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THE INFLUENCE OF STORAGE METHOD ON THE SENSORY CHARACTERISTICS OF SMEAR-RIPENED CHEESE

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ABSTRACT

The paper is focused on the possibility of extending the shelf life of smear-ripened cheeses by storing them in different conditions but preserving their sensory characteristics. The cheeses were stored in the following conditions: A - storage in a refrigerator at 4 – 8 °C, B - storage in a refrigerator at 4 – 8 °C and one week in a freezer at -18 °C, C - storage in a refrigerator at 4 – 8 °C and 7 weeks in a freezer at -18 °C. A sensory analysis of smell, colour and appearance, the degree of ripeness, consistency and taste was performed. For rating, unstructured line scales were used. As the best storage method for preserving the sensory characteristics and extending the shelf life proved out to be the storage in a refrigerator at 4 – 8 °C (samples A) and the second best method for extending the shelf life was the storage in a refrigerator at 4 – 8 °C and 7 weeks in a freezer at -18 °C.

Keywords: Ripening cheeses, sensory analysis, consistency, ripeness

INTRODUCTION

Smear-ripened cheese belongs to the category of acid-set cheeses and has a strong or even pungent smell and taste, distinctive orange or golden-yellow smear and solid consistency (**Teubner, 1998**). The cheese gains these characteristics during ripening especially due to the activity of proteolytic bacteria *Brevibacterium linens*. The surface microflora mainly consists of yeasts (*Debaryomyces hansenii* and *Geotrichum candidum*), food-grade staphylococci (*Staphylococcus equorum*), and coryneform bacteria (e.g., *Corynebacteriumcasei*, *Brevibacterium linens*, *Microbacterium gubbeenense*, and *Arthrobacter arilaitensis*) (**Fuquay, 2011**). The decrease in acidity of cheese surface and removal of the yeast film (by rinsing with water) stimulate the subsequent growth of desired smear bacteria (**Bockelmann *et al.*, 2005**; **Irlinger *et al.*, 2012**).In the process of protein breakdown, organoleptically active peptides are formed, as well as volatile fatty acids, ammonia, hydrogen sulphide, biogenic amines and other substances forming the smell andtaste **(Fox et al., 2004).** *Brevibacterium linens* also forms the typical colour of the cheese.
The taste of this kind of cheese is significantly influenced by the content of salt. The salt is added in the curd before ripening (**Görner and Valík, 2004**).The maximum content of salt in the final product is 5.5 %**(Teubner, 1998**). **Pachlová *et al.* (2013)** found that free amino acid concentrations and sulphur compounds are positive with improved flavour.
The ripening progresses from the surface to the centre which has a positive influence on the cheese characteristics. We can observe the progress of ripening at cross section, the upper layer is turning yellow and the inner core stays more or less white, based on the progress of enzymes produced by aerobic proteolytic microflora **(Görner and Valík, 2004**).
Smear-ripened cheeses are almost always stored at refrigerating temperatures. The aim of the paper was to find out how different temperatures of cold storage influence the sensory characteristics of smear-ripened cheeses and whether there is a possibility of extending the shelf-life and at the same time preserving the sensory characteristics.

MATERIAL AND METHODS

Material

For sensory analysis, smear-ripened cheese samples of small round shape (100 g) were used. The samples of smear-ripened cheese were transported to the laboratory in isothermal packaging immediately after production and then stored in different temperature regimes: samples A - in a refrigerator at 4 – 8 °C for 5 weeks, i.e. until the end of their shelf life; samples B - in a refrigerator at 4 – 8 °C for 5 weeks and then 1 week in a freezer at -18°C, samples C - in a refrigerator at 4 – 8 °C for 5 weeks and then 7 more weeks in a freezer at -18°C. Altogether, 105 samples were analysed.

Sensory analysis

The sensory analysis took place at the Department of Food Technology of Mendel University in Brno in a sensory laboratory with individual booths which complies with the conditions set by ČSN ISO 8589 (2008). The sensory analysis lasted 18 weeks and was performed by a sensory panel of seven regular judges. All the judges have a "Judge's Certificate", issued by the Czech Agriculture and Food Inspection Authority in Brno. The samples were analysed using a method of sensory profile with line unstructured scales (100 mm, 1 mm = 1 point) with verbal descriptions of the end points (0 points the worst value, or the lowest, 100 points the best, or the highest). The following descriptors were evaluated: smell (mild - characteristic for this type of cheese, strong, highly pungent), colour and appearance (uneven surface, pale to grey coating, little smear, extensive unripe areas on the surface - even surface, smooth, shiny, orange to golden yellow smear, adequate layer of smear, uniform ripeness on the surface), the degree of ripeness (not ripe - ripe at the whole cross section), consistency (soft, with a distinct core placed in the middle, flexible, solid - softer, without a perceptible core), flavour (curdy, flat - typical, sharply pungent, characteristic for this kind of cheese).
Before analysis, the samples stored in a freezer were left to thaw in a refrigerator at 4 – 8 °C. Before the evaluation, the samples were heated to room temperature and handed to the judges anonymously, under a numeric code. Bread and water were used as neutralisers.

Statistical methods

The data from all the determinations were subjected to analysis of variance by means of the Statistical package STATISTICA, version 6.1 (StatSoft, Inc.) applicable for multifactorial experiments, and the comparison of means was performed by Tukey's test.

RESULTS AND DISCUSSION

From the measured values were calculated mean values, standard deviations and coefficients of variation. Using a subsequent statistical analysis, a statistical difference at the level of probability P = 0.95 was determined.

The results of sensory analysis of smear-ripened cheeses stored in a refrigerator for the whole time (samples A)

Samples A were stored in a refrigerator for the whole time. One group of samples was rated at the end of shelf life, that is after five weeks, and the other one after two weeks after the end of shelf life, that is after seven weeks of storage. The results of the sensory analysis are shown in Table 1.

Table 1 The results of the sensory analysis (Tukey's test) of smear-ripened cheese samples rated at the end of shelf life and at the end of storage life (shelf life + 2 weeks), stored at 4 – 8 °C in a refrigerator.

storage	Mean values of sensory characteristics–mm of unstructured line scales				
	smell	colour and appearance	degree of ripeness	consistency	taste
at the end of shelf life (4 – 8 °C)	71^{A}	74^{A}	82^{A}	73^{A}	73^{A}
after shelf life + 2 weeks (4 – 8 °C)	83^{B}	82^{A}	92^{B}	83^{B}	83^{B}

Note: A,B: mean values marked with different indices are significantly different (P<0.05)

Extending shelf life by 2 weeks had a positive influence on the smell of the samples. The development of smell is determined mainly by the chemical changes of the individual cheese components and the breakdown through the activity of microorganisms and their enzymes during the ripening process. At the same time, the smell is also significantly influenced by the quality of processed milk, the amount and kind of microbial pure cultures, the amount of rennet and the technological procedure itself, especially proper fermentation of cheese-curd during the processing and moulding up to 24 hours after production (Kněz, 1960). Through statistical analysis, a statistical difference at the level of probability P < 0.05 was determined.

As for the degree of ripeness, we can state that the extension of shelf life by two weeks resulted in a positive rating of the degree of ripeness and thus the extension of shelf life by 2 weeks is possible. Through statistical analysis, a statistical difference at the level of probability P < 0.05 was determined.

Consistency is mainly dependent on the degree of ripeness, during which chemical and physical changes occur and cheeses might lose their firmness, curdiness and can become softer. The extension of shelf life by two weeks resulted in a better consistency, the cheeses were softer. Through statistical analysis, a statistical difference at the level of probability P < 0.05 was determined.

As for taste, we can state that the extension of shelf life by two weeks did not lead to its deterioration, on the contrary, it was perceived as better by the judges. According to **Smit *et al.* (2000)**, many biological processes occur during the ripening of cheeses and these represent the basic requirements for the development of taste. The taste may be worsened by the increased activity of starting cultures with highly active peptidase. Their activity leads to an unstable taste. The most noteworthy is the degradation of methionine, during which sulphur mixtures are activated and bitter taste is formed.

The results of evaluation (Table 1) reveal that the samples with higher score were the ones stored in a refrigerator (4 – 8 °C) and rated two weeks after the end of shelf life, i.e. after 7 weeks of storage, with the following descriptors: smell, degree of ripeness and taste. Statistical analysis (Tukey's test) proved a significant statistical difference at the level of probability (P <0.05).

As for the "colour and appearance" descriptor, samples stored for 2 weeks after the end of shelf life were rated as better, but statistical analysis did not prove any statistically significant difference.

In case of this storage regime, as more suitable in terms of sensory qualities proved out to be the storage at 4 – 8 °C for two more weeks after the end of shelf life.

The results of sensory analysis of smear-ripened cheeses stored in a refrigerator and for a short time in a freezer (samples B)

Samples B were stored in a refrigerator and in a freezer. One group of samples B was stored in a refrigerator at 4 – 8 °C and was evaluated at the end of shelf life, i.e. after five weeks. The other group of samples was stored in a refrigerator until the end of shelf life and then in a freezer for one week (-18 °C). The results of sensory analysis are shown in Table 2.

Table 2 The results of sensory analysis (Tukey's test) of smear-ripened cheeses evaluated at the end of shelf life stored at 4 – 8 °C and at the end of storage life (shelf life + 1 week in a freezer at -18 °C)

storage	Mean values of sensory characteristics–mm of unstructured line scales				
	smell	colour and appearance	degree of ripeness	consistency	taste
at the end of shelf life (4 – 8 °C)	66^{A}	68^{A}	71^{A}	57^{A}	63^{A}
after shelf life +1 week (-18 °C)	72^{A}	72^{A}	86^{B}	72^{B}	73^{A}

Note A,B - mean values marked with different indices are significantly different (P <0.05)

The results of evaluation reveal that the samples with higher score in the categories "ripeness" and "consistency" were the ones stored in a refrigerator (4 – 8 °C) until the end of shelf life and subsequently for 1 week in a freezer (-18 °C). Statistical analysis (T.t.) proved a statistically significant difference (P<0.05), whereas in the case of appearance and taste descriptors, better results were attained by samples stored in a refrigerator for the whole time until the end of shelf life.

Extending the shelf life by two weeks did not result in the deterioration of smell, but it made more intense. Neither the colour nor appearance of the samples deteriorated, on the contrary, they were better coloured and had a better appearance. A typical feature of the colour of smear-ripened cheeses is bacterial flora *B. linens*. This study was performed through the evaluation of indirect effects of surface microflora*B. linens* using spectrocolorimetry. In the case of biofilm, brightness, saturation and hue angle were evaluated (**Leclercq-Perlat *et al.*, 2004**).

With the shelf life extended by two weeks, the samples were much more ripened than at the end of shelf life. Biochemical changes which occur during cheese ripening include the metabolism of residual lactose, the conversion of lactate, metabolism of citrate. All of these have a significant influence on the final degree of cheese ripeness **(O'Mahony *et al.*, 2006)**.

The consistency of samples was more flexible and rated more positively than in the case of samples at the end of shelf life. **Kněz (1960)** states that the changes of mineral salts content and their bonds as well as the content of water and its bond influence the final consistency of cheeses. When the water content is lower due to dessication, the elasticity of cheeses changes and thus, in the second stage, their taste changes as well. Consistency of samples can also be influenced by the addition of neutralizing salt. However, high amount of calcium salts results in a firm and solid consistency, high amount of sodium salt leads to a soft consistency or even melting, but also taste flaws, such as a flat or soapy taste **(Cwiková and Nedomová, 2007).**

After extending shelf life by two weeks, the taste was rated as better even though we cannot prove it conclusively. In some samples, the judges detected an excessive amount of salt. Edible salt contributes to the basic taste of cheese and at the same time regulates the speed of ripening. Greater taste flaws occur more frequently when the cheeses are undersalted rather than oversalted. Especially bad-tasting are such cheeses which are not salted enough and ripen at high temperatures **(Zimák, 1988; Kněz, 1960)**.

With this regime, as more suitable proved to be the storage of samples until the end of shelf life at 4 – 8 °C and then 1 week in a freezer at -18 °C.

The results of sensory analysis of smear-ripened cheeses stored in a refrigerator and for a long time in a freezer (samples C)

Samples C were stored in a refrigerator and in a freezer. One group of samples C was stored in a refrigerator at 4 – 8 °C and was evaluated at the end of shelf life, that is after five weeks. The other group of samples was stored in a refrigerator until the end of shelf life and then 7 weeks in a freezer at -18 °C. The results of sensory analysis are shown in Table 3.

Table 3 The results of sensory analysis (Tukey's test) of smear-ripened cheeses evaluated at the end of shelf life stored at 4 – 8 °C and at the end of storage life (shelf life + 7 weeks in a freezer at -18 °C)

storage	Mean values of sensory characteristics–mm of unstructured line scales				
	smell	colour and appearance	degree of ripeness	consistenc y	taste
at the end of shelf life (4 – 8 °C)	71^{A}	74^{A}	82^{A}	73^{A}	73^{A}
after the end of shelf life + 7 weeks (-18 °C)	82^{B}	80^{A}	85^{A}	76^{A}	77^{A}

Note: A,B-mean values marked with different indices are significantly different (P<0.05)

Through statistical analysis, highly significant difference was determined (P<0.05). Based on the results, it is possible to state that the samples after seven-week freezing were rated as better by the judges, which was very surprising.
In the case of smell, no statistically significant difference was detected (P<0.05). The colour and appearance of samples were almost unchanged by freezing because there was neither deterioration nor improvement.
In the case of the degree of ripeness, statistically insignificant difference (P<0.05) was detected between the samples. Ripeness was still evaluated positively in samples stored in a freezer for seven weeks after the end of shelf life.
The consistency of samples after seven-week freezing after the end of shelf life was rated very positively even though worse consistency was expected because of freezing, Statistical analysis did not determine a significant difference (P<0.05).
The factors which have the greatest influence on consistency are renneting and the quality of curd. By controlling these factors, it is possible to increase the amount of moisture as well as the softness of cheeses. Another factor contributing to the improvement of consistency of low-fat cheeses is surface ripening with the help of *B. linens* bacteria. After extending the shelf life by freezing to seven weeks, the taste was very pleasant and strong. The judges rated the samples as better than at the end of shelf life. This finding was very surprising because the judges expected an unpleasant taste due to freezing, but it did not manifest. Stronger taste of cheeses is caused by higher acidity which accelerates the in-depth breakdown of proteins and a higher amount of fatty acids is formed. Higher acidity is caused by a higher amount of lactic acid and also the presence of extracted fat (**Kněz, 1960**). Statistical analysis determined a statistically insignificant difference between the samples (P < 0.05).
In the case of this regime, as the most suitable seemed to be the storage of samples until the end of shelf life at 4 – 8 °C and then for 7 weeks in a freezer at -18°C.

Comparison of all three methods

Table 4 shows the results of sensory analysis of smear-ripened cheese samples stored in different temperature regimes: in a refrigerator at 4 – 8 °C, for 5 weeks, that is until the end of shelf life (samples A); in a refrigerator at 4 – 8 °C (5 weeks) and 1 week in a freezer at -18 °C (samples B); in a refrigerator at 4 – 8 °C (5 weeks) and 7 weeks in a freezer at -18 °C (samples C).

Table 4 The results of sensory analysis (Tukey's test) of smear-ripened cheese samples stored under different temperature conditions: in a refrigerator at 4 – 8 °C, for 5 weeks, that is until the end of shelf life (samples A); in a refrigerator at 4 – 8 °C (5 weeks) and 1 week in a freezer at -18 °C (samples B); in a refrigerator at 4 – 8 °C (5 weeks) and 7 weeks in a freezer at -18 °C (samples C).

storage	Mean values of sensory characteristics–mm of unstructured line scales				
	smell	colour and appearance	degree of ripeness	consistency	taste
4 – 8 ºC, 5 weeks, (A)	71^{A}	74^{A}	73^{A}	73^{A}	73^{A}
4 – 8 ºC, 5 weeks + 1 week in a freezer (-18 ºC), (B)	66^{A}	68^{A}	57^{B}	57^{B}	63^{B}
4 – 8 ºC, 5 weeks + 7 weeks in a freezer (-18 ºC), (C)	71^{A}	74^{A}	73^{AC}	73^{AC}	73^{AC}

Note: A,B-mean values marked with different indices are significantly different (P<0.05)

When rating smell, it was determined through statistical analysis that there is no statistically significant difference.
The results presented above imply that in terms of sensory quality, the best smell was present in samples A stored in a refrigerator until the end of shelf life and in samples C stored in a refrigerator until the end of shelf life and subsequently in a freezer for 7 weeks. Samples B had the weakest smell. According to **Cwiková and Nedomová (2007)**, the smell is greatly influenced by volatile sulphuric compounds which are formed for example by the *Brevibacterium linens* bacteria, giving rise to a more powerful and intense smell.
As for the colour and appearance, statistical analysis (P<0.05) determined a statistically insignificant difference between all samples.
All the results presented above imply that the sensorically best colour and appearance were present in samples A and C stored in a refrigerator until the end of shelf life. Samples B had a less intense smell. What contributes to the amount and colour of smear at the end of shelf life is for example lower humidity and lower content of atmospheric oxygen during ripening when the surface gets dry and the growth of microorganisms stops, which results in the formation of a thinner layer of paler smear (**Cwiková and Nedomová, 2007**).
Through statistical analysis of the degree of ripeness, statistically significant difference was determined (P<0.05) between the samples A - B and C - B.
Based on these findings we can state that the best degree of ripeness was proved statistically as well as sensorically in samples A and C which were stored until the end of shelf life in a refrigerator at 4 – 8 °C. Samples B had a low degree of ripeness due to storage in a freezer for the duration of one week. The samples stored in a freezer for a long time attained worse results at the end of shelf life than those stored under other conditions. These results can be caused by the fact that there occurred a slowdown of growth because of insufficient inflow of oxygen, lack of proteolytic microflora or a breach of storage conditions (**Kovařík *et al*., 2010**).
In the case of consistency, statistical analysis determined a statistically highly significant difference (P<0.05) between samples A-B and C-B.
The best consistency was achieved in samples A and C which were stored in a refrigerator at 4 – 8°C until the end of shelf life. In the case of samples B, the consistency was more solid due to storage in a freezer for one week. Based on the results gathered from FT-NIR spectrophotometer **Kozelková *et al.* (2011)** arrived to a conclusion that smear-ripened cheeses produced in the spring period and that produced in the summer period are different, which can be caused by a different composition of milk and this finding might have a significant influence on the consistency of the final products.
As for taste, statistical analysis determined a statistically significant difference (P<0.05) between the samples A-B and C-B.
The best taste was attained by samples A and C which were stored at 4 – 8 °C in a refrigerator until the end of shelf life. In the case of sample B, the taste was conclusively worse because of the storage in a freezer for 1 week. According to **Kovařík *et al.* (2010)** the results revealed that a long-term storage in a freezer led to the deterioration of sensory quality in smear-ripened cheese. But for example the storage in dry ice did not have any provable negative influence on the taste of smear-ripened cheeses.
As for the other storage methods, the taste was classic and as expected. According to **Cwiková and Nedomová (2007)**, this classic taste is caused by a proper way of ripening, whereby the microbial enzymes get inside the cheese and the breakdown of its individual components takes place.

CONCLUSION

This paper focused on the possibility of extending the shelf life of smear-ripened cheeses without losing their sensory quality. The aim was to monitor the sensory quality of samples in three different storage regimes, at 4 – 8 °C in a refrigerator until the end of shelf life (samples A), at 4 – 8 °C in a refrigerator until the end of shelf life and 1 week in a freezer at -18 °C (samples B) and at 4 – 8 °C in a refrigerator until the end of shelf life and then 7 weeks in a freezer at -18 °C (samples C).
The overall results imply that in terms of sensory quality, the best regimes were storage in a refrigerator at 4 – 8 °C (samples A) and also storage in a refrigerator at 4 – 8 °C and 7 weeks in a freezer at -18 °C (samples C). This statement is substantiated by the fact that the score of all monitored descriptors in the given samples did not go below 70%. The samples rated as the worst by the judges were the ones stored in a refrigerator at 4 – 8 °C and for 1 week in a freezer at -18 °C (samples B). In these samples, insufficient ripeness was detected and consequently also more solid consistency, which ultimately influenced the final rating. Statistical analysis at the level of probability 95% determined that there was no statistically significant difference between the storage in a refrigerator at 4 – 8 °C (samples A) and the storage in a refrigerator at 4 – 8 °C and 7 weeks in a freezer at -18 °C (samples C), so both of these storage regimes can be employed.
Sensory analysis cannot determine which of these storage regimes is the best in terms of health safety. That is why these statements must be supplemented and substantiated by further chemical, microbiological and other instrumental analyses which are also very important for the quality of the final product. Among these analyses are for example the determination of the content of biogenic amines, determination of the content and kind of microorganisms, the content of salt, determination of elasticity and many others.

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