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The effect of freezing and storing processes on the suitability of goat milk for the production of ice-cream desserts

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SUMMARY – Ice-creams made from both fresh, and defrosted milk were tested: immediately after the ice-cream mixture was prepared, after the hardening process, and after 5 weeks of storage. The following parameters were evaluated: acidity (pH), titratable acidity (°SH), percentage of fat and dry matter contents, as well as viscosity and the degree of aeration (fluffiness). Analysis results proved the suitability of defrosted goat milk for ice-cream production. However, ice-creams made from fresh milk received slightly better results in the organoleptic analysis.

Key words: Goat milk, ice-cream, freezing, storage, organoleptic analysis.

RESUME – *"Effet des processus de congélation et stockage sur l'adéquation du lait de chèvre pour la production de crèmes glacées". Des desserts glacés sont préparés à partir de lait de chevre respectivement frais ou décongelé. Des mesures de l'acidité active (pH), acidité titrométrique (°SH), teneur en lipides, teneur en matière sèche ainsi que des mesures de viscosité et de degré d'aération sont faites. Les échantillons sont prélevés pour des analyses directement après préparation du mélange glacé, après le processus de trempage de la glace et ensuite après cinq semaines de stockage. Les résultats des analyses ont confirmé l'hypothèse de l'utilité du lait de chèvre décongelé pour la production de glaces bien que les résultats de l'appréciation sensorielle aient été légèrement inférieurs par rapport aux résultats obtenus pour des glaces produits à partir de lait de chèvre frais.*

Mots-clés : *Lait de chèvre, glaces, congélation, stockage, appréciation sensorielle.*

Introduction

Goat milk and its products are gaining increasing popularity on the Polish market as they extend the range of dairy produce available in our country. Ice-cream made from goat milk, due to its nutritional and antiallergenic properties, may be an attractive alternative both for children and young people, primarily consumers of ice-creams, and for the older generation as well.

As goat milk is available only seasonally, raw milk and cheese paste are frozen and later used as a raw material for further processing and cheese production.

Freezing is connected with some deterioration of organoleptic characteristics. For this reason, pasteurization is recommended before freezing, in order to inactivate lipase and protease, which may result in worse raw material quality in spite of the low temperature. Limited organoleptic changes are obtained in case of freezing milk thickened using the ultrafiltration method (Wszo_ek, 1997).

It was the aim of this paper to evaluate the suitability of fresh and frozen goat milk as a raw material for ice-cream production. Creamy ice-cream was produced using whole goat milk – both frozen and fresh. Physical and chemical properties of ice-cream mixtures and ice-creams were evaluated and also analysed organoleptically.

Materials and methods

Material used in the experiments consisted of batches of ice-cream made from goat milk on laboratory scale in the Department of Dairy Technology at the Agricultural University of Pozna_.

Ice-cream mixtures were differentiated on the basis of the kind and amount of added dairy products, and prepared according to standard recipes. The basic raw material in the production of creamy ice-cream was milk – both fresh and frozen, coming from the Agricultural Experimental Station Z_otniki, of the Agricultural University of Pozna_. The milk came from goats of the Polish Improved White breed. After pasteurization at the temperature of 75°C for period of 25 seconds, all the milk was transferred to 3 litre plastic containers and frozen to the temperature of –18°C for the period of 2 months. The remaining milk was used directly to produce ice-cream. The amount of fat in fresh goat milk was 3.8%, and in the frozen one 3.7%.

The other raw materials used in the experiment were: (i) milk fat in the form of butter (the so called extra type) with fat content of 82.5%; (ii) sucrose as a sweetener and starch syrup SL; and (iii) stabilizer type Palsgaard 5924.

Stabilizer type Palsgaard 5924 is a homogenous mixture of emulsifier and stabilizers. It contains mono- and diglycerides of fatty acids E-471, carboxymethyl cellulose sodium chloride E-466, guar gum E-412 and carrageenan E-407. It has the form of lose powder, slightly yellow in colour and neutral in taste. The addition of such a stabilizer to ice-cream significantly delays the melting process, prevents the formation of ice crystals, facilitates aeration as well as stabilizes the product and increases the resistance of ice-cream to temperature changes during freezing and distribution.

Ice-cream mixtures were prepared on the basis of a standard recipe with the intended fat content of 10%. The composition of ice-cream mixtures made using fresh and frozen goat milk was as follows: whole liquid milk 64.17%, whole powder milk 11%, butter 6.26%, sugar 12%, stabilizer 0.55%, starch syrup 6.02%.

The process of preparing ice-cream mixtures was always the same, the only thing that differed was the kind of ingredients. All liquid components, together with butter, were transferred to a tank and subsequently heated to 60°C until butter melted completely. After mixing all loose ingredients the mixture was pasteurized at the temperature of 85°C for 15 seconds. After pasteurization and cooling the mixtures to 16°C, their viscosity was determined using the RN 211 rotational cylinder viscometer. The ice-cream mixtures were then filtered through sieves with 1.00 mm mesh diameter, and homogenized at the temperature of 65°C and the pressure of 20 Mpa in the Niro-Soavi 3006 H homogenizer (Company Rannie, Holland). After the mixtures were cooled to 16°C, their viscosity was determined again and then they were cooled to the temperature of 2-4°C. At this temperature the mixtures underwent a short, 4-hour long process of maturing. At the end of that process the viscosity of the ice-cream mixtures was determined again and then the ice-cream mixtures were transferred to the horizontal freezer (Company Giusti, Great Britain), where they were frozen to the temperature of approximately –4°C. The produced ice-cream was placed in unit packages and hardened in the refrigerator (Company Williams, Great Britain) at the temperature of –23°C for the period of 30 minutes. The degree of aeration was then established for the obtained ice-cream. Subsequently the ice-creams were put in the freezer, where they were stored for the period of 5 weeks at the temperature of approximately –18°C (Timm, 1985).

Three samples were taken from each batch of ice-cream to be used for measurements, which were performed in accordance with the Polish Standard (PN) – 67/A-86430.

The following parameters were measured for each ice-cream mixture: (i) dry matter content, using the drier method at the temperature of 130°C; (ii) fat content, using the Gerber butyrometer; (iii) viscosity at varying rotational speeds and different spindle diameters (the RN 211 rotational cylinder viscometer); (iv) pH, using the Elmetron CP 315 pH-meter; (v) titratable acidity with the titrimetric method; and (vi) the degree of aeration (fluffiness).

The organoleptic assessment was done at the ice-cream temperature of –6°C. Every time ice-creams were evaluated by 6 people, who used a 5-point scale to assess aroma, flavour, texture and consistency (Bodyfelt *et al.,* 1988; Liptay-Reuter and Ptach, 1998).

The statistical analysis of obtained data was performed using the GLM procedure of the SAS package (1989).

Results and discussion

The dry matter and fat contents in the ice-cream mixtures are presented in Table 1.

Table 1. The dry matter and fat contents in the investigated ice-cream mixtures (n=6)

Ice-cream mixture	Dry matter (%)					Fat (%)				
	$\bar{x}$	x_{max}	x_{min}	SD	V(%)	$\bar{x}$	x_{max}	x_{min}	SD	V(%)
Fresh milk	46.28	46.30	46.26	0.01	0.03	9.84	10.00	9.68	0.10	1.08
Frozen milk	41.37	41.45	41.30	0.05	0.13	8.91	9.25	8.76	0.18	2.03

The dry matter and fat contents were similar to the values determined earlier in the recipe.

The homogenization process in case of both mixtures resulted in a decrease in viscosity after pasteurization. It may be assumed that the lowered viscosity was the effect of disintegration and scattering of fat globules during homogenization at the temperature of 65°C.

An increase in viscosity occurred in both ice-cream mixtures along with the maturing process. It may be assumed that the 4-hour long period of maturation of the mixtures facilitated the absorption of water by the stabilizer (the so called stabilizer swelling) and made fat crystallization possible (Dzwolak and Ziajka 1997).

The effects of the type of goat milk used as well as of the individual stages of production are presented in Table 2.

Table 2. Acidity of ice-cream mixtures (n=6)

Ice-cream mixture	After pasteurization			After homogenization			After maturation		
		°SH	pH		°SH	pH		°SH	pH
Fresh milk	$\bar{x}$	7.48^{Aa}	6.57^{Ab}	$\bar{x}$	7.65^{Ac}	6.59^{Ab}	$\bar{x}$	7.74^{Ac}	6.63^{Ab}
	x_{max}	7.70	6.59	x_{max}	7.69	6.60	x_{max}	8.00	6.65
	x_{min}	7.20	6.57	x_{min}	7.63	6.57	x_{min}	7.60	6.60
	SD	0.18	0.01	SD	0.02	0.01	SD	0.14	0.01
	V(%)	2.14	0.10	V(%)	0.30	0.15	V(%)	1.80	0.27
Frozen milk	$\bar{x}$	7.39^{Ab}	6.29^{Aa}	$\bar{x}$	7.43^{Aa}	6.35^{Aa}	$\bar{x}$	7.58^{Aa}	6.46^{Aa}
	x_{max}	7.40	6.31	x_{max}	7.46	6.37	x_{max}	7.60	6.49
	x_{min}	7.37	6.28	x_{min}	7.41	6.34	x_{min}	7.56	6.44
	SD	0.01	0.01	SD	0.01	0.01	SD	0.01	0.02
	V(%)	0.13	0.19	V(%)	0.21	0.18	V(%)	0.18	0.26

^{A,B,C}Means with different capital letters in rows differ significantly: $P<0.05$.
^{a,b,c}Means with different small letters in columns differ significantly: $P<0.05$.

Lower values of pH in the ice-cream mixture prepared from frozen milk in comparison to the ice-cream mixture made from fresh milk probably results from lower pH value of frozen milk used in ice-cream production. Neither of the mixtures exceeded 9°SH as the value given in literature for creamy ice-cream.

The effect of the kind of goat milk used and of the time of storage on ice-cream aeration is presented in Table 3. The degree of aeration ranged between 56.92% and 61.27% before storage and was slightly lower after 5 weeks' storage time, being 56.67 and 60.24%, respectively. The kind of raw material used had a statistically significant effect on the degree of ice-cream aeration both before and after storage. The 5 week long storage period did not result in a significant decrease in aeration in the investigated ice-cream, which could have been the effect of stabilizer used in the experiment.

Table 3. The effect of the kind of goat milk used and of the time of storage on ice cream aeration (n=6)

Type of ice-cream	Parameter	Degree of aeration (%)	
		Before storage	After 5 weeks of storage
Made from fresh milk	$\bar{x}$	58.83^{Aa}	58.67^{Aa}
	x_{max}	60.04	59.70
	x_{min}	57.96	57.82
	SD	0.92	0.92
	V(%)	1.56	1.57
Made from frozen milk	$\bar{x}$	61.27^{Ab}	60.24^{Bb}
	x_{max}	62.02	60.86
	x_{min}	59.64	58.79
	SD	0.83	0.73
	V(%)	1.35	1.21

^{A,B}Means with different capital letters in rows differ significantly: $P<0.05$.
^{a,b}Means with different small letters in columns differ significantly: $P<0.05$.

Sensory examination, performed at the temperature of –6°C, brought relevant information on the quality of obtained ice-cream. The percentage of goat milk in individual batches of ice-cream had a statistically significant effect on one analysed quality factor, i.e., aroma. Statistically significant differences were also observed between ice-cream made from frozen and fresh goat milk in terms of flavour, texture and consistency. Analysing the quality factors in terms of aroma, the examined ice-creams received good marks. In the evaluation of flavour, texture and consistency, ice-cream made from fresh milk obtained good marks, but a more pronounced goat aftertaste resulted in the frozen milk ice-cream receiving only a satisfactory mark.

The more pronounced goat flavour of ice-cream prepared from frozen milk could have been caused by spontaneous lipolysis, i.e., initiated by prompt freezing of fresh milk without any mechanical interaction (IDF, 1975; Staniszewski, 1998). It could have also been caused by induced lipolysis, as a result of which the structure of fat globules was destroyed, induced by the crystallization of milk fat (IDF, 1980; Walstra and Jenness, 1984).

A barely satisfactory mark for texture and consistency of ice-cream made using frozen goat milk was caused by its looser consistency, watery and the presence of ice crystals. It may be assumed that a lowered quality of goat milk after thawing considerably affected the low evaluation marks, which these ice-creams received for flavour, texture and consistency. On the basis of data presented in literature, it may be inferred that slow freezing of milk to the temperature of approximately –18°C resulted in the formation of large ice crystals, which in turn caused the destruction of coatings of fat globules. Thus after thawing, fractions of free fat were formed, lowering the quality of the raw material, and as a consequence, also that of a finished product (_witka and Zyngiel, 1995).

Conclusions

(i) Results of physical and chemical examination of ice-cream mixtures and ice-creams made from goat milk were consistent with the standards required for creamy ice-cream produced from cow milk.

(ii) The kind of goat milk used had a significant effect on pH and potential acidity of ice-cream mixtures.

(iii) The type of ice-cream had a significant effect on the degree of aeration, both before and after storage. However, the 5 week long storage period did not influence significantly the degree of aeration.

(iv) Frozen goat milk is slightly less suitable for ice-cream production. It can be inferred from the results of sensory evaluation, indicating lowered values of quality factors such as flavour, texture and consistency.

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