Effect of different refrigeration treatments on the physicochemical characteristics of raw goat milk curd-style cheese

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Abstract

The aim of this experimental study was to establish the effect of freezing rate on the quality of goat curd–style cheese. After 3 month of frozen storage, samples were slowly thawed at 4-6°C and preserved at the same level of temperature for 15 days. The physicochemical parameters of the product were analyzed for the following treatments: 1- samples without freezing; 2- samples frozen at small freezing rate by natural convection of air; 3 – samples frozen by immersion in salt solution ;4 –samples frozen by deep freezing at -70°C; 5 – samples frozen by very high freezing rate using liquid nitrogen immersion.

The samples were analyzed during 15 days of storage at 4-6°C for both types chilled and frozen-thawed curd cheese. In the first day after thawing, the chemical-physical parameters showed similar values, but different behavior was observed during storage period of the thawed samples. The results shows a significant statistic differences among the treatments related to physicochemical analysis performed on certain samples.

Keywords: Goat milk curd-style cheese, physicochemical analysis, freezing methods, freezing-thawing

1. Introduction

In the last decades, cheeses have got a large commercial importance for the food industry because it can be used as ingredients, such as: pizza toppings, fillings for appetizers, burgers, pasta sauces and pastries products. Traditionally, mozzarella cheese, cheese powder, processed cheese made from cow milk and imitation cheese were the main types used.

When compared to cow milk products like cream cheese, goat cheese is lower in fat, calories and cholesterol. It also provides more calcium and fewer carbohydrates than cream cheese. Even though goat cheese has less calories, it has a full, rich and creamy flavor [1-4].

For young girls going through the rapid growth spurts of puberty, getting calcium from dairy products, such as goat's milk, may be better for building bone than taking a calcium supplement, suggests a study published in the American Journal of Clinical Nutrition [1].

The main issue that occurs in the industrial production of goat cheese is the seasonal nature of milk production, which has large fluctuations between summer and winter.

The willingness to increase the storage of goat's milk cheeses comes from the necessity of covering the market demand throughout the year and to improve sustainability and profitability of the dairy goat industry.
It is well known that cold treatments are applied to maintain the qualitative characteristics of perishable foods by slowing down the biochemical reactions and inhibition of microbial activity. But there is an undesirable side of freezing process namely that can cause damage to the structure and quality of cheese [4,5].

For this reason, the present study has been developed in order to assess the possibility of using of goats’ milk protein curd as a by-product in various frozen foods, ready to eat type and also to determine whether one or more freezing methods can be applied in order to preserve the curd for a longer period of time maintaining at the same time a better quality of it.

2. Materials and Method

2.1. Preparation of goat milk curd-style cheese

The raw whole milk was acidified by its native micro biota. The coagulation process of milk took place at 32°C by adding about 1,5 % of commercial calf rennet (strength 1/10000). The coagulum was cut into pieces (8 -10 mm cubes). The coagulum was left to stand for 45 minutes to remove the whey, then transferred into the cotton bags for drainage. The draining was done after 5 hours at 20°C.

**Sampling.** The blocks of curd –style cheese weighing 2 -2.5 kg were divided into samples with dimensions of 50 × 40 × 25 mm (approximately 50 g). The samples thus prepared were subjected to vacuum prepackaging or directly freezing according with freezing method.

2.2. Set up of the freezing methods

The freezing procedures used were:

1. Freezing by natural convection of air at -20°C using a professional refrigerator.
3. Immersion freezing in salt solution at eutectic conditions (concentration of brine 23% and -15°C ).
4. Freezing by liquid nitrogen immersion (-196°C) using a pilot scale equipment with continuous spraying of liquid nitrogen.

2. The samples number 1 and 2 were vacuum packed before freezing and samples number 3 and 4 were vacuum packed after freezing. The freezing procedures were applied until in the thermal center of samples were recorded between -15 and -25°C. The samples were stored for 3 months at -20°C, then were slowly thawed and kept for 15 days at 4...6°C.

2.3. Physicochemical analysis

For these determinations the cheese samples were grated and homogenized and then used.

Total solids (TS) content was determined in according to ISO standard SR EN ISO 5534 [6]. The fat content was determined in according with reference method SR EN ISO 1735:2005 [7]. Total N content was assayed by semi micro – Kjeldhal method [8] using a micro Kjeldhal alanyzer (RAYPA Trade), and protein content was calculated by percentage of N x 6,38. NaCl content was determined the potentiometric titration method [9]. All analysis were performed in triplicate.

2.4. Statistical analyses

Analyses of variance was performed using the IBM SPSS Statistics Base 19, Tukey’s multiple comparation test. The level of significance of differences between treatments was determined at p<0.05.

3. Results and Discussion

Present study aims to assess the effects on physicochemical characteristics resulting from: method of freezing;duration of frozen storage; chilled shelf life after thawing.

3.1. Variation of dry matter content

The control sample has significant differences from the sample frozen at -20°C (p <0.05, sig. 0.041) and stronger significant differences compared with the sample frozen in brine (p <0.05, sig. 0.001) . Also the sample frozen in salt solution showed a highly significant differences from the sample frozen by spraying liquid nitrogen (p <0.05, sig. 0.01) and significantly from the sample frozen at -70°C (p <0.05, sig. 0.041). The sample frozen at -20°C sample differ significantly from the sample frozen by spraying liquid nitrogen (p <0.05 sig. 0.039).

The curd –style cheese samples frozen in brine, with the highest dry matter content immediately after thawing (48%) showed the lowest percentage increase for this parameter during storage at 4 – 6°C. The dry matter content of the sample frozen in
salt solution is explained on the one hand, by the removal of whey during freezing in brine, the salt affecting the syneresis process, reducing the water content of curd – style cheese [3,5]. On the other hand, the difference of concentration between the aqueous phase of cheese and salt solution has the diffusion of salt into the curd and the reverse migration of the aqueous phase into the brine [2].

![Figure 1. Dry matter variation during storage at 4-6°C for 15 days](image)

However, the freezing procedures applied through different freezing temperatures and rate, has depended the syneresis process while held at 4 - 6 °C, especially for curd – style cheese sample frozen at -20 °C and the sample frozen in salt solution.

3.2. Variation of lipid content

The changes in lipid content during the cold treatments applied are shown in Figure 2. Following the values recorded for the amount of fat can be observed that the sample frozen in brine had a fat content by about 2.3% lower than the control sample because with the passing of water from cheese into brine, migrates and other substances such as casein fragments, soluble proteins, lactose, lactic acid, minerals and fat (Costin, 2003). Storage conditions of the thawed samples did not significantly affect the fat content, the lower limits ranging around 45% fat / dry matter. The biggest losses in fat were recorded for samples frozen in salt solution and for samples frozen at -20°C respectively, even after the first day of thawing. The most significant differences were recorded between control sample and the sample frozen in brine (p <0.05, sig. 0.013). Between control sample and sample was frozen at – 20°C has been a slight difference (p <0.05, sig. 0.043).

3.3. Variation of N content and protein content

Total nitrogen content remained relatively constant during freezing, with a slight decrease during storage at 4 – 6°C (Table 1).
**Figure 2.** Fat content variation during storage at 4-6°C

**Table 1.** Variation of total nitrogen content and protein content respectively, during storage at 4-6°C

<table>
<thead>
<tr>
<th></th>
<th>Days</th>
<th>Protein (6.38 x TN)</th>
<th>Total Nitrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control sample</td>
<td>0</td>
<td>15,24</td>
<td>2,39</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>15,22</td>
<td>2,38</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>14,80</td>
<td>2,32</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>14,55</td>
<td>2,28</td>
</tr>
<tr>
<td>Slow freezing by natural convection of air at -20°C</td>
<td>1</td>
<td>15,31</td>
<td>2,4</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>14,55</td>
<td>2,28</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>13,97</td>
<td>2,19</td>
</tr>
<tr>
<td>Freezing by immersion in NaCl solution</td>
<td>1</td>
<td>15,70</td>
<td>2,46</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>14,80</td>
<td>2,32</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>13,46</td>
<td>2,11</td>
</tr>
<tr>
<td>Deep freezing at -70°C</td>
<td>1</td>
<td>16,00</td>
<td>2,59</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>16,27</td>
<td>2,55</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>15,69</td>
<td>2,44</td>
</tr>
<tr>
<td>Quick freezing using liquid nitrogen.</td>
<td>1</td>
<td>15,80</td>
<td>2,63</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>15,90</td>
<td>2,58</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>15,70</td>
<td>2,62</td>
</tr>
</tbody>
</table>
However, the samples frozen by direct contact with liquid nitrogen were recorded a content of total nitrogen of approximately 9.5% higher than control sample with a significant statistical difference (p < 0.05). Also, the protein content per 100 g dry matter did not suffer major changes after the freezing treatment (Figure 3). During the period storage at 4-6 °C, the amount of protein per 100 g dry matter recorded insignificant losses parallel with the increase of non-protein nitrogen fraction, as a result of proteolytic processes catalyzed by microbial enzymes that survived freezing process.

3.4. Variation of salt content

Salt content was clearly higher in the sample frozen in brine that absorbed up to 7.5% NaCl during freezing, the amount absorbed increasing to 8.1% NaCl during storage at 4-6 °C due to loss of moisture. Highly significant differences are present between the sample frozen in brine and the other samples (p < 0.05, sig. 0.000). The decrease of samples moisture is the reason for an increase of salt content.

![Figure 3. Variation of protein content during storage at 4-6 °C](image1)

![Figure 4. Variation of salt content during storage at 4-6 °C](image2)
4. Conclusion

Physico-chemical characteristics of goat milk curd-style cheese were not greatly influenced by freezing processes used. Making a comparison among different samples, freezing process in salt solution having a concentration of 23% NaCl influenced most profoundly the physico-chemical characteristics, especially contents of dry matter, fat and salt. Samples frozen at -70°C have recorded the closest values compared to control sample. This is due to both higher freezing rate and the fact that at this temperature the enzymatic activity is considerably lower but not equal to zero. The samples frozen at -20°C shows significant changes of dry matter content and fat content due to slow freezing rate which favored the formation of large and irregular ice crystals. During the 15 days of storage at 4–6°C, the samples did not suffer major changes, the variation of the main physical-chemical characteristics values being relatively small.

References

6. *** SR EN ISO 5534:2004 – Cheese and processed cheese. Determination of total solids content (Reference method)