INFLUENCE OF FAT CONTENT AND STARTER CULTURES ON THE QUALITY OF FERMENTED DAIRY PRODUCTS

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The objective of this study was to investigate the effect of fat content and type of the starter culture (traditional or probiotic) on physico-chemical quality, rheological and textural characteristics of the fermented dairy products during 14 days of storage. Seven different fermented dairy products of two different groups: stirred and set yoghurts were used in this study. The rheological and textural characteristics of the analyzed type of fermented dairy products after the production and during storage are dependent on the chemical composition, particularly fat content.

KEY WORDS: fermented milk products, starter cultures, rheology, texture

INTRODUCTION

Fermented dairy products play an important role in the human diet, as a very important part of the modern lifestyle. These products are very diverse groups of high valuable nutritional products. They are produced in strictly controlled and technologically defined conditions by fermentation with selected microorganisms – starter cultures (1, 2). Great progress in modern technology of fermented dairy products has been made by the development of new types of starter culture – probiotic bacteria, like Lactobacillus and Bifidobacterium strains (3). These strains can be used instead of the traditional thermophilic starter cultures (Streptococcus thermophilus and Lactobacillus delbrueckii spp. bulgaricus) (4). Nowadays, the fermented dairy beverages are produced with different fat content and enriched with a variety of ingredients (milk proteins concentrate, whey proteins concentrate, skim milk powder, casein, vitamins, inulin, etc.), different aromatic and functional ingredients (5-8).

In order to enhance the quality of fermented dairy products, beside the optimization of a technological process and choice of starter culture, a variety of ingredients with known chemical composition is used (9-13). Structure of the gel and its textural characteristics are influenced by several factors, including proteins concentration, incubation temperature, heat treatment of the milk, and type of starter culture (14).

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**EXPERIMENTAL**

**Materials**

In this study, the quality of seven different commercial fermented dairy products were analyzed:

- Sample 1 – yoghurt produced from pasteurized milk with 3.2% milk fat;
- Sample 2 – yoghurt produced from pasteurized skim milk with 0% fat;
- Sample 3 – fermented dairy product from pasteurized milk with 1% fat and probiotic starter cultures and 1.5% oligofructose;
- Sample 4 – yoghurt produced from pasteurized milk with 2% fat;
- Sample 5 – sour milk produced from organic milk with 2.8% fat;
- Sample 6 – Greek style yoghurt from pasteurized and homogenized extra fat milk with 9.7% fat;
- Sample 7 – sour milk produced from milk with 6% fat.

**Methods**

Physico-chemical analyses of different types of fermented dairy products were performed by the following methods (15): pH value – with a pH meter (EcoScan pH6, Eutech Instruments, Nijkerk, Netherlands); total solids (TS)-(IDF/ISO21:2010); total proteins - by Kjeldahl method (SRPS EN ISO 8968-1:2008); ash content - by the incineration at the temperature of 550°C (IDF 90:1979); while total sugar content was calculated as follows:

\[
\text{total sugar} = \text{total solids} - (\text{total proteins} + \text{milk fat} + \text{ash})
\]

and the energy value from the following formula:

\[
\text{Energy value} = (\text{protein} \times 4.4 + \text{milk fat} \times 9.3 + \text{total sugar} \times 4.1) \\
\times 4.186 \text{ (kJ/100g)}
\]

Textural characteristics (firmness, consistency, cohesiveness and index of viscosity) were measured on a Texture Analyser TA XD plus (Stable Micro System, Godalming, England) at +4°C. The force of compression was measured using back extrusion cell (A/BE) with a diameter of 35 mm, and using 5 kg load cell. The option „Return to Start“ was used and a speed disk displacement before and during the test was 1.0 mm/s. The disk had exceeded the distance of 30 mm. Replicate measurements of firmness for each sample were done independently after 1st, 7th and 14th day of storage.

Viscosity of samples was measured at +4°C using a viscometer HAAKE RheoStress 600HP (Karlsruhe, Germany) with cone and plate sensor PP60Ti (gap 1 mm). Hysteresis loop area was recorded at increasing shear rate from 0 to 200 s, followed by its decrease in
the same span within 180 s of downward flow curve. The thixotropic test was initially applied to characterize the flow behavior of the samples and was calculated by RheoWin Data Manager 4 program package (Thermo Haake, Karlsruhe, Germany).

**Statistical analysis** of the results was carried out using the computer software program "Statistica 9" and were expressed as average, standard deviation of values obtained in three independent experiments.

**RESULTS AND DISCUSSION**

**Physico-chemical characteristics of fermented dairy products**

According to the results presented in Table 1, the pH values of stirred yoghurt (samples 1, 2, 3 and 4) were between 4.22 (sample 1) and 4.40 (sample 3). The values for set yoghurt varied between 4.17 (sample 7) and 4.54 (sample 6). The content of total solids and milk components depended on product type. The lowest total solids had stirred yoghurt – sample 2 (9.05%). Energy values of fermented products varied in dependence of milk fat content.

<table>
<thead>
<tr>
<th>Sample</th>
<th>pH</th>
<th>Total solids (%)</th>
<th>Total solids without fat (%)</th>
<th>Ash (%)</th>
<th>Total protein (%)</th>
<th>Total sugar (%)</th>
<th>Energy value (kJ/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.22</td>
<td>11.59</td>
<td>8.29</td>
<td>0.77</td>
<td>2.99</td>
<td>4.53</td>
<td>261</td>
</tr>
<tr>
<td>2</td>
<td>4.23</td>
<td>9.05</td>
<td>8.95</td>
<td>0.70</td>
<td>3.12</td>
<td>5.03</td>
<td>148</td>
</tr>
<tr>
<td>3</td>
<td>4.40</td>
<td>11.14</td>
<td>10.04</td>
<td>0.76</td>
<td>3.08</td>
<td>6.20</td>
<td>206</td>
</tr>
<tr>
<td>4</td>
<td>4.30</td>
<td>10.63</td>
<td>7.54</td>
<td>0.74</td>
<td>2.93</td>
<td>3.86</td>
<td>241</td>
</tr>
<tr>
<td>5</td>
<td>4.28</td>
<td>11.85</td>
<td>7.67</td>
<td>0.71</td>
<td>3.06</td>
<td>3.88</td>
<td>286</td>
</tr>
<tr>
<td>6</td>
<td>4.54</td>
<td>17.35</td>
<td>8.11</td>
<td>0.89</td>
<td>3.29</td>
<td>3.97</td>
<td>487</td>
</tr>
<tr>
<td>7</td>
<td>4.17</td>
<td>16.16</td>
<td>8.68</td>
<td>0.86</td>
<td>3.48</td>
<td>4.32</td>
<td>430</td>
</tr>
</tbody>
</table>

**Rheological characteristics of fermented dairy products**

The rheological characteristics were analyzed after production and after 14th day of storage of the samples at +4°C. The obtained results indicate that all samples are thixotropic system (Figure 1). All fermented dairy products exhibited a typical shear thinning, thixotropic and time-dependent flow behavior as described by Rohm (1993) (8) and Patocka et al. (2007) (10). A higher yield stress was noticed in the type of set yogurts than in stirred yoghurts, which is a result of better networking of its matrix and absence of final stirring. It was noticed that the samples produced from milk with 3.2% fat had significantly higher yield shear stress than samples produced from milk with 0 and 1.0% fat in the group of stirred yoghurts. These values were in accordance with the literature data (16-18).
During the storage (14 days), all samples of stirred yoghurt showed similar rheological characteristics compared to this properties after the production. Two set yoghurt (samples 5 and 7) had better rheological properties and higher value of yield stress compared to the values after production (Figure 2).

Values of the hysteresis loop area were calculated based on the flow curves of fermented dairy products (Figure 3). The hysteresis loop area (HLA) is the indicator of yoghurt structural breakdown and rebuilding (degree of thixotropy) during shearing (19, 20). Samples of the set yoghurts showed the highest hysteresis loop area values at +4°C, followed by the samples of stirred yoghurt. The highest values of HLA in set yoghurt indicate better structural reversibility of these samples during the shearing. The differences in the value of HLA among different types of fermented milk products could be explained by a structuring effect of using starter culture, different chemical composition of samples, and process parameters during the manufacture (18, 21). The average HLA va-
value of stirred fermented dairy products is 1180 Pa/s. The set yoghurt samples had much higher values of HLA, then stirred yoghurt, and also higher values in comparison to the literature data.

Figure 3. Hysteresis loop area of fermented milk products

These results are in correlation with the results of textural characteristics which were also higher after 14 days of storage.

Textural characteristics of fermented dairy products

Textural characteristics of fermented dairy products after the production are presented in Table 2. The type of fermented milk products and its chemical composition had significant impact on the overall textural characteristics of the samples, which is also presented in the literature (22, 23).

Table 2. Textural characteristics of fermented dairy products after production

<table>
<thead>
<tr>
<th>Sample</th>
<th>Firmness (g)</th>
<th>Consistency (gs)</th>
<th>Cohesiveness (g)</th>
<th>Index of viscosity (gs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>17.207±1.27</td>
<td>435.508±30.84</td>
<td>-11.352±1.40</td>
<td>-7.556±1.89</td>
</tr>
<tr>
<td>2</td>
<td>13.979±0.22</td>
<td>354.037±4.88</td>
<td>-8.632±0.29</td>
<td>-3.109±0.10</td>
</tr>
<tr>
<td>3</td>
<td>13.468±0.13</td>
<td>346.188±5.77</td>
<td>-8.384±0.10</td>
<td>-3.048±0.07</td>
</tr>
<tr>
<td>4</td>
<td>13.949±0.36</td>
<td>352.534±5.57</td>
<td>-8.241±0.11</td>
<td>-2.975±0.16</td>
</tr>
<tr>
<td>5</td>
<td>192.268</td>
<td>3667.425</td>
<td>-101.455</td>
<td>-206.740</td>
</tr>
<tr>
<td>6</td>
<td>38.157±0.68</td>
<td>914.412±46.12</td>
<td>-25.824±0.66</td>
<td>-75.135±1.61</td>
</tr>
<tr>
<td>7</td>
<td>356.994</td>
<td>7119.068</td>
<td>-177.505</td>
<td>-338.767</td>
</tr>
</tbody>
</table>

The lowest firmness was obtained for the samples of stirred yoghurts. The firmness of stirred yoghurt (samples 1, 2, 3 and 4) was between 13.468 g (sample 3) and 17.207g (sample 1). The lowest firmness for the set yoghurt had sample 6 (38.157g) and the highest sample 7 (356.994g). Like firmness, the lowest cohesiveness was obtained for stirred yog-
hurt, between -8.241 g (sample 4) and -11.352 g (sample 1). The set yoghurts had higher cohesiveness. Among them, sample 6 again had the lowest (-25.824 g) and sample 7 the highest value (-177.505 g).

Moreover, sample 7 of set yoghurt had the highest value of textural characteristics, which is in correlation with the chemical composition. As it was expected, the stirred yoghurt had significantly lower values of all textural characteristics due to the different technological process of production and final stirring of the products. Even, addition of 1.5 % oligofructose to samples 3 did not improve its textural characteristics, which indicated a more significant impact of the milk fat content (sample 1-3.2% milk fat, sample 3-1.0% milk fat) on textural characteristics of this type of fermented milk products. These results are in correlation with the rheological characteristics and chemical compositions of the samples.

During the storage, the textural characteristics of all types of fermented dairy products changed. The changes of firmness of the samples are shown in Figure 4. The obtained values of firmness were higher on the 14th day than on the 7th day of storage. The activity of the applied starter culture (postacidification) and fat content during the storage had a great influence on the measured values of firmness. These results are in concordance with the previous data (17,18).

![Figure 4](image)

**Figure 4.** Firmness of fermented milk products during storage: a) stirred yoghurt, b) set yoghurt

**CONCLUSION**

The differences in the physico-chemical, rheological and textural characteristics between two groups (seven samples) of fermented dairy products after the production and during 14 days of storage were observed.

The obtained results showed that the total solids, milk fat content and starter cultures had great influence on the quality of the analyzed samples. The highest yield stress and hysteresis loop area were noticed in the type of set yoghurts. The results of the rheological parameters of fermented dairy products are in correlation with their textural characteristics.

Set yoghurts had better textural characteristic (firmness, consistency, cohesiveness and index of viscosity) in comparisons to stirred yoghurt samples. Generally, during the
storage samples of stirred and set yoghurt showed better rheological properties and higher firmness compared to the values after the production.

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REFERENCES


УТИЦАЈ САДРЖАЈА МЛЕЧНЕ МАСТИ И СТАРТЕР КУЛТУРЕ НА КВАЛИТЕТ ФЕРМЕНТИСАНИХ МЛЕЧНИХ ПРОИЗВОДА

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Испитан је утицај масти и врсте стартер културе на физичко-хемијски квалитет, реолошке и текстуралне карактеристике ферментисаних млечних производа током 14 дана складиштења. Анализиране су две различите групе ферментисаних млечних производа: течни и чврсти Јогурт.

Узорци чврстог Јогурта имају боља реолошка својства и веће вредности текстуралних карактеристика (чврстоћа, конзистенција, кохезивност и индекс вискозите-
та) у поређењу са узорцима течног јогурта. Током периода складиштења узорци течног јогурта показују сличне карактеристике, као и након производње. Вредности приносног напона, површине хистерезисне петље и чврстоће су веће код два узорка чврстог јогурта током складиштења у поређењу са анализираним параметрима након производње.

Кључне речи: ферментисани млечни производи, стартер културе, реологија, текстура

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