Investigation of potential prebiotic activity of rye sprout extract

Negin Noori, Hassan Hamed, Mina Kargozi, Peyman Mahasti Shotorbani

**A B S T R A C T**

Rye (Secale cereale) is one of a number of cereal species that grow wild in the northwest of Iran, Turkey, and Central Asian countries. It is revealed that sprouts possess higher vitamins, antioxidant, flavonoids and fiber than grains. For evaluation of the potential prebiotic activity of rye sprout extract (RSE), the grains were soaked in water, germinated and dried by a freeze-dryer. The in-vitro viability and relative growth ratio (RGR) of probiotic bacteria, as well as their antimicrobial activities and their retention in symbiotic yogurt during 56 days cold storage in presence of RSE, were investigated. The sensory properties (odor, color, texture, taste and overall acceptance) of symbiotic yogurt with different amounts of RSE in comparison with control group were evaluated. The results showed that adding various concentrations of RSE increased the viability of both *Lactobacillus acidophilus* and *Bifidobacterium animalis* (p < 0.05), although this increase in *B. animalis* was better than *L. acidophilus*. Comparison of RGR of treated samples indicated that adding RSE even 0.25% can increase the growth and survival of probiotic in comparison with control. The results also showed that adding of RSE promoted the antimicrobial activities of probiotics. In symbiotic yogurt, probiotic populations remained higher than the minimum recommended therapeutic dose for an extended period of cold storage. There was no significant difference between sensory parameters of control specimens and symbiotic yogurt. According to our results, the symbiotic effect of RSE and probiotics highlights the potential application of RSE as a prebiotic in dairy and other functional products.

**ARTICLE INFO**

Keywords: Rye sprout extract Prebiotic *Lactobacillus acidophilus* *Bifidobacterium animalis* Antimicrobial activities Synbiotic yogurt

1. Introduction

The term “functional food” refers to a normal type of food with an additional ingredient that provides a health benefit beyond satisfying traditional nutrient requirements (Gonzalez, Adhikari, & Sancho-Madriz, 2011). Nowadays, functional foods are an exciting trend in food industries and nutrition field (Bigiardi & Galati, 2013). Probiotics and prebiotics are used as functional components in dairy products in order to obtain maximal health benefits. The term probiotic is defined as “live microorganisms which when administered in adequate amounts confer a health benefit on the host” (Hill et al., 2014) and prebiotic is specified as a non-digestible food ingredient that beneficially affects the host by selectively stimulating the growth and/or activity of the gastrointestinal microflora, and thus improves the host health (Gibson, 2004; Roberfroid, 2007). Probiotic bacteria cannot thrive well in digestive tract without prebiotics (Cruz et al., 2010). The combination of probiotics with prebiotics has a synergistic effect on the host health (Krumbeck, Maldonado-Gomez, Ramer-Tait, & Hutkins, 2016). It has been suggested that adding non-digestible food ingredients known as prebiotics to certain foods may increase the viability of bacteria passing through the gastrointestinal tract and thus exert a beneficial effect on human health (Iyer & Kailasapathy, 2005; Khalf, Dabour, & Fliss, 2010; Mookiah, Siew, Ramasamy, Abdullah, & Ho, 2014). Prebiotic activities of some cereal ingredients such as inulin, fructooligosaccharides (FOS) and galactooligosaccharides (GOS) have been confirmed (Bhattacharyya et al., 2015; Fernandes, do Rosario, Mocellin, Kunz, & Trindade, 2016).

Rye (Secale cereale) is one of a number of cereal species that grow wild in the northwest of Iran, Turkey and Central Asian countries (Zeder, 2008). Rye is widely used to make crisp bread, and it has high amount of gliadin and low content of glutenin. It also contains a higher proportion of soluble fiber, which may be useful in controlling energy intake and reducing the risk for development of obesity (Astrup & Brand-Miller, 2012; Pietzak, 2012). Rye plant has a rather high content of natural antioxidants compared to wheat and other cereals. It is revealed that rye sprout possesses higher vitamins, antioxidant, flavonoids and fiber than its grain (Goncharenko & Timoshchenko, 2014).

Additionally, yogurt is the most popular dairy fermented product and traditional food for a lot of consumers in the world due to its...
therapeutic, nutritional, and sensory properties (Yildiz, 2016). According to mentioned issues and nutritional value of rye as well as the possibility of use of RSE as prebiotic in fermented products and food supplementation, the main goal of the present study was to investigate the potential prebiotic activity of rye sprout extract including the in-vitro viability and relative growth ratio (RGR) of probiotic bacteria, as well as their antimicrobial activities, sensory characteristics and their retention in synbiotic yogurt during cold storage at 4 °C.

2. Materials and methods

2.1. Microorganisms and chemicals

Yogurt starter culture containing Lactobacillus delbrueckii subsp. bulgaricus and Streptococcus salivarius subsp. thermophiles were purchased from Chr. Hansen Company (Horsholm, Denmark). Lyophilized strains of Lactobacillus acidophilus LA-5 and Bifidobacterium animalis subsp. lactis, strain BB-12 were obtained from the microbial collection of Department of Food Hygiene, University of Tehran on the basis of their experience in the sensory analysis. In each analysis, diﬀerent incubation times (0, 12, 24 and 48 h) compared to zero time (t=0), as indicated by the corresponding subscript. An RGR value greater than unity indicates that the tested RSE exerts a growth stimulant effect on LA-5 and BB-12, in comparison to G as a simple carbon source (Rubel, Pérez, Genovese, & Manrique, 2014).

2.2. Preparation of water extract of rye sprout

Rye (Secale cereale) was supplied from Jolfa City (northwest of Iran) and identified by Iranian Institute of Medical plants. Grains of rye were soaked in water for 72 h and after six days the sprouts will have grown to 5–8 cm. Fresh rye sprouts were dried by a freeze-dryer (Operon Co, FDO-8606, Gyeonggi-do, South Korea). The dried germinated grains were powdered using a grinder soaked in distilled water, shaken for 48 h and then filtered. This procedure was repeated again by distilled water and the pooled filtrate was freeze-dried again for 48 h. The dried extract was stored at 4 °C until use.

2.3. In vitro prebiotic activity of rye sprout extract

The necessary inoculum of each probiotic was prepared by inoculating from the lyophilized culture in de man-rogosa-sharpe (MRS) broth which was incubated for 18 h at 37 °C. Second subcultures were prepared in the same condition. The bacterial suspension was adjusted to optical density of 0.1 at 600 nm, using a Spectronic 20 spectrophotometer (Milton Roy Company, Rochester, NY) and enumerated by duplicate plating from 10-fold serial dilutions on MRS agar and counting the colonies after 24 h incubation at 37 °C. Working cultures were adjusted to the required concentration of 10⁶ CFU ml⁻¹. To evaluate the prebiotic activity of rye sprout extract (RSE), the media with different concentrations of RSE (0%, 0.25%, 0.5%, 0.75%, and 1%, w/v) were prepared and inoculated with approximately 10⁶ CFU ml⁻¹ of activated L. acidophilus LA-5 and B. animalis BB12. The modified media that contain glucose was used for incubation of prebiotic inoculum at 37 °C for 48 h. The enumeration of LA-5 and BB12 was carried out on MRS and MRS-C (0.05% l-cystine, w/v) agar (Merck, Darmstadt, Germany) at different incubation times (0, 12, 24 and 48 h) aerobically and anaerobically, respectively.

2.4. Relative growth ratio (RGR)

For assessment of the in-vitro prebiotic activity of RSE samples, the relative growth ratio of the probiotic LA-5 and BB-12 were calculated using the expression:

\[
RGR = \left( \frac{B_t - B_0}{G_t - G_0} \right)_p
\]

where p subscript indicates probiotic bacteria (LA-5 and BB-12), P represent the growth rates of probiotics with different concentration of RSE (0.25%, 0.5%, 0.75%, and 1%, w/v) in comparison with G as a basal carbon source of the medium (glucose; 0.5% w/v), at different times of incubation (t = 2, 4, 8, 12 and 24 h) compared to zero time (t=0), as indicated by the corresponding subscript. An RGR value greater than unity indicates that the tested RSE exerts a growth stimulant effect on LA-5 and BB-12, in comparison to G as a simple carbon source (Rubel, Pérez, Genovese, & Manrique, 2014).

2.5. Antimicrobial activities of probiotics incorporated with RSE

Antimicrobial activities of the LA-5 and BB-12 culture (ca.10⁶ CFU ml⁻¹) grown in mMRS (modified MRS supplemented with 0.5% glucose) broth media containing different concentration of RSE (0.5% and 1%, w/v) was determined and compared with that grown in mMRS without RSE (James, 2014). The test organisms used were E. coli O157: H7, Salmonella Typhimurium phagetype II, Listeria monocytogenes ATCC 19118 and Staphylococcus aureus ATCC 6538.

2.6. Production of synbiotic yogurt

The pre-culture of probiotics (LA-5 and BB-12) were prepared by dissolving 100 mg of freeze-dried culture in 50-ml of sterilized skim milk (121 °C for 20 min). After blending and activation at 42 °C for 30 min, 1 ml of the pre-culture was inoculated into 250 ml of skim milk. Enumerations of these pre-cultures ranged from 7.1 to 7.4 Log CFU ml⁻¹. The yogurt starter cultures (L. bulgaricus and S. thermophilus) were prepared according to the recommendations received from Chr. Hansen procedure. To prepare the synbiotic yogurt, the pre-culture of probiotics and yogurt starter cultures were used to inoculate 3 L of reconstituted skim milk that had been heat-treated at 95 °C for 5 min, and finally RSE in different concentrations (0%, 0.25%, 0.5%, 0.75% and 1%, w/v) was added and cooled to fermentation temperature (42 °C). The incubation was then carried out and when pH reached 4.5 at the end of the fermentation period, the samples were cooled and kept at 4 °C until the probiotic bacteria were counted.

2.7. Evaluation of prebiotic activity of rye sprout extract in yogurt

Enumeration of L. acidophilus was performed by the standard enumeration techniques using ten-fold serial diluting prepared in 0.1% v/v buffered peptone water at pH 7.0. MRS-Maltose agar (MRS enriched with 0.2% Tween 80 and supplemented with 1% maltose, 0.05% cysteine, and 1.5% agar) was specifically used for the differential enumeration of L. acidophilus (Tabasco, Paarup, Janer, Peláez, & Requena, 2007). The enumeration of B. animalis was carried out by the method of Roy (2001) using a selective MRS medium supplemented with neomycin, paromomycin, nalidixic acid and lithium chloride. Duplicate plates were incubated anaerobically using a GasPak system (Merck, Darmstadt, Germany) at 37 °C for 72 h.

2.8. Sensory assessment

A panel of 10 trained panelists was selected among the staff of the University of Tehran on the basis of their experience in the sensory analysis. In each analysis, different amounts of RSE (0.25%, 0.5%, 0.75% and 1%, w/v) were added to the yogurts compared with the control group. Next, the samples were assessed using an acceptability analysis (color, odor, flavor, texture and overall acceptability) on a 9-point hedonic scale that included 9, like extremely; 8, like very much; 7, like moderately; 6, like slightly; 5, neither like nor dislike; 4, dislike slightly; 3, dislike moderately; 2, dislike very much; 1, dislike extremely (Hamedi, Razavi-Rohani, & Gandomi, 2014).

2.9. Statistical analysis

The experimental data of bacterial counts and sensory assessment
were analyzed by One Way ANOVA and Tukey test, using SPSS 21.0.

Statistical software SPSS 21.0 for Windows, SPSS Inc.).

3. Results

3.1. Viability of probiotic bacteria in culture media

The effects of RSE on the viability of L. acidophilus and B. animalis in modified media containing different concentrations of RSE was studied for 48 h at 37 °C. Adding various concentrations of RSE increased the growth and survival of bacteria and these effects were significant for both L. acidophilus and B. animalis (p < 0.05). The bacterial growth also had a significant relationship with the increase in RSE (p < 0.05), although this increase in B. animalis was better than L. acidophilus. As it can be seen in Fig. 1, at least 2 log increase in bacterial count compared with the control group was observed in 1% w/v RSE after 24 h incubation. The prebiotic activity of RSE in the treated groups during 48 h at 37 °C in comparison with control groups was clearly seen.

3.2. The effect of RSE on RGR of probiotics

Fig. 2 shows the relative growth ratio (RGR) of L. acidophilus and B. animalis at different times of incubation period (0–24 h) on MRS medium containing different concentrations of RSE and glucose as a control. The results indicated that adding RSE even 0.25% can increase the growth of probiotic in comparison with control. At 12 and 24 h of incubation, the growth of both prebiotics was significantly higher than glucose containing samples. The results also showed that the higher was the concentration of RSE, the higher was bacterial growth, which was due to high prebiotics impacts of RSE on probiotic microorganisms.

3.3. Antibacterial activity of probiotics incorporated with RSE

A significant decrease was observed in all the tested organisms including E. coli O157: H7, S. Typhimurium phagetype II, L. monocytogenes ATCC 19118 and S. aureus ATCC 6538 by adding RSE in presence of L. acidophilus and B. animalis after growing in broth media. The results also showed that addition of RSE promoted the antimicrobial activities of probiotic bacteria (Figs. 3 and 4). Among the treatments, the combined administration of RSE and the probiotic bacteria was found to be the most effective against gram-positive bacteria, as a significant reduction in S. aureus counts was observed compared to other bacteria (p < 0.05). The highest log decrease belonged to 1% of RSE plus L. acidophilus against S. aureus. With supplementation, the counts of all bacteria remained at a low level even during the follow-up period.

3.4. Viability of probiotic bacteria in synbiotic yogurt during cold storage

The counts of L. acidophilus and B. animalis in yogurt at the cold storage time (up to 2 months) are illustrated in Table 1. The number of viable L. acidophilus cells treated with different concentrations of RSE remained one to five weeks higher than the initial dose (10^6 CFU g^-1) compared with the control groups. The survival of B. animalis in synbiotic yogurt was higher than L. acidophilus, but this difference was not significant (p > 0.05). The highest counts of L. acidophilus and B. animalis were 8.42 and 8.74 log CFU g^-1 respectively in the samples treated by 1% RSE during 7 days of storage. In general, probiotic populations in RSE-yogurt remained higher than the minimum recommended therapeutic dose (10^6 CFU g^-1) for an extended period of cold storage at 4 °C.

3.5. Sensory evaluation of synbiotic yogurt

The samples were evaluated based on 9-point hedonic scale, and the
score of 7 or more considered satisfactory. The summary of the sensory results (color, odor, taste, texture and overall acceptance) are stated in Fig. 5. The results showed that the control specimens and synbiotic yogurt with RSE had a high value of all sensory parameters and there was no significant difference between them. The changes of color and texture in samples treated with RSE were not significant in comparison with the control group, whereas the notable declines in odor, taste, and overall acceptance were observed in RSE 1% groups (p < 0.05). Although samples treated by 0.75% had the same quality as well as the control groups. Low concentrations of RSE had no remarkable adverse impact on sensory features, but the higher amount could decrease some of the sensory properties of yogurt. The yogurt with 0.5% RSE was the most preferred sample by the panelists, as it received the highest score of sensory attributes.

4. Discussion

During rye sprouting, the concentration of vitamins, minerals, amino acids, proteins, and phytochemicals are increased. This is very important because these nutrients are essential for human health (Marton, Mandoki, Csapo-Kiss, & Csapo, 2010). The chemical composition analysis of RSE showed a higher amount of crude protein and crude fiber in comparison with rye grain. The increase in fiber and other components could promote the growth of probiotic bacteria. Also, more properties of cereal sprout products such as anti-cancer (Murillo & Mehta, 2001), antioxidant effect (Hsu, Chiang, Chen, Yang, & Liu, 2008), and antimicrobial effect (Jeong et al., 2010) have been listed in previous studies. According to the results, the population of both probiotic bacteria was affected by different concentrations of rye sprout extract as a prebiotic in culture media and yogurt. Therefore, it can be concluded that RSE could promote the growth of *B. animalis* and *L. acidophilus*. Madhukumar and Muralikrishna (2010) reported that xylooligosaccharides obtained from Bengal gram husk and wheat bran act as active prebiotic components.

The probiotic bacteria treated by RSE were able to survive and showed a numerically significant growth in culture media compared to the control groups, and the number of *B. animalis* increased more than *L. acidophilus* after the incubation period. This result showed that RSE had a good effect as natural prebiotic on probiotic bacteria. Further studies on the prebiotic effect of natural compounds have been reported (Hwang, Phan, Lu, Hieu, & Lin, 2016; Peshev & Van den Ende, 2014; Valdés et al., 2015). As it has been indicated in Figs. 1 and 2, a dose-dependent manner was observed for the prebiotic effect of RSE in the culture media. The population of *B. animalis* and *L. acidophilus* compared with the control was increased up to 2 log when 1% of RSE was applied. This observation was in agreement with the findings of
Fig. 4. Antimicrobial activity of B. animalis alone and in combination with RSE (0.5% and 1%, w/v) at different times of incubation.

Table 1
The L. acidophilus LAS and B. animalis BB12 counts (mean ± SD) in symbiotic yogurt during 56 days storage at 4 °C (log CFU g⁻¹).

<table>
<thead>
<tr>
<th>L. acidophilus LAS</th>
<th>RSE (w/v)</th>
<th>Day of Storage</th>
<th>0</th>
<th>1</th>
<th>7</th>
<th>14</th>
<th>21</th>
<th>28</th>
<th>35</th>
<th>42</th>
<th>49</th>
<th>56</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>6.24 ± 0.03a</td>
<td>6.70 ± 0.00a</td>
<td>6.75 ± 0.01a</td>
<td>6.64 ± 0.19a</td>
<td>6.64 ± 0.00a</td>
<td>&lt;6</td>
<td>––</td>
<td>––</td>
<td>––</td>
<td>––</td>
<td>––</td>
<td></td>
</tr>
<tr>
<td>0.25</td>
<td>6.31 ± 0.00ab</td>
<td>7.13 ± 0.02b</td>
<td>7.23 ± 0.02b</td>
<td>7.16 ± 0.02b</td>
<td>6.87 ± 0.00b</td>
<td>6.40 ± 0.01b</td>
<td>&lt;6</td>
<td>––</td>
<td>––</td>
<td>––</td>
<td>––</td>
<td></td>
</tr>
<tr>
<td>0.50</td>
<td>6.33 ± 0.01abc</td>
<td>7.13 ± 0.03abc</td>
<td>7.55 ± 0.01abc</td>
<td>7.45 ± 0.01abc</td>
<td>7.09 ± 0.02abc</td>
<td>6.39 ± 0.01abc</td>
<td>6.13 ± 0.02abc</td>
<td>&lt;6</td>
<td>––</td>
<td>––</td>
<td>––</td>
<td></td>
</tr>
<tr>
<td>0.75</td>
<td>6.36 ± 0.01abc</td>
<td>7.35 ± 0.01abc</td>
<td>7.91 ± 0.00abc</td>
<td>7.45 ± 0.01abc</td>
<td>7.24 ± 0.01abc</td>
<td>7.16 ± 0.02abc</td>
<td>6.40 ± 0.01abc</td>
<td>6.38 ± 0.01abc</td>
<td>&lt;6</td>
<td>&lt;6</td>
<td>&lt;6</td>
<td></td>
</tr>
<tr>
<td>1.00</td>
<td>6.43 ± 0.08abc</td>
<td>8.14 ± 0.02abc</td>
<td>8.42 ± 0.01abc</td>
<td>7.69 ± 0.01abc</td>
<td>7.64 ± 0.00abc</td>
<td>7.48 ± 0.01abc</td>
<td>7.34 ± 0.01abc</td>
<td>6.76 ± 0.00abc</td>
<td>6.66 ± 0.04abc</td>
<td>6.47 ± 0.02abc</td>
<td>––</td>
<td></td>
</tr>
</tbody>
</table>

*Values followed by the same letters are not significantly different at the 0.05 level.

<table>
<thead>
<tr>
<th>B. animalis BB12</th>
<th>RSE (w/v)</th>
<th>Day of Storage</th>
<th>0</th>
<th>1</th>
<th>7</th>
<th>14</th>
<th>21</th>
<th>28</th>
<th>35</th>
<th>42</th>
<th>49</th>
<th>56</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>6.27 ± 0.04ab</td>
<td>6.79 ± 0.00ab</td>
<td>6.87 ± 0.00ab</td>
<td>6.82 ± 0.01ab</td>
<td>6.53 ± 0.02ab</td>
<td>&lt;6</td>
<td>––</td>
<td>––</td>
<td>––</td>
<td>––</td>
<td>––</td>
<td></td>
</tr>
<tr>
<td>0.25</td>
<td>6.31 ± 0.00ab</td>
<td>7.54 ± 0.01ab</td>
<td>7.72 ± 0.00ab</td>
<td>7.62 ± 0.01ab</td>
<td>6.96 ± 0.00ab</td>
<td>6.96 ± 0.00ab</td>
<td>&lt;6</td>
<td>––</td>
<td>––</td>
<td>––</td>
<td>––</td>
<td></td>
</tr>
<tr>
<td>0.50</td>
<td>6.34 ± 0.01ab</td>
<td>7.61 ± 0.01ab</td>
<td>7.87 ± 0.00ab</td>
<td>7.72 ± 0.00ab</td>
<td>7.35 ± 0.02ab</td>
<td>7.08 ± 0.06ab</td>
<td>6.34 ± 0.02ab</td>
<td>6.13 ± 0.03ab</td>
<td>&lt;6</td>
<td>––</td>
<td>––</td>
<td></td>
</tr>
<tr>
<td>0.75</td>
<td>6.36 ± 0.01ab</td>
<td>8.18 ± 0.02ab</td>
<td>8.15 ± 0.03ab</td>
<td>7.62 ± 0.00ab</td>
<td>7.41 ± 0.03ab</td>
<td>7.24 ± 0.03ab</td>
<td>6.86 ± 0.01ab</td>
<td>6.73 ± 0.00ab</td>
<td>6.68 ± 0.01ab</td>
<td>&lt;6</td>
<td>––</td>
<td></td>
</tr>
<tr>
<td>1.00</td>
<td>6.43 ± 0.08ab</td>
<td>8.42 ± 0.02ab</td>
<td>8.74 ± 0.00ab</td>
<td>8.62 ± 0.01ab</td>
<td>7.78 ± 0.00ab</td>
<td>7.59 ± 0.01ab</td>
<td>7.40 ± 0.01ab</td>
<td>6.82 ± 0.01ab</td>
<td>6.81 ± 0.05ab</td>
<td>6.60 ± 0.08ab</td>
<td>––</td>
<td></td>
</tr>
</tbody>
</table>
Goderska, Nowak, and Czarnecki (2008) that indicated the addition of saccharides to the medium significantly increased the total number of different strains of lactobacillus acidophilus and Bifidobacterium bifidum after 48 h. Also, Goderska et al. (2008) confirmed that all strains of Bifidobacterium bifidum grew better in the medium with the addition of saccharides, including prebiotics. Khalf et al. (2010) also proved the prebiotic properties of maple sap on the viability of probiotic bacteria in vitro model. The improvement in bacterial count as a result of different prebiotics addition in fermented milk has already been reported (Aghajani, Pourrahmad, & Mahdavi Adeli, 2014; de Souza Oliveira, Perego, de Oliveira, & Converti, 2011a; Garcia-Oliveira et al., 2013; Sah, Vasiljevic, McKechnie, & Donkor, 2016; Shaghahi, Pourrahmad, & Adeli, 2013), but up to now no studies have been conducted to express the effect of RSE in fermented dairy products such as yogurt. Therefore, this part of the study represents the effect of RSE on the survival of B. animalis and L. acidophilus in yogurt after nine weeks of storage at 4 °C. According to the result, the addition of RSE in yogurt increased the counts of both probiotics with particular concern to bifidogenic effect during cold storage at 4 °C for 9 weeks. de Souza Oliveira et al. (2011a) implied the bifidogenic effect of inulin as a prebiotic to improve the growth and counts of a probiotic in fermented skim milk. The same results were reported for other prebiotics such as lactulose (de Souza Oliveira, Perego, de Oliveira, & Converti, 2011b), and FOS (Rodrigues et al., 2011). In this study, the sybiotic yogurt samples with 1% RSE were disliked by the majority of the consumers which might be due to the presence of sour aroma note in those samples, but 0.5% and less were acceptable by the panelists. The rheological results showed that the consumption frequency of fermented dairy products and the awareness of its health benefits was not the factor that affected the overall liking of the treated samples. This finding is in accordance with Kähkönen, Tuorila, and Lawless (1997) and Gonzalez et al. (2011) studies.

Sybiotic effect of RSE and probiotics in yogurt highlights the potential application of RSE as a prebiotic in dairy and other functional products.

5. Conclusion

In conclusion, the development of dairy products containing rye sprout flour and probiotic could be an interesting approach for the area of functional foods. As a result, improving the survival of probiotic bacteria in yogurt with different concentrations of rye sprout extract has a prebiotic activity in dairy products.

References


