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Influence of the maturation process on the sheep's milk of Camembert cheese fatty acid profile change

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Abstract

The aim of this research was to study the fatty acid composition of Camembert cheese fat phase. The object of the research was the sheep's milk Camembert soft cheese. The Camembert soft cheese was made from sheep's milk pasteurized at 63°C for 30 minutes before production, using cultures Penicillium camemberti, Geotrichum candidum, as well as Lactococcus lactis, Lactococcus cremoris, Lactococcus diacetylactis, Leuconostoc mesenteroides ssp. cremoris. The study of the cheese fatty acid composition during maturation was carried out using the gas chromatography method in accordance with the state industry standard of the Russian Federation 32915-2014 "Milk and dairy products. The determination of fatty acid composition of the fat phase by gas chromatography". The fatty acids profile in the process of cheese maturation changed significantly. There was an increase in the short chain fatty acids concentration: oil (C4:0) kapron (C6:0), capryl (C8:0). A change in the lauric acid content (C12: 0) and myristic acid (C14: 0) showed a similar trend but with less dynamics. On the 14th day of maturation, the concentration of lauric acid (C12:0) increased by 30%, myristic acid (C14:0) -- by 13%. At the beginning of the maturation period, the C18:1n9t isomer consisted about 70% of the total fatty acid trans-isomers. During maturation, the concentration of C18:1n9t decreased by 98%. It was found that, regardless of the maturation period, fatty acids C10: 0, C14: 0, C16: 0, C18: 0, C18: 1 t11 and C18: 1c9 consisted about 73% of the total fatty acids. There was a decrease in the concentration of w-6-polyunsaturated fatty acids with a simultaneous increase in the concentration of w-3 polyunsaturated fatty acids. The results can serve as a basis for comparative analysis development tools and strategies aimed at improving the nutritional characteristics of sheep's milk cheese.

Keywords: cheese, technology, lipids, fatty acids, maturation

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1. Introduction

Milk fat is a major component of most varieties of cheese, and many consumers limit their consumption of cheese, as more than 60% of the total fatty acids in milk fat are saturated fatty acids. In recent years, consumption of low-fat dairy products has become

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increasingly popular among consumers who care about their health, which has led to the development of new dairy products with improved fatty acid composition and increased biological value [1-10]. However, fat reduction has been proved to be a challenge, as fat is important for the dairy products texture and taste, especially for cheese. Fat reduction in cheeses leads to undesirable texture, lack of characteristic taste or the presence of foreign flavors. Therefore, it is important to study the technological processes that form the sensory qualities of cheeses. The white thin crust with surface mold of Penicillium camemberti, in cheeses such as Camembert, forms a complex ecosystem. Penicillium camemberti, Geotrichum candidum are used for the production of Camembert cheese from pasteurized milk. Soft cheeses maturing with the participation of surface microflora form a complex ecosystem that is not studied well. Furthermore, the lipolytic activity of the surface microflora leads to typical cheese sensory properties. Short-chain fatty acids contribute directly to the organoleptic characteristics of cheeses [11--13]. In the scientific literature there are results of researches devoted to the study of fatty acids concentration in cow's milk cheeses. However there is practically no information about the fatty acid profile change in sheep's milk cheeses during maturation [13--15]. Thus, the purpose of this research was to study the fatty acid composition of the fat phase of cheeses such as sheep's milk Camembert during maturation. The results can serve as a basis for the development of comparative analysis tools and strategies aimed at improving the nutritional characteristics of sheep's milk cheese.

2. Methods and Equipment

2.1. Methods

2.1.1. Diagrammatic representation

The object of the research was the sheep's milk Camembert soft cheese. The Camembert soft cheese was made from sheep's milk pasteurized at 63°C for 30 minutes before production, using cultures Penicillium camemberti, Geotrichum candidum, as well as Lactococcus lactis, Lactococcus cremoris, Lactococcus diacetylactis, Leuconostoc mesenteroides ssp. cremoris. After the application of calcium chloride and rennet, in a dose providing the total duration of coagulation lasted for 30-45 minutes. Before molding, the clot was cut into 1-1.5cm cubes. Then the cheese grain was dewatered and stirred. Then the molding, self-pressing and were carried out. After that maturation was performed at a temperature of 8±2 °C for 14 days.

The study of the cheese fatty acid composition during maturation was carried out using the gas chromatography method in accordance with the state industry standard of the Russian Federation 32915-2014 "Milk and dairy products". Determination of fatty acid composition of the fat phase by gas chromatography".

To assess the quality of lipids in the fat phase of Camembert cheese, the atherogenicity index (AI) and thrombogenic index (TI) were calculated according to the formulas [17]:

$$AI = \frac{[12:0(4\cdot 14:0)+16:0]}{\omega-3\ PUFA\ +\omega-6\ PUFA\ +MUFA} \quad (1)$$

$$TI = \frac{(14:0+16:0+18:0)}{0,5\cdot MUFA\ +0,5\cdot\omega-6\ PUFA\ +3\cdot\omega-3\ PUFA} + \frac{\omega-3\ PUFA}{\omega-6\ PUFA} \quad (2)$$

where PUFA stands for polyunsaturated fatty acids, MUFA stands for monounsaturated fatty acids

3. Results

Lipids in foodstuff can undergo hydrolytic or oxidative degradation. However, in cheese, oxidative changes are very limited due to the low redox potential. However, triglycerides in all varieties of cheese undergo hydrolysis under the action of endogenous or exogenous lipases, which leads to the release of fatty acids in the cheese during maturation. Ruminant animals' milk fat triglycerides are rich in short-chain fatty acids, which when released have low taste thresholds that contribute significantly to the flavor of many varieties of cheese.

The sensory characteristics acceptability of cheese depends largely on the taste that is formed during maturation. Two important compounds classes that contribute to the flavor are volatile sulfur compounds and fatty acids. Free fatty acids contribute to the cheese taste and aroma formation to a large extent.

Lipolysis is one of the main biochemical processes that contribute to the development of taste during cheese maturation. The characteristic taste of soft cheeses such as Camembert, especially made from sheep's milk, is formed largely as a result of the fat phase exposure to mold Penicíllium camemberti. We studied the influence of starter cultures Lactococcus lactis, Lactococcus cremoris, Lactococcus diacetylactis, Leuconostoc mesenteroides ssp. cremoris and Penicillium camemberti, Geotrichum candidum on fatty acid profile change in Camembert cheese. The profile of fatty acids in the process of cheese maturation changed significantly (Figure 1).

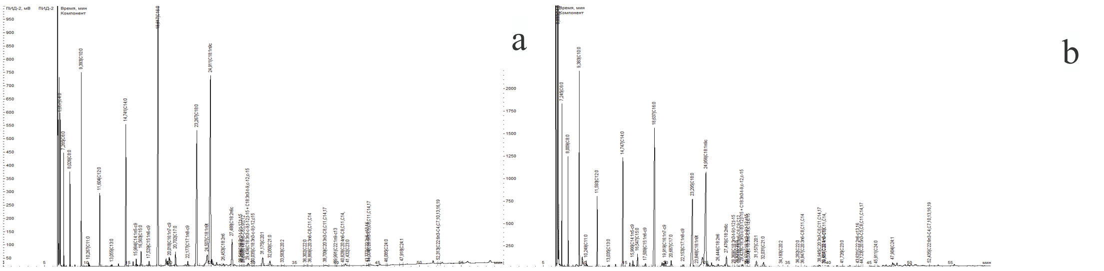

Figure 1: change of fatty acid profile of soft sheep's milk Camembert-like cheese in the process of maturation: a) without maturation; b) maturation period-14 days.

Short-chain free fatty acids contribute to the final taste characteristics of cheese. Table 1 shows the dynamics of changes in the composition of fatty acids during maturation. There was an increase in the short chain fatty acids concentration: oil (C4:0) kapron (C6:0), capryl (C8:0). The change in the lauric acid (C12:0) and myristic acid (C14:0) content was characterized by a similar trend. On the 14th day of maturation, the concentration of lauric acid (C12:0) increased by 30%, myristic acid (C14:0) -- by 13%. The concentration of palmitic acid (C16:0) and stearic acid (C18:0) reduces as well.

Table 1: Effect of the maturation process on the saturated fatty acids content in sheep's milk cheese produced by the Camembert type, %.

Fatty acid	The cheese maturation period		
	no maturation	7 days	14 days
C4:0	2.532	3.459	5.227
C6:0	2.836	3.767	5.806
C8:0	2.842	2.913	4.824
C10:0	7.272	6.230	10.439
C11:0	0.158	0.291	0.354
C12:0	3.539	3.642	4.811
C13:0	0.070	0.083	0.092
C14:0	8.323	8.768	9.445
C15:0	0.918	1.001	1.068
C16:0	22.688	24.715	18.285
C17:0	1.092	0.612	0.662
C18:0	13.804	10.239	11.172
C20:0	0.007	0.005	0.001
C21:0	0.609	0.740	0.862
C22:0	0.041	0.069	0.117
C23:0	0.009	0.009	0.022
C24:0	0.002	0.047	0.019
∑ saturated fatty acids	66.742	66.590	73.206

Table 2 shows the change in the monounsaturated fatty acids composition of sheep's milk Camembert cheese during maturation. The most common C18: 1 trans-isomer is C18:1n9t, consisting up 60 to 80% of the total fatty acids trans-isomers. During maturation, the concentration of C18:1n9t decreases by 98%.

Table 2: Maturation process effect on the of monounsaturated fatty acids content in sheep's milk Camembert-like cheese, %.

Fatty acid	The cheese maturation period		
	no maturation	7 days	14 days
C14:1n5-c9	0.449	0.676	0.562
C15:1n6-c9	0.333	0.312	0.316
C16:1n7-c9	0.523	1.080	0.643
C17:1n8-c9	0.379	0.235	0.236
C18:1n9t	2.055	1.029	0.023
C18:1n9c	23.836	23.407	19.461
C20:1	1.033	0.512	0.990
C22:1n9-C13	0.007	0.018	0.031
C24:1	0.036	0.306	0.608
∑MUFA (monounsaturated)	28.651	27.575	22.870

Based on the table 2 data analysis result, we can conclude that there is a decrease in the monounsaturated fatty acids concentration during maturation. The concentration of the CIS-isomer of oleic acid (C18:1n9c) decreased by 18%.

Table 3: Maturation process effect on the of polyunsaturated fatty acids content in sheep's milk Camembert-like cheese, %.

Fatty acid	The cheese maturation period		
	no maturation	7 days	14 days
C18:2n6	0.256	0.326	0.457
C18:2n6c	3.453	4.328	1.910
C18:3n3-t-9, t-12, t-15	0.025	0.034	0.034
C18:3n6-C6, C9, C12	0.003	0.069	0.133
C18:3n3-t-9, t -12, c-15	-	-	-
C18:3n3-c-9,t-12,t-15 + C18:3n3-t-9, c-12, c-15	0.398	0.360	0.410
C18:3n3-c-9, t-12, c15	0.015	-	0.026
C18:3n6-C9, C12, C15	-	0.132	0.132
C20:2	0.075	0.068	0.135
C20:3n6-C8, C11, C14	0.050	0.027	0.040
C20:3n3-C8, C11, C14,	0.224	0.332	0.499
C20:4n6-C8, C11, C14, C17	0.022	0.029	0.031
C22:2n6-C13, 16	0.014	0.049	0.075
C20:5n3-C5, C8, C11, C14, 17	0.006	0.032	0.018
C22:6n3-C4, C7, 10, 13, 16, 19	0.066	0.049	0.024
∑ polyunsaturated fatty acids	4.607	5.835	3.924

By the end of the maturation period, the polyunsaturated fatty acids concentration decreases by 14 %. However, it is necessary to note the increase in the linoleic acid concentration.

As a result of the analysis of the fatty acid profile changes during the Camembert cheese maturation, it was found that, regardless of the maturation period, the fatty acids C10: 0, C14: 0, C16: 0, C18: 0, C18: 1t9 and C18: 1c9 consist about 73 % of the sum of all fatty acids. Figure 2 presents data on changes in the C10 fatty acid profile: 0, C14: 0, C16: 0, C18: 0, C18: 1 t11 and C18: 1c9 in the process of cheese maturation.

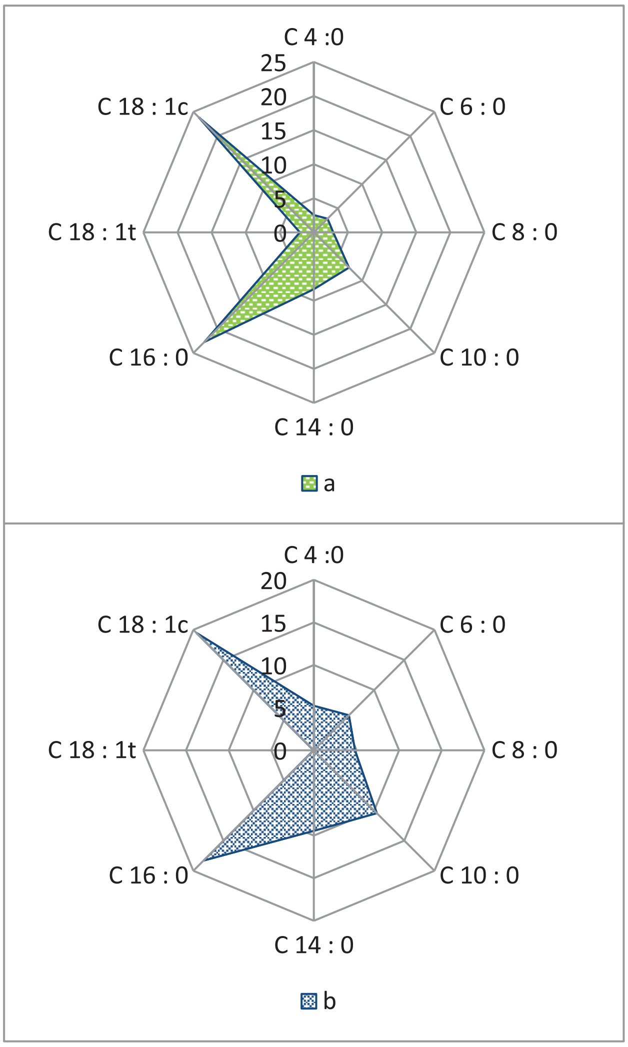

Figure 2: Fatty acid profile of the fat phase of Camembert-like cheese during maturation: a) without maturation b) maturation period of 14 days.

Figure 3 shows the change in the fatty acids' ratio during the cheese maturation. The amounts of fatty acids in all samples decreased in following order: saturated fatty acids> monounsaturated fatty acids > polyunsaturated fatty acids. The atherogenicity index is closely related to the qualitative and quantitative fatty acids composition. There is a positive correlation between the variables under consideration. Which means, an increase of myristic (C:14) and palmitic (C:16) acids in milk leads to an increase in the atherogenicity index. There is also a negative correlation between the sum of unsaturated fatty acids with long chains and the atherogenicity index. The atherogenicity index decreases with an increase of unsaturated fatty acids content with long chains ($\sum$ C : 18; C : 20; C: 22) as part of the fat phase of sheep's milk soft cheeses.

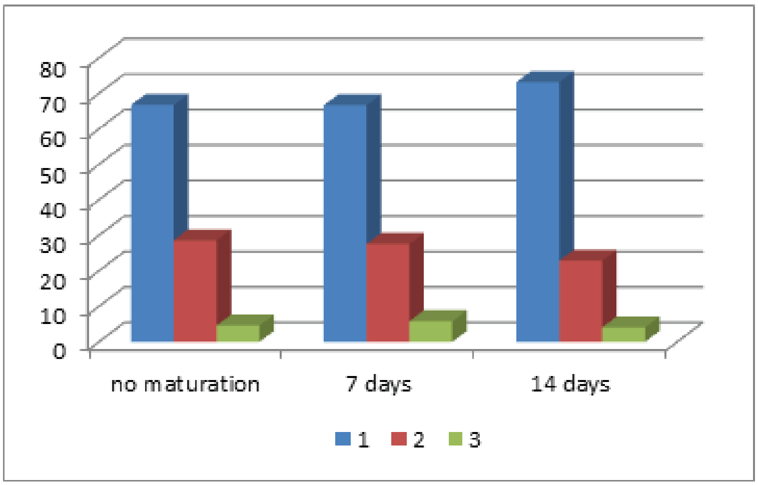

Figure 3: Sum of saturated, monounsaturated, polyunsaturated fatty acids ratio in the Camembert cheese maturation process: 1 - saturated fatty acids; 2 - monounsaturated fatty acids; 3 - polyunsaturated fatty acids.

The main types of W-3 fatty acids used by the body are: α-linolenic acid (C18: 3n-3, αLA), eicosapentaenoic acid (C20: 5n-3), docosapentaenoic acid (C22: 5n-3) and docosahexaenoic acid (C22: 6n-3). Nutritional recommendations are based on different ratios such as w-3 polyunsaturated fatty acids / w-6 polyunsaturated fatty acids and polyunsaturated fatty acids / saturated fatty acids. These values are used to estimate the nutritional value of fat for human consumption. A healthy diet should contain about 4 times more ω-6 fatty acids than ω-3 fatty acids. The ω-6 / ω-3 ratio is an important determinant for reducing the risk of many chronic diseases. Table 4 presents data on the lipids nutritional value in sheep's milk Camembert cheese.

In the process of maturation there is a change in the w-3 and w-6-polyunsaturated fatty acids ratio. There is a w-6-polyunsaturated fatty acids concentration decrease and a simultaneous w-3 polyunsaturated fatty acids concentration increase. The obtained data indicate the possibility of directed regulation of fatty acid profile during the cheese's maturation process.

Table 4: Fat human consumption biological value Indicators.

Name of the indicator	The cheese maturation period	
	no maturation	14 days
w-3 polyunsaturated fatty acids	0.734	1.011
w-6 polyunsaturated fatty acids	3.864	2.777
w-6 / w-3	5.264	2.747
Polyunsaturated fatty acids / saturated fatty acids	0.069	0.054
Atherogenicity index	1.695	2.238
Thrombogenic indec	2.66	2.795

4. Discussion

We investigated the regularities characterizing the fatty acid composition transformation process during sheep's milk Camembert cheese maturation. It was found that, regardless of the maturation period, fatty acids C10: 0, C14: 0, C16: 0, C18: 0, C18: 1 t11 and C18: 1c9 included about 73% of the total fatty acids. By the end of the maturation period, the polyunsaturated fatty acids concentration decreases by 14 %. The increase in hypercholesterolemic and a decrease in hypocholesterolemic fatty acids concentration during the maturation of cheese influenced the increase in the atherogenicity index and thrombogenic index.

5. Conclusion

Fatty acids with less than twelve carbon atoms characterize the sheep's milk fat phase fatty acid composition feature and can be used to detect different types of milk mixtures in sheep's milk cheese. The obtained results naturally describe the lipolysis process during the soft cheeses maturation process with the participation of Penicillium camemberti.

Qualitative and quantitative fatty acid sheep's milk composition used for cheese production, technological production features, the symbiotic starter cultures use in the production process are closely connected to the organoleptic cheese characteristics. The data from this study can be used to develop control tools and strategies to improve the nutritional characteristics of sheep cheese.

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Conflict of Interest

The authors have no conflict of interest to declare.

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