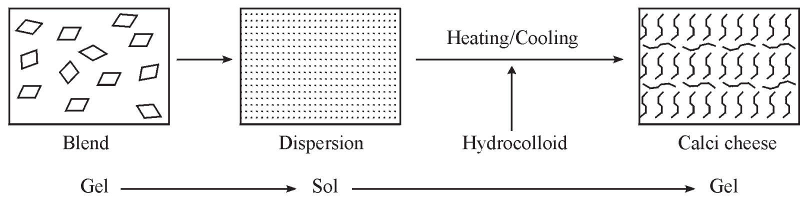

Fig. 1 Heat-treatment process without peptization

According to Fig. 1, the main point of the new technology is that the melting salt does not break down the calcium from the protein net, so the peptization does not take place, which later on would form the space-net by the way of sol-gel transformation. The cheese particles are mechanically dispersed in the water phase and depending on the character of the end product (spreadable, cuttable, sliceable) the gel structure is formed by hydrocolloids. This technology also gives the opportunity of calcium enrichment, contrary to the traditional melting, where the added quantity of melting salt must be higher proportionally with the calcium content [6].

During the investigations melting salts were added to a part of the samples heat processed with hydrocolloid to decide whether the melting process takes place in such a case.

The heat induced changes in the samples were measured with SETARAM Micro DSC-II ultrasensitive scanning calorimeter. The mass of cheese samples was between 700 and 900 mg. The experiments were performed in the conventional batch type cells having a volume of 1 cm^3. The measurements were carried out in the temperature range of 0–100°C with a heating rate of 0.3°C min^{-1} after the adjustment of the thermal balance when the fluctuation of heat flow was below 0.5 μW. The examinations were carried out both during the technological flow of process and in the end products. The melting process and heat treatment took place in DSC cells.

In order to be able to investigate the endotherm process of transformation of proteins, the baseline was corrected by means of PeakFit pogram on the DSC curves.

The microstructure of the new heat-processed cheeses without peptization after fixing, dehydration, bedding and slicing [7] was examined in semithin samples with lightmicroscope and in thin one with JEOL 1200 EX type electronmicroscope by transmissional running.

Results

In Fig. 2 the DSC-curves of traditionally processed cheeses containing only melting salts are shown. In Fig. 2a the thermodynamic changes during production/heat-processing can be seen. A DSC-curve of a ready processed cheese made with peptization is demonstrated in Fig. 2b. Figure 2 demonstrates that the melting of fats is done between temperature 0–40°C, followed by the endotherm thermodynamic process of the gel-sol transformation. Their initial temperatures during the production and at the end products are 81, 75°C, respectively.

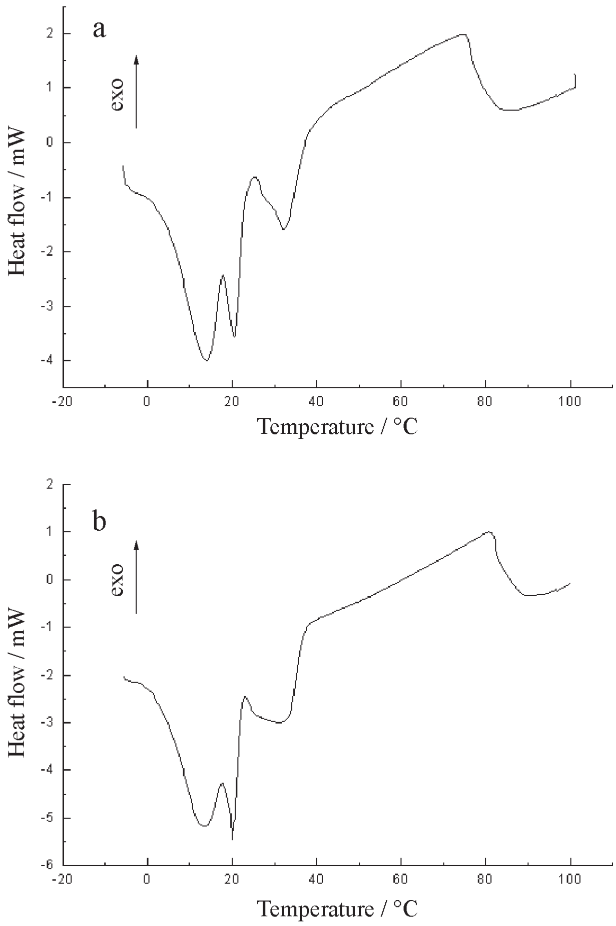

Fig. 2 DSC curves of traditionally processed cheeses containing only melting salts during production (a) and in the product (b)

In Fig. 3 the DSC-curves of the new, processed cheeses containing only hydrocolloids are shown. Figure 3a shows the thermodynamic changes during production/heat-processing. Figure 3b shows the DSC-curve of the ready processed cheese made without peptization. Figure 3 shows well that, during the production, subsequently the melting of fats, over 40°C temperature, the initial temperature of the endotherm process of gel-sol transformation is 61°C and in the case of end product is 68°C. This temperature for processed cheese with peptization is higher.

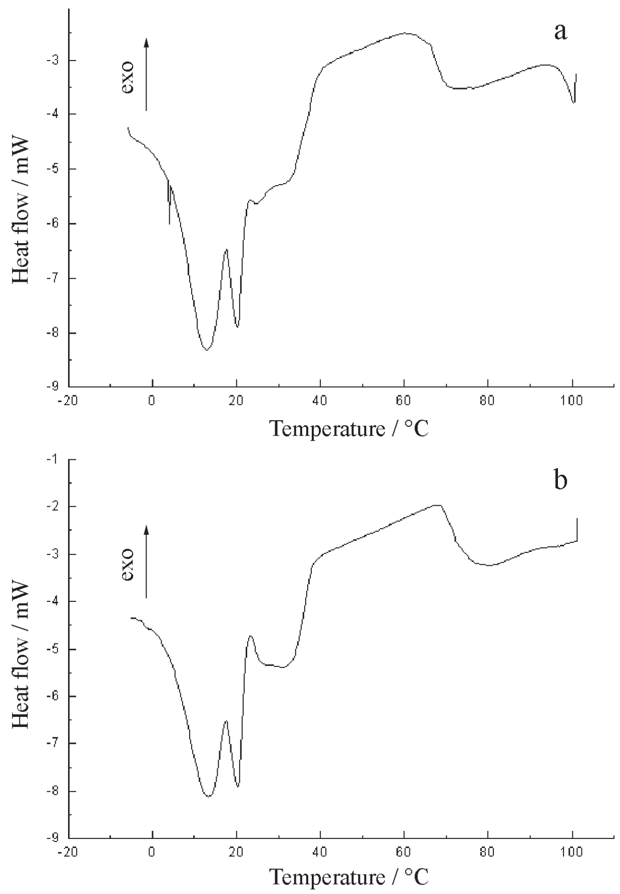

Fig. 3 DSC curves of new processed cheeses containing only hydrocolloids during production (a) and in the product (b)

In Table 3 the measured initial temperature ranges of gel-sol tranformations are summarized. The data of Table 3 shows well the differences between the heat-process with melting salts and adding hydrocolloids. This difference still exists at the end products but decreased. There are no changes in differences even if melting salts are used beside hydrocolloids. In case of second heating of the product we have measured same temperatures, so the process is reversible.

Figure 4 illustrates the baseline corrigated DSC-curves done by PeakFit program. Figure 4 well illustrates that the biggest transformation of proteins occurs during the melting process (a) followed by the processed cheese (b) and the transformation is substantially smaller during the melting process without peptization (c) and the transformation is minimum in heat-treated cheeses made without peptization (d).

Table 3 Initial temperature ranges of gel–sol transformation

Denomination and characteristics	Initial temperature/°C
Cheese+2% melting salt during heat processing	81–90
1. Gel–sol transformation of heat-processd cheese	75–87
2. Gel–sol transformation of heat-processd cheese	75–85
Cheese+2% hydrocolloid during heat processing	61–72
1. Gel–sol transformation of heat-processd cheese	68–74
2. Gel–sol transformation of heat-processd cheese	68–74
Cheese+2% hydrocolloid + 2% melting salt during heat processing	60–71
1. Gel–sol transformation of heat-processd cheese	66–70
2. Gel–sol transformation of heat-processd cheese	66–70

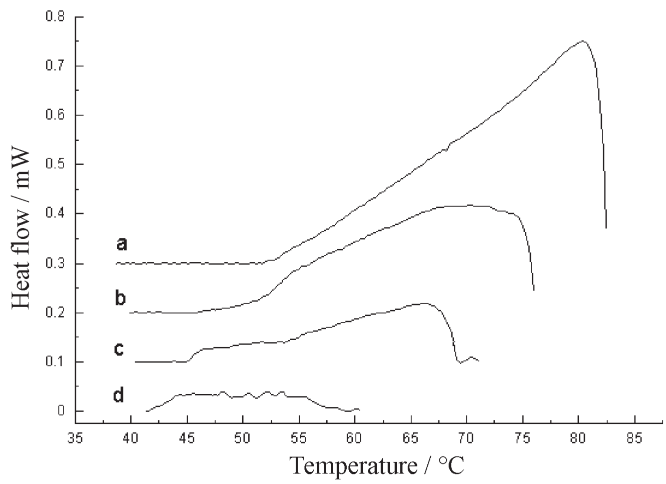

Fig. 4 DSC curves characteristics for transformation process of proteins in cheeses during melting (b) and heat–treatment without peptization (d), in processed cheese (a) and in heat-treated cheese made without peptization (c)

In Fig. 5 can be seen the light microscopic picture of processed cheeses made with peptization (a) and without peptization (b), which were made on semithin (200 nm) slices. Light microscopic photographs made of cheeses well demonstrate that while the emulsion fat phase is bedded into the homogenous structure due to peptization by the effect of melting salt, till the dispergated cheese particles with the original fat emulsion are remained in cheese heat processed without peptization.

The transmissional electronmicroscopic picture of processed cheeses made with peptization (a) and without peptization (b) are shown in Fig. 6. It is well demonstrated in Fig. 6 that emulsion fat phase is incorporated into the melted homogenous protein phase in processed cheese made with peptization. On the other hand the milk

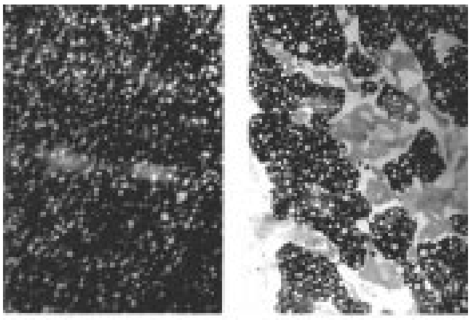

Fig. 5 Light microscopic picture of processed cheeses made with peptization (a) and without peptization (b). *N*=1000

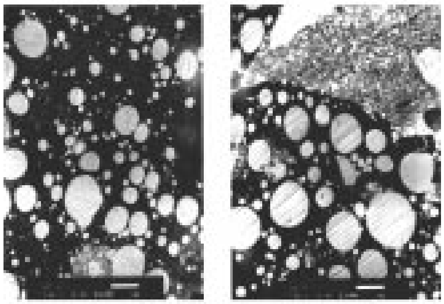

Fig. 6 Electronmicroscopic picture of processed cheeses made with peptization (a) and without peptization (b). *N*=4000

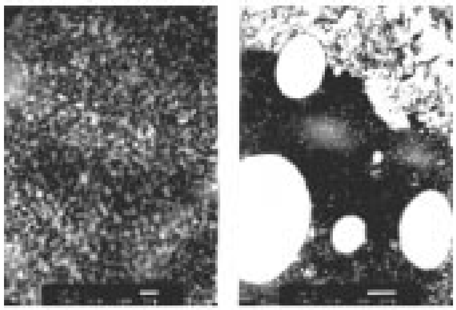

Fig. 7 Microstructure of processed cheese made with peptization (a) and without peptization (b). *N*=100 000

protein is bounded to the stabilizer and only the fat phase can be found in protein particles in processed cheeses made without peptization.

The differences in the structures can be seen well at the high magnification (Fig. 7). Proteins of processed cheese made with peptization are stretched and show a fit together spongy structure. The protein structure of heat-processed cheese without peptization shows a nature cheese-like grainy structure, while the connecting stabilizer shows a threaded structure.

Conclusions

The examinations made by DSC and electronmicroscopic method showed that there were essential differences between the structures of traditionally processed cheeses and processed cheeses without peptization produced with hydrocolloids.

The structure of processed cheeses, above all, was examined with an electronmicroscope. The publications agree on that the peptization produces a spongy structure which consists of shorter or longer protein chains depending on the technology, mainly on the temperature of melting [1, 8].

Based on electronmicroscopic examinations it has been stated that there can be found protein particles and gel-forming huge molecules of hydrocolloids reacted with the proteins in the processed cheeses without peptization produced with hydrocolloids. Even then the same structure is to be formed if melting salts are given beside the hydrocolloids.

We have not found any data in the literature on thermodynamic examination of the sol-gel transformation by DSC method. The differences found in submicroscopical structure are proved by our examinations. The sol-gel transformation caused by peptization takes place at higher temperature (82–90°C) than the swelling temperature (61–72°C) of hydrocolloids so the peptization does not take place even adding melting salts beside the hydrocolloids. In this manner the melting salts act as buffer salts and emulsifyier.

Though the temperature ranges of endotherm processes indicating the sol-gel transformation are near to each other the characteristic difference still exists. At the same time this also provides an opportunity for the determination from an end product whether it was produced by heat-processing with or without peptization.

The corrigated baseline DSC-curves well demonstrate the differences between processed cheeses made with and without peptization, which shows well that in the proteins a substantially bigger changes occur during peptization than during heat-treatment without peptization.

The results of light- and electronmicroscopic examinations well show that the structure of heat-treated cheeses with peptization and without peptization differs essentially in spite of the fact that the products manufactured by the two types of processes can be produced in almost the same compositions and texture with the exception of Ca:P ratio.

The structure of cheeses manufactured by the two types of processes differs firstly as follows. When peptization takes place the protein phase is homogenous, the stretched threads are connected and the emulsion fat phase is bedded into this protein structure. The microstructure is inhomogenous in case of heat-processing without peptization, the dispergated cheese particles can be seen well, and their structure is the same as of nature cheese [4], but the surface proteins of these particles are connected with each other forming together the structure of processed cheese.

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