Effect of lactic acid bacteria producing exopolysaccharide on physico-chemical and rheological properties of Iranian white cheese

Sara Rezazadeh¹, Mohammad Hojjatoleslany²*, Sahel Soha³, Mohammad Ali Shariati³

ABSTRACT: Iranian white cheese, a saltwater cheese, is reaching the stage of containing high concentrations of salt in the brine of calcium chloride up. Exopolysaccharide production of lactic acid bacteria in recent years due to their role in the rheology and texture of food is of great interest. Salt water white cheese samples were prepared using cow's milk. Control samples, cheese produced by a non-starter exopolysaccharide, and a sample cheese made with lactic culture capable of producing exopolysaccharide produced by Christian Hansen company name was R704 and R708. In this study, full-fat cheese and low-fat cheese ripening process after 45 days, 45 days and 90th after reaching chemical and rheological properties of Iranian white cheese were based on national standards. The results showed that cheeses made with exopolysaccharides produced the highest humidity in my 45 day compared to control cheeses were. In the 45th day after cheese tissue production of the exopolysaccharide starter in the context of utility, comparing the two starter exopolysaccharide produced cheeses with more desirable than cheeses made with starter R704 R708 starter had. Compared to the full-fat cheese, low-fat cheeses had higher moisture content.

Keywords: Iranian white cheese, exopolysaccharide, Physico-chemical properties, Texture

INTRODUCTION

Iranian white cheese, is important in the diet of our people. The cheese in brine reaches its maturity, on an industrial scale is about 30 to 45 days. After the initial period to reach maturity, the samples were stored for 45 days at 4°C (Ehsani et al., 2011).

International Organization for Standardization (ISO, 1992) as Food texture all rheological characteristics, structural (surface), features the tangible product is defined using the sense of touch. Characteristics of the tissue plays a major role in the buying decision is for the consumer. For some foods, the texture is more important than flavor and color of the product is to the consumer. The main character texture quality cheese. The overall mouth feel and flavor of the cheese is taken into consideration (Gunasekaran et al., 2003).

The use of exopolysaccharide (EPS), producing lactic acid bacteria (LAB) could be a potential attention for thickening agents to increase moisture content and improve texture cheese. Since many LAB are food grade microorganisms with generally recognized as safe (GRAS) application, use of their EPS in food has an obvious advantage over polysaccharides produced by non-food grade bacteria, such a dextran, gellan, pullulan, xanthan and bacterial alginates (Dabour et al., 2006).
exopolysaccharides produced by lactic acid bacteria in recent years because of its role in the rheological properties and texture of the food has been great. This type of lactic acid bacteria with beneficial intestinal flora to create EPS (probiotics), Able to produce functional products with high storage capacity and the flavor is good,(Ghamari, 2009).

One of the main applications of biotechnology in food additive is produced. Among the additives that are produced using biotechnology We can produce various microbial polysaccharides such as Exopolysaccharides produced by lactic acid bacteria in dairy products noted (De Vuyst et al., 1997).

The aim of this study was to investigate the effect of exopolysaccharides produced by lactic acid bacteria triggers the chemical and rheological properties of Iranian white cheese. The use of exopolysaccharides produced by lactic acid bacteria can potential alternative to retain moisture and improve the texture features and the increasing acceptance of the final product. The specific polysaccharide secreted by lactic acid bacteria, during the fermentation process, fermentation product can improve stability and sensory characteristics.

**MATERIALS AND METHODS**

**Materials**
- Milk: For the production of cheese, made from fresh cow's milk was used Golpayegan Pegah Dairy Company.
  - features full-fat milk (Acidity: 15, pH: 6.69, fat: 2.9)
- initiate extracellular polysaccharides Lactococcus lactis Subsp. Cremoris and Lactococcus lactis subsp. Lactis Prepared by the Company CHRHansen Denmark with ID code (R704 and R708).

**Cheese making**
Iranian white cheese with low fat milk 1.35% fat the control samples were produced at levels cheese factory is Golpayegan, samples produced with starter R704, Samples produced with starter R708 and the sample produced with starters R704+R708 the were mixed to following formulations factory production. Four other Iranian white cheese with whole milk 2.9% fat were prepared by previous starters.

Iranian white cheese made from cow's milk produced in the factory of Pegah Golpayegan. Specified amount of raw milk pasteurized for 15 seconds at a temperature 78 °C then was cooled to a 35 °C temperature. The starting temperature was added to the the starting temperature was added to the and then about 30 minutes to reach the starting pH 6.2-6.3 milk was time. Rennet is then added and the clotting time of milk into curd.

After coagulation and clot formation with longitudinal and transverse slices over gore sugar cube-sized pieces of the clot was in order to achieve a pH of approximately 5.1 and water separation clot was forming.

Then the mold in salt water for 4 hours were up 20% to a final pH 4.8 is achieved. The mold cheese in brine 12% at 45 days temperature 4-5 °C in aleppo for the maintenance during cheese ripening period is up.

**Chemical analysis**
Cheese samples produced on chemical tests mensuration moisture, dry matter, proteins, fat, acidity and pH according to the relevant national standards On days 45 and 90 (middle reach a maximum time period imaginable for) after production were tested and evaluated.

**Amount moisture**
The moisture content of samples per cent National Standards No. 1357 Were determined (National Standard 1753: 1379). 5 g samples taken constant weight in a container that has already been and weighed to have uniform sample and placed in an incubator 100 °C to 105 °C until constant weight is reached (completely dry). The difference in weight, moisture and volatile matter is and what remains is a dry extract.

**Fat**
Fat samples were determined according to Standard No. 760 (method jerber) (National Standard 760: 1349).

**Measurement of protein**
Protein samples in terms of dry matter were determined in accordance with national standard No. 1811 (National Standard 1811: 1377).
Acidity and pH

Cheese acidity and pH were measured according to standard national numbers in 2852 (National Standard 2852: 1371).

Texture profile analysis (TPA)

In this study to assess the texture of the cheese machine Texture Analyzer Brookfield Model: CT3 4500, rate 0.5 mm sec, and parts for cheese 20×20×20mm was used. The TPA test compaction force 50% of the pieces of cheese during the sweep cycle texture by brookfield by probe TA 3/1000 was applied and factors: Hardness, Springiness, Cohesivness, Adhesivness, Chewiness Gumminess examined.

Statistical Analysis

Design of experiments using factorial experiment was conducted in a completely randomized design with three replications. A comparison between the results obtained by Duncan's multiple range test using Software SPSS version 18 was investigated.

RESULTS AND DISCUSSION

According to table 1, 2, 3 and 4 can be seen the acidity of cheese fat and low-fat cheese the time to maturity is increased. The use of high-fat cheese use exopolysaccharide R704 and R708 causes significant changes (the 95% confidence level), the acidity in the cheese producing exopolysaccharide were compared to the control cheese. The starter of the EPS in the preparation of low-fat cheese has no effect on the acidity of the samples.

According to tables 1, 2, 3 and 4 can be seen the pH of the cheese-fat and low-fat cheese during ripening has declined over time.

Results acidity and pH in different treatments Iranian white cheese on days 45 and 90 post-production suggests that, production of lactic acid by lactic bacteria strains, low pH reduced the amount of and increases its acidity (Dorosti et al 2010).

With the advancement of cheese ripening, reducing the inhibitory effect of lactose and lactic acid. The activities of some strains of lactic decreases the amount of acid produced and consequently, the titratable acidity is not increased. The pH value is reduced during cheese ripening. Studies Aly, Lindsay and Katsiari cheddar cheese on Ultrafiltration fat a the results of the present study is similar (Aly 1995; Lindsay et al., 1982; Katsiari et al., 2000).

Polysaccharides secreted by lactic bacteria terms of structure and high molecular weight polysaccharide Will increase water absorption. Since polysaccharides bind to water and moisture retention properties are its implementation is a key strategy for improving the performance of low-fat cheese (Tadayoni et al., 2009). According to Table 1, In the 45 th day after cheese fat production, there was no significant difference between the moisture content of the samples, but cheese control in the cheese produced in the lowest moisture the starter was exopolysaccharide, and in the cheeses made with starter R704 and R704 + R708 had the highest moisture content. The increased moisture similar Zius and Shah in 2007 research on low-fat Mozzarella cheese is this is the lowest level of moisture cheese of the polysaccharide was observed in the control cheese (Zius and shah, 2007).

In 2001, using primers for the exopolysaccharide-producing have studied the properties of low-fat cheese. The data obtained from this study showed EPS which increase moisture retention and improve Mozzarella cheese is melting (Jeffery et al., 2001).

I'm on day 90 post-production and increased shelf-life, I have reduced moisture retention over 45 days and cheese production EPS triggers moisture showed less than in the control cheese. This process reduces the moisture, similar study Lavasani in 2006, the researchers effects of partial replacement of NaCl with of KCl on the physicochemical properties, sensory and rheological Iranian white cheese was studied. Data from this study can be downloaded during the entire treatment process, a slight decrease of the moisture content, and between different treatments found no significant difference in the amount of moisture (Lavasani et al., 2006). The cause can be
caused due to prolonged storage in salt water is reverse osmosis. See tables 1, 2, 3 and 4 can be downloaded the proportion of low-fat cheese the fat cheese moisture is higher.

Field moisture, I'm on day 45 post-production, there was no significant difference between the samples, but most of the moisture cheeses made with EPS' starter the high moisture content of the cheese produced in the R704 and R704+R708 were maintained in tissue the cheese produced with starter EPS with ID R704 Showed a higher ability to retain moisture. With increasing survival time, cheese moisture dropped and high moisture content in cheese was observed, reduced-fat cheese are also considerably higher moisture retention in the context of full-fat cheese showed.

See also table 5, reduced-fat cheese and full-fat cheeses had significantly more protein. The difference between the moisture content and low-fat cheese and fat, it is probably due to differences in protein content, So that high levels of fat and protein in cheese may be dropped protein network with high water absorption and therefore it is much higher (Romeih et al., 2002).

Tables 1, 2, 3, and 4 dry-fat and low-fat cheeses on days 45 and 90 the Iranian white cheese show. 45 th day after cheese ripening by high-fat and low-fat cheese, no significant differences were observed in dry matter. Karami in 2009, changes in rheological properties of cheese during ripening of Iranian Ultrafiltration Ftay looked. Studies show that during periods of significant changes were observed in the dry matter of cheese (Karami et al., 2009).

But in my 90 days of high-fat and low-fat cheese, the control cheese and cheeses prepared EPS a primer significant difference was observed at 95% and increases the shelf-life of dry matter was followed. Fat Iranian white cheese in terms of different treatments on days 45 and 90 in table 1, 2, 3 and 4 are shown. The graphs can be observed between the different treatments found no significant difference in the percentage of fat (p>0.05) was observed. The results with the results of studies Aly and Katsiari on feta cheese (Aly 1995; Katsiari et al., 2000), Fitzgerald and Buckley on cheddar cheese (Fitzgerald and Buckley; 1989), and Lavasani Corresponded on Iranian white cheese (Lavasani et al., 2006).

**Table 1.** Chemical evaluation of full-fat cheese daily 45

<table>
<thead>
<tr>
<th></th>
<th>R704+R708</th>
<th>R708</th>
<th>R704</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>68.24</td>
<td>65.2</td>
<td>68.54</td>
<td>64.29</td>
</tr>
<tr>
<td>Dry matter</td>
<td>31.76</td>
<td>34.8</td>
<td>31.46</td>
<td>35.71</td>
</tr>
<tr>
<td>Acidity</td>
<td>0.27</td>
<td>0.285</td>
<td>0.345</td>
<td>0.375</td>
</tr>
<tr>
<td>pH</td>
<td>4.44</td>
<td>4.47</td>
<td>4.38</td>
<td>4.39</td>
</tr>
<tr>
<td>Fat</td>
<td>16.83</td>
<td>17.6</td>
<td>17.5</td>
<td>17.83</td>
</tr>
</tbody>
</table>

The letters a, b... show no significant difference (at 95% confidence level) is the difference between samples

**Table 2.** Chemical evaluation of full-fat cheese daily 90

<table>
<thead>
<tr>
<th></th>
<th>R704+R708</th>
<th>R708</th>
<th>R704</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>60.07</td>
<td>61.87</td>
<td>62.88</td>
<td>65.67</td>
</tr>
<tr>
<td>Dry matter</td>
<td>39.92</td>
<td>38.287</td>
<td>37.11</td>
<td>34.32</td>
</tr>
<tr>
<td>Acidity</td>
<td>0.96</td>
<td>0.525</td>
<td>0.975</td>
<td>0.75</td>
</tr>
<tr>
<td>pH</td>
<td>3.91</td>
<td>3.84</td>
<td>3.93</td>
<td>3.9</td>
</tr>
<tr>
<td>Fat</td>
<td>17.5</td>
<td>17.33</td>
<td>18.16</td>
<td>17.33</td>
</tr>
</tbody>
</table>

The letters a, b... show no significant difference (at 95% confidence level) is the difference between samples

**Table 3.** Chemical assessment 45 th day of low-fat cheese

<table>
<thead>
<tr>
<th></th>
<th>R704+R708</th>
<th>R708</th>
<th>R704</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>73.58</td>
<td>72.28</td>
<td>73.14</td>
<td>71.22</td>
</tr>
<tr>
<td>Dry matter</td>
<td>26.41</td>
<td>27.72</td>
<td>26.85</td>
<td>28.77</td>
</tr>
<tr>
<td>Acidity</td>
<td>0.42</td>
<td>0.435</td>
<td>0.405</td>
<td>0.495</td>
</tr>
<tr>
<td>pH</td>
<td>4.56</td>
<td>4.64</td>
<td>4.74</td>
<td>4.49</td>
</tr>
<tr>
<td>Fat</td>
<td>9.16</td>
<td>8</td>
<td>8.33</td>
<td>8.5</td>
</tr>
</tbody>
</table>

The letters a, b... show no significant difference (at 95% confidence level) is the difference between samples
Table 4. Chemical assessment 90th day of low-fat cheese

<table>
<thead>
<tr>
<th></th>
<th>R704+R708</th>
<th>R708</th>
<th>R704</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>63.48</td>
<td>63.6</td>
<td>63.43</td>
<td>68.81</td>
</tr>
<tr>
<td>Dry matter</td>
<td>36.52</td>
<td>36.4</td>
<td>36.56</td>
<td>31.18</td>
</tr>
<tr>
<td>Acidity</td>
<td>0.825</td>
<td>0.9</td>
<td>0.975</td>
<td>1.05</td>
</tr>
<tr>
<td>pH</td>
<td>4.08</td>
<td>4.14</td>
<td>4.08</td>
<td>4.29</td>
</tr>
<tr>
<td>Fat</td>
<td>10.33</td>
<td>11.66</td>
<td>11.5</td>
<td>11.66</td>
</tr>
</tbody>
</table>

The letters a, b... show no significant difference (at 95% confidence level) is the difference between samples.

Table 5. Measurement of protein 45th day of cheese

<table>
<thead>
<tr>
<th></th>
<th>Low-Fat</th>
<th>Full-Fat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>49.28</td>
<td>32.70</td>
</tr>
<tr>
<td>R704</td>
<td>36.18</td>
<td>30.1</td>
</tr>
<tr>
<td>R708</td>
<td>44.37</td>
<td>35.96</td>
</tr>
<tr>
<td>R704+R708</td>
<td>44.58</td>
<td>28.82</td>
</tr>
</tbody>
</table>

The letters a, b... show no significant difference (at 95% confidence level) is the difference between samples.

Sensory evaluation

Figure 1. full-fat cheese sensory evaluation

Figure 2. sensory evaluation of low-fat cheese
The sensory evaluation of low-fat cheese initiated by extracellular polysaccharides improves the texture of the cheese, but fat cheese primers extracellular polysaccharide statistically significant difference in the texture of the cheese and the cheese was not seen.

**Features tissue**

**Texture analysis**

Iranian white cheese texture profile analysis test results are as follows:

**Springiness**

Represents the continuity of deformation is in one instance, when pressed by teeth grinding, before rupture occurs body building products and relies heavily on domestic bonds (Fox et al., 2000; Gunasekaran et al., 2003). According to figure 1 and 2, springiness the control cheeses and cheeses made with starters of EPS is no significant difference. Two variable EPS and fat, significant effect the continuity of cheese had not and treatments were not significantly different. These results are similar to results of Hassan Rashidi in 2011 ultrafiltration of cheese was on feta (Rashidi et al., 2011). Ziua and Shah in 2005 the cause of this phenomenon weaknesses in the internal link structure with soft cheeses to know more the resulting pressure on the cheese fabric by the meter easily and irreversible deformation occurs (Ziua and shah, 2005). According to the survey results, Coca in 2004 the Springiness between high-fat and low-fat cheese samples, no significant differences were reported (Koca and Metin et al., 2004).

![Springiness full-fat cheese, 45 and 90 day](image1)

![Springiness low-fat cheese, 45 and 90 day](image2)

**Gumminess**

Is the energy required to grind a semi-solid food when they are ready to be swallowed (Fox et al., 2000; Gunasekaran et al., 2003). According to figure 3 and 4 can be seen the resinous form of the full-fat cheese, low-fat cheese, gumminess increased. A review Hassan Rashidi in 2011 ultrafiltration on cheese feta, the survey data was the extreme fat loss treatments that have been reducing the amount of gumminess condition is severe. Increases with increasing fat resinous form (Rashidi et al., 2011).
Chewiness

Is the energy required to chewiness a solid food until ready to swallow and chewiness or ingesting a certain amount of food is necessary (Fox et al., 2000; Gunasekaran et al., 2003). Due to the high-fat and low-fat cheese graphs 5 and 6 45 th and 90 th day after production, control cheese least have chewiness and the maximum chewiness made of cheese the starter is the EPS. Unlike the results of research Ahmed in 2005 and Zius and Shah in 2005. In this study, using EPS Chewiness condition was reduced relative to the control sample (Ahmed et al., 2005; Zius and Shah, 2005). In this study, in the case of full-fat cheese, low-fat cheese than in reduced chewiness. Variable effect of EPS The chewiness was significant at Increase in chewiness form. Coca in 2004 a study, reducing the amount of fat, chewiness decreased (Koca and Metin et al., 2004).

Adhesivness:

The sense of perspective the force required to separate the food from the roof of the mouth while eating and in terms of mechanical work required to overcome the adhesivness forces between the food and other food substances that are in contact with them (Fox et al., 2000; Gunasekaran et al., 2003). Figure 7 is the there is the adhesivness of the cheese is high in fat, with increased shelf-life. According to figures 7 and 8 is the adhesivness of low-fat cheese, fat and increasing shelf-life is increased. In 2010, Costa et al. the effect of EPS on the half-fat cheddar cheese texture, the study came to the same conclusion (Costa et al., 2010). Reducing the amount of fat
or of adhesiveness required to separate the probe from the sample decreased. This result is similar to a survey in 2007 by Ziust et al.; the 90th day of low-fat cheese Mozzarella cheese were the most adhesiveness (Zius and Shah, 2007).

**Cohesivness**

The sense of perspective degree or intensity of the partial pressure of the sample between the tongue and the roof of the mouth and goes back to its original size and the mechanical view of the deformed after removing the power goes back to its original state (Fox et al., 2000; Gunasekaran et al., 2003). According to figure 9 and 10 am on day 45 post-production fat cheese the cheese samples produced with starter EPS and control samples significant differences (The 95% confidence level) there are the lowest cohesivness is related to the control cheese. Maximum cohesivness the fat cheese the cheese is made R704 is a starter and low-fat cheese, cheese made with starter R704+R708 have the highest cohesivness.

90th day after the full-fat cheese, most of those related to cheese made cohesivness with starter R704. The low-fat cheese, cheese made with starter R708 maximum cohesivness was and total cheese produced the starter of the EPS maximum cohesivness was compared to the control cheese.

Zius and Shah in 2005, Low-fat Mozzarella cheese on a survey conducted the Cohesivness of the starter EPS and the use of whey protein concentrate increased compared to the control cheese. Starter EPS significant effect the cohesivness was cohesivness is increased. Because it increases the effect of moisture and reduce the rigidity of the protein matrix of cheese weakness, and thus reduce its ability to return to its original shape after removing as much power (Zius and Shah, 2005).

The low-fat cheese, with reduced fat cohesivness is reduced. Hassan Rashidi in 2011 by examining the different treatments in the percentage of fat in the attachment to this conclusion (Rashdi et al., 2011). Saint-Eve in 2009 cohesivness of low-fat cheese reported less than full-fat kind (Saint-Eve, 2009).
Hardness

Sense in terms of the force required to compress the sample between the teeth grinding and the mechanical force necessary to achieve the vision a transformation is specified (Fox et al., 2000; Gunasekaran et al., 2003). Figure 11 shows the after 45 days of full-fat cheeses, which have the greatest difficulty, the control cheese and less hardness cheese made EPS is devoted to the starter. Use of starter EPS 45 day the cheese is soft tissue. However, increasing the shelf-life in my 90 days of production, this trend has changed this day is less strict controls and cheese.

According to figure 12, it can be seen that the low-fat cheese on day 45 of my most hardness cheese is to control my cheese produced in 45 days the starter EPS soft tissue more were compared to the control cheese. However, have 90 days after the production process has changed the least difficult to control cheese and most hardness cheeses are made with starter of EPS. Zius and Shah in 2007, low-fat Mozzarella cheese texture features were examined the results indicate the starter of the EPS tissue stiffness is reduced compared to the control cheese (Zius and Shah, 2007). This result is similar with the results. But there is a point, in review Zius and Shah increasing the shelf-life hardness cheese produced with starter of EPS has declined, but with increasing duration of survival hardness cheese produced with starter of EPS has been enhanced, and texture of the cheese is more difficult. The researchers in 2005 mozzarella cheese by using starter concentrates in the study of protein and EPS reached this conclusion (Zius and Shah, 2005).

In 2005, the Ahmed improved the textural properties of cheese Karish signed off by the acidic extracellular polysaccharides cultures studied. Our results indicate that the use of cultured EPS the lack of hardness cheese starter is reduced by EPS (Ahmed et al., 2005).

Comparison of high-fat cheese and low-fat cheese, show hardness cheese produced in the lower-fat cheeses with higher fat content. In both types of cheese starter R704 desires other starters of EPS found in this study.
Discussion

The results of this study indicate that the use of starter EPS to improve the moisture Iranian white cheese to be effective, but the long-term maintenance of this type of cheese in brine the activity of lactic acid bacteria manufacturer of low EPS due to the high concentration of salt water little impact on improving moisture retention Iranian white cheese has a long life. Reduced-fat cheese considerably more protein and moisture of full fat cheese. In the sensory evaluation of low-fat cheese made the starter exopolysaccharides were higher rating.

Use the starters EPS to improve the texture of Iranian white cheese can be effective, but the long-term maintenance of this type of cheese in brine the activity of lactic acid bacteria producing EPS low due to the high concentration of salt water have little impact on improving the texture of Iranian white cheese.

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National Standard No. 16349-2: in 1392, the milk and milk products - Sensory analysis - Recommended methods for sensory evaluation.

National Standard No. 16349-3: in 1392, the milk and milk products - Guidance for the assessment of conformity with product specifications for sensory properties and scoring methods.


