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DSC AND ELECTRONMICROSCOPIC INVESTIGATION OF DISPERSION-TYPE PROCESSED CHEESES MADE WITHOUT PEPTIZATION

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Abstract

In contrast with the traditional method of cheese processing, where Ca breaks down from the protein chain and protein is peptized, a new technology has been elaborated, during which cheese is dispersed without phosphate-containing processing salt, when the gel is formed by plant hydrocolloids.

Raw material of constant composition was processed with a phosphate-containing salt or in the presence of hydrocolloids. Thermodynamic processes occurring during the processing and in the end-products were examined by an ultra-sensitive micro DSC method. The structures of end-products were also investigated by electronmicroscopy.

The temperature ranges of the endothermal processes indicating the transformations of protein and hydrocolloids can be distinguished: 81–90°C for peptization processing and 61–72°C for processing without peptization. The differences are less in the end-products: 75–87°C in traditional processed cheese and 68–74°C in processed cheeses made without peptization. In contrast with the spongy structure of traditional processed cheeses consisting of peptized proteins, processed cheeses made without peptization involve structure-forming elements created by the interaction of linear macromolecules of hydrocolloids and cheese proteins.

Keywords: dispersion-type processed cheese, DSC, ELMI

Introduction

Since 1990, the per capita consumption of whole milk and milk products in Hungary has continuously decreased. This has primarily influenced the Ca supply of the Hungarian population, as shown in Table 1 [7].

The data in Table 1 reveal that the daily Ca consumption has decreased from 800 mg/capita in 1990 (the minimum desirable level) to below 700 mg/capita. This means that the Ca:P ratio has decreased below the optimal 1:1. This decrease can explain the subsequent increase in osteoporosis.

The Ca and P contents of some foods and their ratios are listed in Table 2 [6].

It is obvious from the data in Table 2 that many of the dairy products have a high Ca content and a Ca:P ratio over 1:1. The exceptions are quarg, with a low Ca content, and processed cheeses, with a high P content because of the added melting salts.

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Table 1 Data on the consumption of calcium (Ca) and phosphorus (P) by the Hungarian population in 1990 and 1995 [7]

	Per capita consumption			
	1990		1995	
	Ca	P	Ca	P
Yearly total/mg	306101	561019	249802	466972
Daily mean/mg	839	1537	684	1279
Comparative index (1990=100)	100	100	82	83
Ca:P ratio	1:1.83		1:1.87	

Table 2 Ca and P contents and Ca:P ratio in different foods [6]

Foods	Ca	P	Ca:P ratio
	content/mg in 100 g		
Cow's milk	120	70	1.71
Sour milk, yoghurt, kefir	120	70	1.71
Skim milk	114	40	2.85
Sour cream and creams	100–130	50–70	2.22–1.70
Evaporated milks and milk powders	300–1200	170–730	2.73–1.64
Cheeses	180–850	100–550	2.00–1.43
Butters	25	20	1.25
Quargs	63–90	180–200	0.50–0.32
Processed cheeses	400–500	900–1000	0.53–0.42
Grains	39–200	300–500	0.40–0.12
Husked grains, groats, flours	8–71	90–350	0.44–0.09
2–4–8 egg noodles	24–25	100–250	0.24–0.10
Bread stuffs	21–295	50–150	2.86–0.30
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
Meat products	8–32	120–250	0.19–0.05

In the interest of decreasing the P content of processed cheeses, the Hungarian Dairy Research Institute earlier developed a process [2] not including the traditional peptization, so that cheeses can be heat-processed without the addition of phosphate salts [5].

Materials and methods

Technology

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

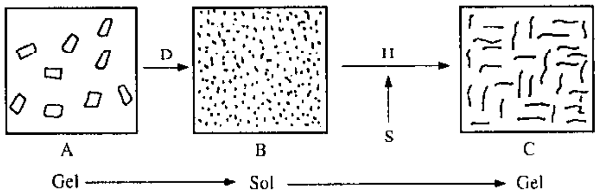

Fig. 1 Heat treatment process without peptization; A: Cheese-liquid mix; B: Cheese dispersion; C: Cheese without peptization; D: Dispersion; H: Heat treatment; S: Structure-forming hydrocolloid

The essence of the new technology is that the melting salt does not break down the Ca from the protein net, so peptization does not take place, which would later form a space-net by means 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 or sliceable), the gel structure is formed with hydrocolloids. This technology also furnishes the opportunity of Ca enrichment, as opposed to traditional melting, where the added quantity of melting salt must be higher in proportion with the Ca content [3].

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

Measuring methods

The heat-induced changes in the samples were measured with a Setaram Micro DSC-II ultrasensitive scanning calorimeter. The mass of cheeses samples was between 700 and 900 mg. For each measurement, the traditional 1 cm^3 batch type pair of measuring cells was used. The measurements were carried out in the temperature range 50–100°C and at a heating rate of 0.3°C min^{-1} after the adjustment of thermal equilibrium when the heat flow fluctuation was below 1 μW. The examinations were carried out both during the technological flow of the process and in the end-products. The melting process and heat treatment took place in the DSC instrument.

The microstructures of the new heat-processed cheeses without peptization after fixing, dehydration, bedding and slicing [1] were examined with a JEM 1200 EX electronmicroscope during transmissional running.

Results

Figure 2 depicts DSC curves of traditional processed cheeses containing only melting salts. In Fig. 2/a, the thermodynamic changes during production/heat processing may be seen, while a DSC curve of a ready processed cheese made by peptization is demonstrated in Fig. 2/b.

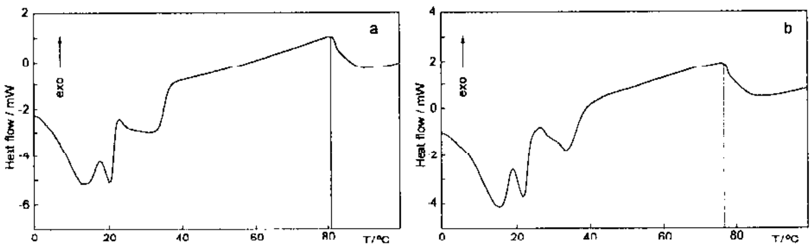

Fig. 2 DSC curves of traditional processed cheeses containing only melting salts during production (a) and in the product (b)

The melting of fats in the interval 0–40°C is followed by the endothermal process of gel–sol transformation. The initial temperatures during the production and for the end-products are 81 and 75°C, respectively.

Figure 3 illustrates DSC curves of the new, processes cheeses containing only hydrocolloids (stabilizer), with the thermodynamic changes during production/heat processing in Fig. 3/a, and the DSC curve of the ready processed cheese made without peptization in Fig. 3/b.

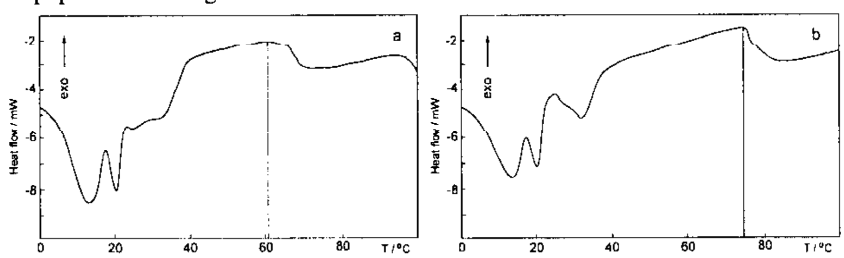

Fig. 3 DSC curves of new processed cheeses containing only hydrocolloids during production (a) and in the product (b)

The initial temperature of the endothermic process of gel–sol transformation is 61°C, and that for the end-product is 68°C, these values being higher than for processed cheese with peptization.

Table 3 lists the measured initial temperature ranges of gel–sol transformation.

The data demonstrate the differences between the heat processes with melting salts or with the addition of hydrocolloids. This difference still exists for the end-products, but is decreased. There are no changes in the differences even if melting

Table 3 Initial temperature ranges of gel–sol transformation of heat-processed cheeses made with melting salts, hydrocolloid and combination of hydrocolloids and melting salts

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

salts are used besides hydrocolloids. In the second heating of the product, the same temperatures were measured, so the process is reversible.

Figure 4 presents electronmicroscopic photographs of processed cheeses without peptization made only with hydrocolloids (a) or containing both melting salts and hydrocolloids (b).

The gel structure is seen to involve a space-net resulting from the protein–hydrocolloid interaction.

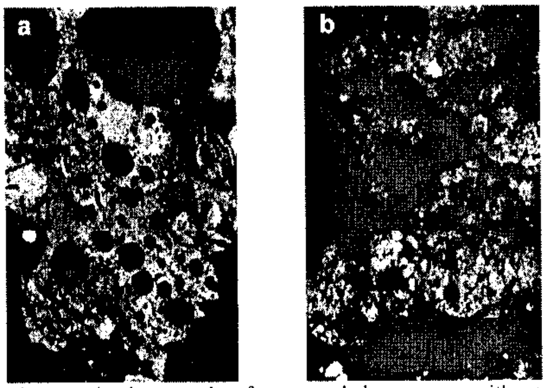

Fig. 4 Electronmicroscopic photographs of processed cheeses; a – without peptization made with hydrocolloids and b – containing both melting salts and hydrocolloids

Discussion

DSC and electronmicroscopic examinations revealed essential differences between the textures of traditionally processed cheese and cheeses processed without peptization, produced with hydrocolloids.

Peptization produces a spongy texture involving shorter or longer protein chains, depending on the technology, and primarily the temperature of melting [1, 8].

Electronmicroscopy indicated that the gel-forming hydrocolloid molecules reacted with the proteins in the processed cheeses produced without peptization with hydrocolloids. The same structure is formed if melting salts are added besides the hydrocolloids.

We have found no literature reports on thermodynamic examinations of the sol–gel transformation by DSC. The structural differences observed submicroscopically were proved by our examinations. The sol–gel transformation caused by peptization occurs at a higher temperature (82 90°C) than the swelling temperature (61–72°C) of hydrocolloids, so the peptization does not take place even following the addition of melting salts besides the hydrocolloids. The melting salts act as buffer salts and emulsifiers.

Though the temperature ranges of the endothermic processes involved in the sol–gel transformation are near each other, the characteristic difference still exists. At the same time, this provides an opportunity to establish whether an end-product was produced by heat processing with or without peptization.

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