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Effect of Freezing Conditions on the Ripening Process and the Quality of Cheese

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Abstract: Kortowski cheese (Münster type) was salted for 100, 75, 50 and 25% of their standard salting time, which is 48 hours. Cheese after 3 weeks of ripening and cheese immediately after salting were stored for 6 and 12 months at -27°C. Cheese of lower salting level ripened faster, both after salting and after frozen storage. The process of protein degradation occurred during frozen storage of ripe cheeses. The content of N-amino acid in ripe cheese after frozen storage and in cheese ripening after storage was almost twice as high as in the cheese that ripened after salting. Separations on Sephadex gel confirm the process of protein degradation during frozen storage of cheese. The conducted research indicated that frozen storage is recommended for Kortowski cheese of reduced salt content and the most favourable solution is to conduct the process of cheese ripening after thawing.

Key words: Cheese, frozen storage, ripening, proteolysis

Introduction

Dietary concerns and the high nutritional value of cheese have contributed to a significant increase in cheese production worldwide. In many countries, because of a seasonal character of milk production in the summer and autumn period when the supply of milk is the most abundant, dairy plants cannot increase cheese production due to limited space in cheese ripening rooms. Although cheese can be stored under chilled conditions, this does not solve the problem, since the use-by term for cheese is limited. To date, it has not been recommended to store hard ripened cheeses below their freezing temperature, which depends on the type of cheese and level of its ripeness. Many researchers have confirmed the feasibility of frozen storage of Mozzarella cheese (Berg *et al*., 1992; Bertola *et al*., 1996; Cervantes *et al*., 1983; Lück, 1977). It was observed that hard cheese loses its quality after frozen storage (McDowall, 1938; Lück, 1977). However, Morris and Combs (1955) and Kasprzyk *et al*. (1994) indicate the feasibility of frozen storage of cheddar cheese, with the quality of cheese after thawing being influenced by its chemical constitution. Our previous research Jarmul *et al*. (1985) confirmed the results reported by Lück (1977) concerning the feasibility of frozen storage of camembert cheese. The role of salt in frozen storage of cheese was noted by Cervantes *et al*. (1983), conducting research on Mozzarella cheese, and Kasprzyk *et al*. (1994) who examined cheddar cheese. Therefore, we undertook research concerning the feasibility of frozen storage of semi-hard Kortowski cheese (Münster type) of various levels of salting and ripeness.

Materials and Methods

Münster type cheeses were salted for 100, 75, 50 and 25% of their standard salting time, which is 48 hours. Münster type cheeses after salting were ripened in cryovac bags for 3 weeks and then stored at -27°C for 6 and 12 months. Some cheeses were frozen immediately after salting and stored at -27°C for 6 and 12 months. After thawing, the cheeses ripened for 3 weeks. The effects of salt and freezing on cheeses were evaluated on the basis of:

- changes in water content (FIL method), pH, NaCl (FIL method) in three layers of cheese (of the same thickness) – inner, outer and middle;
- hardness in three layers of cheese (with a penetrometer AP 4/2);
- changes in N - soluble content at pH 4.6 (11), N - NPN (Schober *et al*., 1961), N - amino acid (Stadhouders, 1960)
- chromatographic separation of cheese proteins on Sephadex gel G-l00 (Schober *et al*., 1961);

Organoleptic assessment of cheeses was conducted collectively, according to quality standards for Münster type cheese.

Results and Discussion

Time of salting influenced water content in cheese. The water content in cheese decreased and its salt content increased along the time of salting (Table 1). During the process of ripening, the process of equalizing of salt content in cheese occurs. Normal diffusion of salt from the surface layer into the middle part of cheese provides information concerning cheese structure. After three weeks of cheese ripening immediately after salting, it was observed that salt content in the analyzed layers of cheese had been equalized. Analogically, during the ripening process of cheeses frozen immediately after

Table 1: Changes in salt content in Kortowski cheese

Level of cheese ripeness	Frozen storage (months)	Standard salting time for cheese /%/	Layers of cheese		
			Outer	Inner	Middle
			NaCl /%/		
Cheese after salting	-	100	2.64	2.15	0.99
		75	2.36	1.42	0.84
		50	2.09	1.27	0.73
		25	1.96	1.34	0.49
Cheese after 3 weeks of ripening	-	100	2.19	2.17	1.92
		75	1.94	1.89	1.88
		50	1.58	1.81	1.74
		25	1.39	1.28	1.28
Cheese after salting and thawing ripened for 3 weeks	6	100	2.21	2.07	2.19
		75	1.67	1.67	1.71
		50	1.55	1.33	1.38
		25	1.35	1.51	1.36
	12	100	2.26	2.21	2.16
		75	1.82	1.82	1.83
		50	1.59	1.44	1.66
		25	1.51	1.46	1.32

Table 2: Level of degradation of proteins in Kortowski cheese

Level of cheese ripeness	Frozen storage (months)	Standard salting time for cheese /%/	Nitrogen forms		
			N-soluble at pH 4.6	N-NPN	N- amino acid
			In % of total N		
Cheese after 3 weeks of ripening	-	100	11.69	8.20	5.01
		75	13.72	9.08	5.64
		50	15.80	9.78	6.02
		25	16.02	10.78	7.28
3-week cheese after thawing	6	100	10.06	8.16	8.81
		75	13.92	8.85	10.96
		50	14.74	9.58	11.34
		25	16.12	9.69	12.01
	12	100	10.92	8.49	10.63
		75	14.06	9.75	11.81
		50	16.28	10.14	14.56
		25	17.18	10.92	17.02
Cheese after salting and thawing ripened for 3 weeks	6	100	10.99	8.95	12.32
		75	12.04	8.99	14.26
		50	16.15	9.03	15.99
		25	16.23	10.42	17.31
	12	100	15.12	9.23	12.36
		75	16.49	10.13	14.56
		50	17.21	10.02	16.45
		25	18.11	11.15	17.97

salting, it was observed that salt content became equalized in the whole body of cheese, which indicated that frozen storage of cheese did not affect the process of diffusion of salt nor the structure of cheese. The process of cheese ripening, immediately after salting, was more intense for cheeses of lower level of salting, which is proven by their having the highest content of analyzed nitrogen compounds (Table 2). During frozen storage of ripened cheese, there was a slight increase in the content of N-soluble at pH 4.6 and N-NPN.

Table 3: Chromatographic separation of Kortowski cheese proteins on Sephadex gel G-100

Level of cheese ripeness	Frozen storage (months)	Standard salting time for cheese /%/							
		100		75		50		25	
		Molecular weight of proteins (Da x 10^{-3})							
		100-110	15-19	100-110	15-19	100-110	15-19	100-110	15-19
		N of peak / N eluated (%)							
Cheese after 3 weeks of ripening	-	81.82	18.18	77.59	22.41	70.00	30.00	66.83	33.17
3-week cheese after thawing	12	79.06	20.94	75.61	24.39	65.90	34.10	64.74	35.26
Cheese after salting and thawing ripened for 3 weeks	12	81.03	18.97	78.18	21.81	68.18	31.82	66.67	33.33

Table 4: Changes in hardness of Kortowski cheese

Level of cheese ripeness	Frozen storage (months)	Standard salting time for cheese /%/	Layers of cheese		
			Outer	Inner	Middle
			Penetrometer degrees		
cheese after 3 weeks of ripening	-	100	163	170	176
		75	174	175	181
		50	179	184	190
		25	182	186	195
3-week cheese after thawing	12	100	192	195	197
		75	196	200	201
		50	202	200	204
		25	208	205	214
Cheese after salting and thawing ripened for 3 weeks	12	100	188	185	189
		75	189	185	189
		50	191	189	197
		25	194	202	202

However, the amount of N-amino acid increased by almost 50%. After 6-months of frozen storage, the changes in the content of soluble and non-protein nitrogen in cheese with standard salting time was similar to those of the cheese ripening immediately after salting. However, the content of N amino-acid increased over twice. In cheeses for which the time of salting was reduced to 50 and 25%, a higher content of N-soluble and N-amino acid was observed. Similarly, a higher content of analyzed nitrogen compounds was observed in cheese ripening after 12-months of frozen storage. This indicates that processes which occur during frozen storage result in the acceleration of the cheese ripening process, which can be observed after thawing. A similar phenomenon was noted by other authors, who found that the process of protein degradation occurred during frozen storage (Sode-Mogensen, 1948; Stadhouders, 1960; Tokita and Hosano, 1968). The above observations are proven by the chromatographic separation of proteins, which indicated that in ripe cheese the amount of protein of the largest molecular weight fell during 12-month frozen storage. In cheese ripening after frozen storage, the amount of proteins in individual peaks was similar to those of cheese ripening immediately after salting (Table 3). Separations of proteins indicate that the process of protein degradation is faster in cheeses with lower levels of salting. The measurements of cheese hardness also indicate that after frozen storage of ripened cheese, its hardness is lower than that of cheeses ripening immediately after salting and after their frozen storage (Table 4). Cheeses with reduced salting time, both after storage at -27°C and ripening after thawing, were characterized by fuller flavour and smell bouquet. Only cheese with a 25% level of salting after 6 months of storage had a slightly spicy taste (Table 5). However, cheese of standard time of salting was not very aromatic and after 12 months of frozen storage it was spicy and slightly impure. The obtained results prove the feasibility of frozen storage of ripening cheeses at -27°C. The most favourable solution is to store cheese frozen immediately after salting and to conduct the process of ripening after frozen storage.

Table 5: Organoleptic assessment of Kortowski cheese after storage at -27°C for 6 and 12 months

Level of cheese ripeness	Frozen storage (months)	Standard salting time for cheese /%/	Flavour and smell	Consistency	Holes
Cheese after salting	-	100	normal for cheese immediately after	normal	none
		75	production, after salting		
		50			
		25			
Cheese after 3	-	100	pleasant, pure, perceptible salt	normal	normal
weeks of ripening		75	typical, slightly perceptible salt	cheese hardness	normal
		50	mild, delicate, pure	increases with	normal
		25	milky, mild, pure	salting level	normal
3-week cheese after thawing	6	100	salty, not much aromatic, no defects	normal,	normal
		75	slightly sour, cheese-like, pure	hardness	normal
		50	mild, pure	increases with	normal
		25	slightly spicy, pure	cheese salting level	normal
	12	100	slightly pungent, slightly impure, salty	brittle	visible cracks
		75	slightly sour, pleasant, slightly salty	brittle	normal
		50	typical, mild, pleasant, pure	elastic, soft	normal
		25	mild, pleasant, milky, pure	elastic, too soft	normal
Cheese after salting	6	100	slightly sour, salty, pure, not much	normal	normal
and thawing ripened for		75	aroma	hardness	normal
3 weeks		50	slightly sour, pure	Increases with	normal
		25	mild, pure, pleasant, cheesy	cheese salting	normal
			Slightly spicy, pure, typical	level	
	12	100	milky, pleasant, pure	soft, buttery	normal
		75	pleasant, typical, pure	soft, normal	normal
		50	pleasant, typical, pure	soft, normal	normal
		25	mild, pleasant, pure	soft, normal	normal

Cheeses with lower salting levels ripened faster and had better organoleptic characteristics. The process of protein degradation occurred during the frozen storage of cheese.

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