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Optimisation of Manufacture and Quality of Cottage Cheese

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Summary

Cottage cheese is a type of fresh soft cheese consisting of individual grains. The manufacture of Cottage cheese from control skim milk with 0.05 % fat (A), skim milk fortified with 1.5 % (w/v) skim milk powder (B), ultrafiltered skim milk with an average of 5.3 % protein (C) and 7.4 % protein (D), as well as from reconstituted skim milk with an average of 11 % total solids (E), were investigated. The fermentation of skim milk was performed at 22 °C with 0.5 % (v/v) mesophilic technical »O« type culture and without rennet addition. The variation of skim milk composition had an important influence on milk fermentation time (16.5–20.5 h), pH value of cheese curd at cutting (pH=4.45–4.82) and yield of cheese (14.6–34.3 %; w/v). Control Cottage cheese (A), made from skim milk (≈8.5 % total solids), had a higher content of water than defined (max. 80 %) by the International Standard. With increased total solids and protein content of cheese milk, the cheeses were higher in protein and ash content and, consequently, lower in water content. Cottage cheese curd made from ultrafiltered skim milk (C and D) were compared to other curds (A, B and E), slightly larger and firmer, more uniform in size and of porcelain shine. The dressing for salted and sweet Creamed Cottage cheese was prepared with commercial sour cream (12 % fat), salt (3 %) or sucrose (25 %) (w/w). All curd samples, mixed with salted dressing (ratio of 1:1) showed softer consistency, but when mixed with sweet dressing (ratio of 3:2) the consistency became firmer during storage at 8 °C. Creamed Cottage cheese (C) prepared from ultrafiltered skim milk had, regardless of the type of dressing, the best sensory characteristics during the entire storage period of 14 days.

Key words: Cottage cheese, skim milk, ultrafiltration, composition, yield, sensory evaluation

Introduction

Cottage cheese is a type of fresh soft cheese, consisting of individual grains (3–12 mm), relatively uniform in size (*1*). Although the specific origin of this cheese is unknown, the name »Cottage« implies that this cheese is originally produced on family farms (*2,3*). Industrial production of Cottage cheeses started approximately in 1915 in USA (*4*) and until today, different ways for production have been developed (*2–18*).

In the literature, variables in curd treatment (*2,5,7, 10*), advantages of ultrafiltration (*3,9,13–18*), methods for extending shelf-life (*3,19,20*) and other possibilities for manufacture of Cottage cheese have been suggested. The impact of skim milk composition was investigated (*21–23*) most often, the type or quantity of added starter culture (*17,24,25*) followed, as well as temperature of

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fermentation applied in long, medium or short set manufacturing procedure (*3,4,11*).

Cottage cheese is a low calorie cheese with minimal fraction of fat. In case of Creamed Cottage cheese, the curd is mixed with »dressing«, a low-fat cream containing different ingredients for specific flavour or nutritive value (*3,4,18,26,27*). Cottage cheese may also be supplemented with probiotic bacteria (*6,11,28,29*).

Cottage cheese has not yet been produced in Croatia and, the purpose of this work was to investigate the influence of milk composition on sensory characteristics and nutritive value, as well as to optimise the manufacturing process of Cottage cheese.

Materials and Methods

Milk samples

Cottage cheese trials were made using different skim milk composition:

- A – skim milk with 0.05 % fat, control, n=10
- B – skim milk fortified with 1.5 % (w/v) skim milk powder, n=5
- C – ultrafiltered skim milk, with ≈ 5 % protein, n=5
- D – ultrafiltered skim milk, with ≈ 7 % protein, n=5
- E – reconstituted skim milk, obtained by dissolving 260 g of low heat skim milk powder in 2000 mL water at 40 °C, n=5.

Skim milk was ultrafiltered with a pilot module DDS-20-1.8 Lab, Denmark, membrane type GR6OPP, to about 3:1 volume concentration at ambient temperature and under inlet and outlet pressures of approximately 3 and 1.5 bar, respectively. The concentrate (9.63 % protein) was diluted with permeate (0.25 % proteins) to approximately 5 % (C) and 7 % protein (D), respectively. The protein was determined by formol titration.

Manufacture of Cottage cheese

The parameters for the manufacturing of cheese by the long-set method (*4*) are presented in Fig. 1. Fermentation of 2 L skim milk was performed at 22 °C with 0.5 % (v/v) mesophilic starter culture, »O« type (production culture obtained from Dukat Dairy Company, Zagreb) and without rennet addition.

Cooking of curd (in water bath) to 55–60 °C was carried out slowly to reach the end point in 120–180 min.

The dressing for salted and sweet Creamed Cottage cheese was prepared with commercial sour cream (12 % fat) with salt (3 %) or sucrose (25 %) addition (w/w). In case of sweet Creamed Cottage cheese, strawberry aroma has been added. The mixture ratio of cheese curd and cream dressing was determined in preliminary trials and selected according to stability and sensory properties of Creamed Cottage cheese during storage at 8 °C.

Analytical and sensory methods

The chemical composition of milk and cheese was determined with the following methods: total solids by drying at 105 °C; total proteins by the Kjeldahl method (factor = 6.38); fat by the Gerber method; ash by incineration at 550 °C; lactose by the Schoorl-Luff method; pH-value (digital pH-meter Knick, type 646) of cheese in 3:10 mixture ratio of curd and distilled water. The calcium fraction of the curd was determined by atomic absorption spectroscopy (*30*). All samples were frozen until analyses. Results of chemical analysis are presented as average value (x) and standard deviation (s.d.).

The »yield of cheese« is expressed as kg cheese obtained from 100 L of skim milk (%) and »cheese yield efficiency« as kg cheese per kg of total solids, or total protein in cheese milk, respectivelly. The yield and yield efficiency are also calculated for cheese with 80 % water (*15–17*).

The apparent viscosity (μ/Pa s) of cheese curd has been determined by using a rotating viscosimeter (Rheotest-3). After homogenisation of curd in the vessel of the instrument, the measurement was performed at the rotation rate of 80.99 s^{-1} for 90 seconds. The samples were held at 20 °C for 20 min and the measurement of the apparent viscosity performed with the shear rate range of 1.799–145.76 s^{-1}.

A panel group of 5 persons evaluated the sensory characteristic of Cottage cheese curd, the day after manufacture, by scoring system according to Tratnik *et al.* (*18*) and Creamed Cottage cheese by using the hedonic scale according to Mistry (*17*). The results of sensory evaluation are presented as average value.

Results and Discussion

The chemical composition of skim milk used for Cottage cheese manufacture is presented in Table 1. The variation of skim milk composition had significant influence not only on the duration of milk fermentation and pH value of cheese curd at cutting (Fig. 1), but also on composition of cheese (Table 2), cheese yield (Fig. 2) and cheese yield efficiency (Table 3). The higher the protein content of cheese milk, the longer the fermentation time until formation of coagulum (Fig. 1) due to increased

Table 1. Chemical composition of skim milk for Cottage cheese manufacture

Ingredient		Fraction in skim milk – w/%				
		A	B	C	D	E
Total solids	x	8.51	9.93	10.73	13.05	11.07
	s.d.	0.06	0.09	0.07	0.04	0.11
Proteins	x	3.24	3.74	5.29	7.36	4.51
	s.d.	0.12	0.02	0.02	0.06	0.15
Lactose	x	4.49	5.29	4.44	4.61	5.56
	s.d.	0.04	0.06	0.09	0.03	0.20
Fat	x	0.05	0.05	0.10	0.10	n.d.
	s.d.	–	–	–	–	–
Ash	x	0.71	0.83	0.89	1.04	0.92
	s.d.	0.04	0.06	0.07	0.01	0.05

x = average value; s.d. = standard deviation; n.d. = not detectable

A = skim milk (control)

B = skim milk fortified with 1.5 % (w/v) skim milk powder

C = ultrafiltered skim milk with ≈ 5 % protein

D = ultrafiltered skim milk with ≈ 7 % protein

E = reconstituted milk from skim milk powder

SKIM MILK
pH=6.55–6.85
A (pH=6.62) C (pH=6.74)
B (pH=6.63) D (pH=6.72)
E (pH=6.83)

↓

PASTEURIZATION
65 °C/30 min
cooling to 23 °C

↓

INOCULATION
mesophilic »O« type culture
0.5 % (v/v)/23 °C

↓

FERMENTATION
at 22 °C until pH=4.45–4.82
A (17.5 h) C (19.5 h)
B (17.2 h) D (20.0 h)
E (17.5 h)

↓

CUTTING
curd size = 8–10 mm
A (pH=4.49) C (pH=4.69)
B (pH=4.60) D (pH=4.78)
E (pH=4.63)

↓

COOKING
30 min after cutting
55–60 °C/120–180 min

↓

WASHING
1. water ≈40 °C/20 min
2. water ≈15–18 °C/20 min
3. water ≈1 °C/20 min

↓

DRAINING
at ambient temperature, 1.5–3 h

↓

COTTAGE CHEESE CURD
pH=4.82–5.29
A (pH=4.93) C (pH=4.91)
B (pH=4.98) D (pH=4.96)
E (pH=5.27)

Fig. 1. Processing parameters for manufacture of Cottage cheese curd
A = skim milk (control)
B = skim milk fortified with 1.5 % (w/v) skim milk powder
C = ultrafiltered skim milk with ≈5 % protein
D = ultrafiltered skim milk with ≈7 % protein
E = reconstituted milk from skim milk powder

buffering capacity of the milk (*17*). The higher protein content in ultrafiltered skim milk (C and D) increased considerably the strength of coagulum and cutting became more difficult. This required modifications in the Cottage cheese manufacture, *e.g.* omission of rennet addition, cutting at a higher pH, lower cooking temperature and/or shorter cooking time (Fig. 1). After cutting the coagulum obtained with ultrafiltered skim milk with ≈5 % (C) and ≈7 % (D) protein, the quantity of nascent whey was not sufficient for proper cooking. Therefore, a

Table 2. Chemical composition of Cottage cheese curd

Ingredient		Fraction in curd – w/%				
		A	B	C	D	E
Total solids	x	18.24	20.34	20.08	21.84	20.97
	s.d.	1.31	0.58	0.03	0.74	1.44
Proteins	x	15.39	16.87	16.77	18.64	17.45
	s.d.	1.83	0.90	0.35	0.45	0.90
Lactose	x	2.00	2.68	2.24	1.95	2.78
	s.d.	0.46	0.35	0.35	0.41	0.55
Fat	x	0.38	0.35	0.22	0.43	n.d.
	s.d.	0.14	0.04	0.02	0.01	–
Ash	x	0.55	0.63	0.72	0.82	0.75
	s.d.	0.11	0.12	0.04	0.07	0.04

x= average value; s.d. = standard deviation; n.d. = not detectable
Lactose = calculated on the basis of total solids

Table 3. Yield efficiency of Cottage cheese curd/(kg/kg)

Cheese	m(Cheese curd)/m(milk soids)		m(Cheese curd)/m(milk protein)	
	a	b	a	b
A	1.72	1.68	4.51	4.41
B	1.63	1.64	4.33	4.36
C	2.43	2.43	4.92	4.93
D	2.63	2.69	4.66	4.77
E	1.97	1.99	4.95	5.00

a – Yield efficiency = on weight basis of cheese
b – Yield efficiency = based on 80 % water content in curd

Table 4. Sensory evaluation of Cottage cheese curd (1 day after manufacture)

Sensory characteristics	Points (0-max.)	Cheese curd – score				
		A	B	C	D	E
External appearance	0–3	2.30	2.47	3.00	3.00	1.50
Internal appearance	0–4	3.14	3.40	3.80	4.00	2.10
Body's consistency	0–2	1.52	1.85	2.00	2.00	1.50
Colour	0–1	1.00	1.00	1.00	1.00	1.00
Odour	0–2	2.00	2.00	2.00	2.00	2.00
Flavour	0–8	7.28	7.20	7.50	7.50	7.00
Total	0–20	17.24	17.92	19.30	19.50	15.10

small amount of warm water had to be added (about 0.5 or 1 L) to this curd. In spite of predictable problems, the firming of curd from ultrafiltered skim milk (C and D) was faster and the cooking time consequently shorter. On the contrary, the firming of control curd (A), as well as of the other types of curd (B and E), was slower because of initially softer coagulum. Lower pH values at cutting and higher cooking temperatures and/or longer cooking time applied on these curds (A, B, E) led to improved quality of curd. In spite of carefulness, the curd from milk A, B, E was unequal in size, especially the curd obtained from reconstituted skim milk (E), which was more crumbly, already at cutting. However, the whey removed after cooking of this curd (E) was still

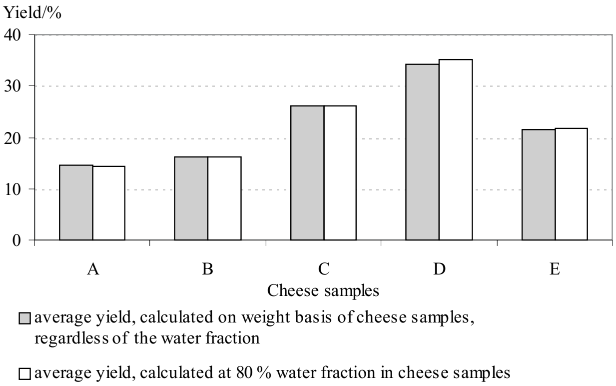

Fig. 2. Yield of Cottage cheese curd

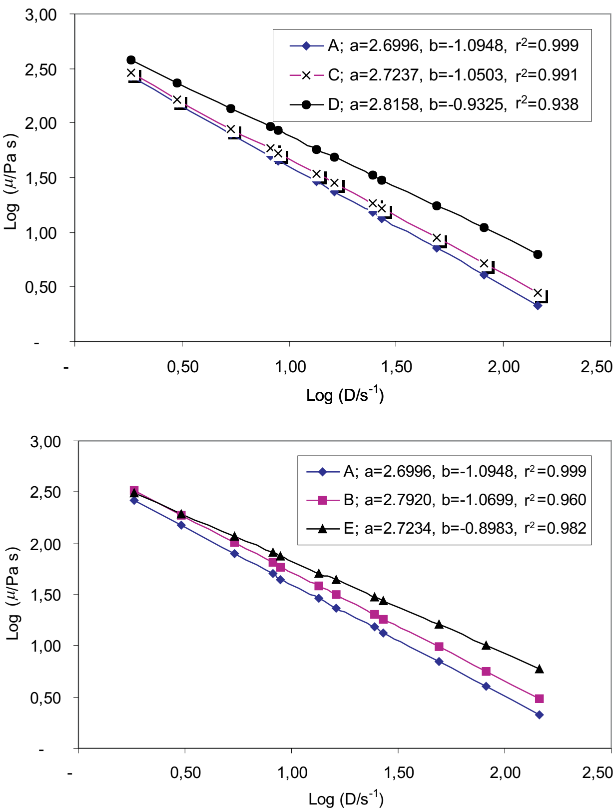

Fig. 3. Logarithmic dependence of apparent viscosity (μ=Pa s) of homogenised Cottage cheese curd on shear rate (D=s^{-1}) applied at 20 °C;
A = 19.7 % total solids (TS); 83.6 % protein; 0.38 % calcium in TS;
B = 20.5 % total solids (TS); 83.9 % protein; 0.52 % calcium in TS;
C = 20.2 % total solids (TS); 83.5 % protein; 0.59 % calcium in TS;
D = 22.7 % total solids (TS); 85.3 % protein; 0.61 % calcium in TS;
E = 20.9 % total solids (TS); 84.3 % protein; 0.60 % calcium in TS

more clear than the whey from the other types of curd, indicating that the loss with fines was not significant.

The firmness of all curd types during cooking has been checked by performing a »free fall test« by dropping few of the cooled curd to the ground. If the curd broke, the cooking time has been prolonged, either at the same or at higher temperature. Although the washing for all types of curd was performed in the same way, the draining characteristics were significantly different. The most easily formed and drained curd was that made from ultrafiltered skim milk (C and D), especially the curd obtained from ultrafiltered milk with the higher protein content (D). The longest time, for both firming and draining was observed for curd obtained from reconstituted skim milk (E). Although this curd had more shattered grains, but smooth texture, it was generally much more alike to control curd (A). Curd obtained from skim milk fortified with skim milk powder (B) had a slightly firmer consistency and generally better appearance than control curd (A).

The best sensory characteristics (Table 4) had curd obtained from ultrafiltered skim milk (C and D), possessing the most uniform size, porcelain shine and firm consistency. Furthermore, the curd was slightly larger and retained its form better, compared to the other samples (A, B, E), in spite of the fact that the coagulum from all milks obtained an equal treatment. Similar observations were also noticed by other authors (*13,16*). Generally, the best scores obtained Cottage cheese curd from milk D, while the worst scores were given for curd from reconstituted skim milk (E). For curd B and E, a slightly chalky taste has been noticed.

Surprisingly, the apparent viscosity values (Fig. 3), determined at lower shear rates, did not differ significantly among the curds, showing only slight differences at higher shear rates. Nevertheless, the highest apparent viscosity showed curd D, and lowest the control curd (A).

For the Creamed Cottage cheese, a dressing made with commercial sour cream has been added. After addition of salted cream dressing all curd samples became softer at the very beginning of storage at refrigeration (8 °C), probably due to replacement of calcium in the curd with sodium from dressing. On the opposite, after addition of sweet cream dressing, the curd became firmer and remained so during the entire storage. In case of Cottage cheese with salted dressing the curd also showed higher absorption properties compared to sweet dressing. As a consequence of this observations, the ratio of curd to salted cream dressing was 1:1, and for the sweet cream dressing of 3:2. Of salted Creamed Cottage cheeses, sample D proved to be the best one during the entire storage period, and sample E had the worst texture (Table 5). Of all curd types, curd D showed the lowest absorption toward sweet cream dressing, resulting in a slightly rubbery texture, dressing separation, unequal colour and less pronounced flavour. During longer storage time curd D become even firmer.

The best total sensory score, during entire storage time had Creamed Cottage cheeses made from ultrafiltered skim milk with protein content slightly above 5 % (C), regardless of dressing type (sweet or salted) added (Table 5). However, the sensory quality either of Cottage cheese curd or Creamed Cottage cheese depended (probably) very much on chemical composition of milk.

With increased total solids and total protein content of skim milk (Table 1), the resulting cheeses were also higher in protein and low in water (Table 2) content. Curd with higher protein content had also higher min-

Table 5. Sensory evaluation of Creamed Cottage cheese during storage at 8 °C

Creamed Cottage cheese		Flavour score (1–10)			Body texture score (1–5)			Appearance score (1–5)			Total score (1–20)		
		1st	7th	14th	1st	7th	14th	1st	7th	14th	1st	7th	14th
Salted (n=3)	A	7.55	8.52	8.02	3.00	2.80	2.50	3.22	3.00	2.75	13.77	14.22	13.27
	B	7.65	8.54	8.05	3.50	3.20	2.80	3.50	3.20	3.00	14.65	14.94	13.85
	C	8.50	9.00	8.80	4.50	4.00	3.80	4.80	4.52	4.52	17.80	17.52	17.12
	D	7.20	8.00	7.80	4.80	4.50	4.45	5.00	4.80	4.80	17.00	17.30	17.05
	E	7.55	8.00	7.80	3.00	2.50	2.35	3.00	3.00	2.70	13.55	13.20	12.85
Sweet (n=3)	A	7.00	7.50	7.50	3.00	3.50	3.50	3.35	3.35	3.22	13.35	14.35	14.22
	B	7.00	7.70	7.70	3.50	4.00	4.00	3.55	3.25	3.00	14.50	14.95	14.70
	C	8.00	8.50	8.50	3.50	4.50	4.60	4.80	4.45	4.45	16.30	17.45	17.55
	D	7.50	7.80	7.50	4.00	4.75	5.00	4.80	4.00	4.00	16.30	16.55	16.50
	E	6.50	7.40	7.00	3.00	3.22	3.22	3.22	3.00	3.00	12.72	13.62	13.22

Flavour = 1 (dislike extremely) to 10 (like extremely); Appearance = 1 (poor) to 5 (excellent)
Body texture = 1 (poor) to 5 (excellent)

eral content (ash), thus influencing the nutritive value positively. According to chemical composition (Table 2), the highest nutritive quality had Cottage cheese made from ultrafiltered skim milk with the highest protein content (D), and the lowest the cheese made from control skim milk (A). Control cheese (A) had a higher water content than defined by International Standard for Cottage cheese (max. 80 %). However, the required amount of min. 20 % total solids can be adjusted by addition of appropriate cream dressing (*11*). On the other side, all cheese curds had a very low fat content (Table 2) and this can be favourable from dietetic point of view. In one trial the final washing of curd was performed with salted water (5 % NaCl). Such a »dry Cottage cheese« without cream dressing could be designated as light functional food.

Cottage cheese D possessed the highest nutritive value (Table 2) and the best sensory properties (Table 4). Generally, Cottage cheese curd, submerged in a salt solution, had shorter storage life compared with unsalted curd. In this study, the shelf life of all cheese samples, regardless whether with or without cream dressing, was up to 15 days. After this period, the first signs of spoilage usually became evident, but always earlier for salted cheese samples.

Differences in milk composition (Table 1), variability of processing parameters (Fig. 1) and ultrafiltration can cause deviations, either in nutritive quality (Table 2) or sensory characteristics of Cottage cheese curd (Table 4), as well as Creamed Cottage cheese (Table 5). The curd yield (Fig. 2) and curd yield efficiency in kg based on total solids or protein (Table 3) are significantly different, as observed in earlier reports on Cottage cheese (*14,15,17*). However, the results of cheese yield efficiencies, defined on total protein basis, were for cheese E unexpectedly high (Table 3). In this case, the most clear whey has also been obtained which might be an explanation. It seems likely that the protein content of milk (Table 1) and cheese curd (Table 2) play the main role for the quality of the products obtained.

Conclusions

The composition of skim milk had a significant influence on the duration of fermentation, pH-value of coagulum at cutting and yield of curd. The cheese curd obtained from control skim milk had higher water content than defined by International Standard for this type of cheese. As the total solids and protein content of the cheese milk increased, the resulting cheese curd had also higher protein and mineral but lower water content. Cheese curd made from ultrafiltered skim milk was slightly larger and firmer, having the most uniform size and porcelain shine. The cheese curd became softer in salted cream dressing, while in sweet cream dressing remained firm during the entire storage. Creamed Cottage cheese made with ultrafiltered skim milk with 5.3 % protein, had the best sensory characteristics regardless of the type of dressing or during 14 days of storage at 8 °C.

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Optimiranje proizvodnje i kakvoće zrnatog svježeg mekog sira

Sažetak

»Cottage cheese« je izvorni naziv za tip svježeg mekog sira zrnate konzistencije. Istražena je proizvodnja sira od: (A) kontrolnog obranog mlijeka s 0,05 % masti; (B) obranog mlijeka obogaćenog s 1,5 % (m/v) obranog mlijeka u prahu; (C) ultrafiltriranog obranog mlijeka s prosječno 5,3 % proteina; (D) ultrafiltriranog obranog mlijeka s prosječno 7,4 % proteina te (E) rekonstituiranog obranog mlijeka s otprilike 11 % suhe tvari. Fermentacija 2 L upotrijebljenih uzoraka mlijeka provedena je pri 22 °C s 0,5 % (v/v) mezofilne tehničke kulture tipa »O«, bez dodatka sirila. Promjena sastava obranog mlijeka bitno je utjecala na trajanje fermentacije (16,5–20,5 h), na pH-vrijednost sirnoga gruša u trenutku rezanja (pH=4,45–4,82) te na veliku promjenjivost prinosa sira (14,6–34,3 %; w/v). Kontrolni zrnati svježi sir (A) dobiven od kontrolnog obranog mlijeka (oko 8,5 % suhe tvari), sadržavao je veći udjel vode od predviđene (maks. 80 %) međunarodnim standardom za taj tip sira. Zbog povećanog udjela suhe tvari i proteina u ostalim uzorcima mlijeka, povećao se i udjel proteina i pepela u uzorcima sira, pa je stoga manji i udjel vode. Sirni gruš, dobiven od ultrafiltriranog obranog mlijeka (C i D), bio je u usporedbi s gruševima A, B i E nešto veći i čvršći, ujednačenije veličine, te porculanskog sjaja. Umak za pripravu slatkih ili slanih uzoraka kremastog zrnatog sira (creamed cottage cheese) načinjen je od komercijalnog kiselog vrhnja (12 % masti) uz dodatak soli (3 %) ili šećera (25 %). Sirni gruš pomiješan u slanom umaku (omjer 1:1) ubrzo je postao mekši, a pomiješan u slatkom umaku (omjer 3:2) sve čvršći tijekom čuvanja pri temperaturi hladnjaka od 8 °C. Najbolje senzorske osobine, tijekom ukupnog vremena čuvanja (14 dana), imao je kremasti zrnati sir (C) pripravljen od ultrafiltriranog obranog mlijeka.