Development of dairy beverage with functional properties on the basis of the whey with cereal culture

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Abstract. Many studies in the field of food hygiene have shown the lack of functional products in the diet, in particular, poor dietary fibre intake is one of the factors contributing to the disease of civilization. The aim of the research is development a dairy beverage composition using a cereal culture. Starter culture has been selected and the impact of yeast and starter cultures on beverage properties has been experimentally investigated. The article discusses the use of wheat and barley grains. Beverage quality properties have been shown depending on quantity and method application of starter culture and grain adjunct quantity. The methods of research were carried out according to standard methods in the ITMO University laboratories. Results of research were production of dairy beverage with high biological value and dessert composition on the whey has been developed. It has become feasible while using germinated barley flour, a large mass fraction of dry substances is transferred to the beverage and amounts to 11.47%. While preparing adjunct additionally roasting process of cereal component was included for organoleptic properties improvement. Physical and chemical characteristics of the beverage are determined, biological value calculation is presented, which shows completeness of the protein component of the beverage. The beverage is enriched with a cereal component, because quarter the dietary fibres requirement is ensured, if the product is intaken in an amount of 250 grams.

1. Introduction

In modern economic conditions, the diet imbalance of most people is the reason for the shortage of essential nutrition factors, which are mandatory for consumption. In particular, it is dietary fiber deficiency in ecologically unfavorable areas. Therefore, the expansion of production of functional food products is becoming increasingly important [1]. Functional food products can be obtained based on the whey. It has high biological value and low-calorie content [2, 3]. “On average, about 50% of milk solids, including about 95% of whey proteins, pass into whey” [4]. However, dietary fiber is not contained in the whey. This can be corrected by the inclusion of a promising plant ingredient in the composition. Consumers today are more aware of the nutritional quality of their foods. In this concept, they avoid products which contain synthetic compounds used as colours, antioxidants, stabilisers, preservatives, etc., and prefer products supplemented with natural plant extracts [5, 6]. By the content of proteins, carbohydrates and fats, barley grains are close to wheat and rye. But it contains more than 10% protein, which is superior to wheat protein in nutritional value. Barley contains a significant amount of dietary fiber. The cereal component (cleaned barley) was selected as a functional ingredient for the development of the beverage because of its chemical and nutritional properties. Pearl barley starch contains 12% of resistant one and 43% of slowly digested one. Due to the presence of dietary fiber barley helps cleanse the body of toxins [7]. “Barley fiber helps lower cholesterol and slows the increase blood sugar level
after eating. When barley products are consumed, substances that contribute to the normalization of peristalsis of the gastrointestinal tract enter the body” [8].

The main principle in improving the technology for processing plant materials is the maximum use of extractive substances of raw materials, including easily digestible carbohydrate and protein substances, and the preservation of biologically active substances in active form in the final products. It is known grain germinated is promoting the enzyme accumulation. In order to achieve this, barley is artificially saturated with water by increasing the moisture content to 43–48% [9, 10].

This paper presents the development of a dairy beverage with functional properties based on whey with cereal culture. It also considers the physicochemical composition and calculates the biological value of the protein component of the beverage.

2. Materials and methods

2.1 Materials
Whey. About 94% of lactose, 74% of minerals and almost all whey proteins, which are mainly represented by β-lactoglobulin and α-lactalbumin and contain valuable essential and sulfur-containing amino acids, pass from milk to whey [3, 10].

Barley flour. There are 477 mg of potassium, a lot of calcium and other dietary minerals in 100 g of barley. Barley is enriched with vitamin B complex. The most valued compound is fiber, which is necessary for our gastrointestinal tract.

Starter culture. Combined starter culture consists of thermophilic streptococcus and acidophilus bacillus (Streptococcus thermophilus, Lactobacillus acidophilus) in a ratio of 4: 1.

Xanthan gum was used as a stabilizer.

2.2 Titratable acidity
Determination of titratable acidity is carried out according to the adapted method IDF 81: 1981. Titrate 20 ml of the sample with a 0.1mol l-1 sodium hydroxide solution till the solution has been turned to pink using 1% phenolphthalein solution as indicator in amount 2-3 drops.

Sample 1: wheat flour (10 g), whey (100 ml), sugar (5 g), starter culture (4 ml), stabilizer (0.25 g).
Sample 2: barley flour (10 g), whey (100 ml), sugar (5 g), starter culture (4 ml), stabilizer (0.25 g).
Sample 3: barley germinated flour (10 g), whey (100 ml), sugar (5 g), starter culture (4 ml), stabilizer (0.25 g).
Sample 4: barley not germinated flour (10 g), whey (100 ml), sugar (5 g), starter culture (4 ml), stabilizer (0.25 g).

2.3 Barley germination
A few conditions are imperative for grain germination such as moisture, heat and oxygen supply. Barley grain was soaked in at a temperature of 20 °C during thirty hours. Water should be changed every seven hours. Then the grain was placed on wet buttercloth in a glass with a lid in a place with low light for eighteen hours. Oxygen access is provided for twenty minutes every eight hours. Grain is crushed and the mealy core is separated from the shells in order to get the most nutrients use.

2.4 Roasting the plant component
Mode No.1: at a temperature of 105 °C for 15 minutes;
Mode No.2: at a temperature of 115 °C for 10 minutes.

2.5 Refractometric method
The determination of the dry matter content is carried out by the refractometric method according to ISO 2173: 2003.

Sample 1: wheat flour (10 g), whey (100 ml), sugar (5 g), starter culture (4 ml), stabilizer (0.25 g).
Sample 2: barley flour (10 g), whey (100 ml), sugar (5 g), starter culture (4 ml), stabilizer (0.25 g).
Sample 3: barley germinated flour (10 g), whey (100 ml), sugar (5 g), starter culture (4 ml), stabilizer (0.25 g).
Sample 4: barley not germinated flour (10 g), whey (100 ml), sugar (5 g), starter culture (4 ml), stabilizer (0.25 g).
25 g of fried flour is poured into 150 ml of whey. The blend is brought to a boil, cools down to 30–40 °C. 10 g of the blend is mixed with 0.25 g of stabilizer and 5 g of sugar and added to 100 ml of whey.

2.6 Calculation of the biological value of the protein component
Table 1 shows the amino acid composition of whey and barley proteins.

| Essential amino acid | Whey  | Barley |
|----------------------|-------|--------|
|                      | Mass fraction (g 100g⁻¹ of protein) | Amino acid score (%) | Mass fraction (g 100g⁻¹ of protein) | Amino acid score (%) |
| Isoleucine           | 4.75  | 158    | 3.28  | 109  |
| Leucine              | 9.00  | 152    | 5.92  | 100  |
| Lysine               | 8.13  | 181    | 2.96  | 66   |
| Methionine + Cysteine| 3.50  | 159    | 3.28  | 149  |
| Tryptophan           | 2.00  | 333    | 1.28  | 213  |
| Phenylalanine + Tyrosine | 5.50  | 145    | 6.64  | 175  |
| Threonine            | 4.75  | 207    | 2.72  | 118  |
| Valine               | 4.75  | 122    | 4.56  | 117  |
| Histidine            | 1.88  | 125    | 1.92  | 128  |

Using the methodology amino acid scores calculation is carried out [11].

Table 2 presents dietary fiber content and Glycemic index (GI) in some plant products.

| The product's name        | Content, g 100 g⁻¹ | The product's name        | Content, g 100 g⁻¹ |
|---------------------------|--------------------|---------------------------|--------------------|
| Wheat flake               | 43.6               | Durum wheat               | 11.3               |
| Barley (grain)            | 17.6               | Buckwheat flour           | 10.0               |
| Rye (grain)               | 16.4               | Rice (grain)              | 9.7                |
| Oat flake                 | 15.4               | Entire wheat flour        | 9.3                |
| Soy                       | 13.5               | Pot barley                | 8.1                |
| Medium rye flour           | 12.4               | Oat groats                | 8.0                |

3. Results and discussion
To study the effect of starter culture and yeast on the beverage indicators, a study was made of the change in titratable acidity of the beverage with various methods of introducing starter culture (a combination of thermophilic streptococcus and acidophilus bacillus in a ratio of 4: 1) and yeast using wheat and barley flour. Figures 1, 2 show the data. At this stage of the study, four samples were considered.
Figure 1. The change in titratable acidity with the simultaneous introduction of yeast and starter culture over time.

Figure 2. The change in titratable acidity upon application of yeast and after 1 h the introduction of starter.

From the results it is concluded that starter culture slightly affects the development of yeast, since the final titratable acidity of the beverage practically does not change from the time of adding the starter. Therefore, yeast was not included in the samples in further studies. According to organoleptic properties, sample 2 with barley flour was selected, since it had a more pronounced sour-milk taste than the sample with wheat flour.

It is a well-known fact that the accumulation of the maximum number of enzymes occurs during sprouting of grain. Thus, for the most efficient use of the grain component as a filler for the developed
beverage, samples with flour from germinated barley grain were studied. Table 3 shows the results of determining the amount of solids transferred to the product depending on grain preparing.

Table 3. Mass fraction of cereal solids in a beverage.

| Sample  | Solids (%) |
|---------|------------|
| Sample 1 | 10.13      |
| Sample 2 | 10.10      |
| Sample 3 | 11.47      |
| Sample 4 | 10.05      |

Accordingly a large mass fraction of solids passes into the solution in the sample with flour from sprouted grain. However, it should be noted that the beverage acquired an unpleasant bitter flavor. To eliminate the resulting specific taste and herbal smell, it was decided to consider an additional stage of processing the plant component by heat treatment of germinated barley flour.

Consequently germinated barley flour was chosen like beverage cereal component. Also, that sample provides the best organoleptic properties, processed using mode No. 2 (heat treatment at a temperature of 115 °C for 10 minutes). Table 4 shows the biological value of the protein component of the beverage.

Table 4. The biological value of the protein component of the beverage.

| Essential amino acid | Mass fraction, g 100g⁻¹ of protein | Amino acid score (%) |
|----------------------|-----------------------------------|----------------------|
|                      | Protein (FAO 2007 year)           | The researched       |
| Isoleucine           | 3.0                               | 4.57                 | 153                  |
| Leucine              | 5.9                               | 8.62                 | 146                  |
| Lysine               | 4.5                               | 7.51                 | 167                  |
| Methionine + Cysteine| 2.2                               | 3.47                 | 158                  |
| Tryptophan           | 0.6                               | 1.91                 | 319                  |
| Phenylalanine + Tyrosine | 3.8                           | 5.64                 | 148                  |
| Threonine            | 2.3                               | 4.51                 | 196                  |
| Valine               | 3.9                               | 4.73                 | 121                  |
| Histidine            | 1.5                               | 1.88                 | 125                  |
| Biological value     | 51 %                              |                      |

The calculation showed the absence of limiting amino acids. It confirms that the protein component of developed beverage is complete. Table 5 shows the calculation of satisfying the daily requirement for dietary fiber in eating [11]. The calculation of meeting the daily needs of the body in dietary fiber was carried out per ration of 250 g.

Table 5. The content of dietary fiber in the product.

| Indicator    | Consumption rate | Mass fraction, g 100 g⁻¹ of the beverage | Daily requirement (%) | Mass fraction, g 250 g⁻¹ of the beverage | Daily requirement (%) |
|--------------|------------------|------------------------------------------|----------------------|------------------------------------------|----------------------|
| Dietary fiber, g | 20.00            | 2.11                                     | 10.56                | 5.28                                     | 26                   |

Accordingly, if the 250 g of the beverage was consumed per day 250 g of the drink per day, the provision of dietary fiber will be a quarter of the daily requirement. Table 6 shows the formulation of the developed beverage.
Table 6. Composition of the beverage.

| Component      | Amount (%) |
|----------------|------------|
| Barley flour   | 8.5        |
| Whey           | 85         |
| Starter culture| 3.5        |
| Sugar          | 2.85       |
| Stabilizer     | 0.15       |

4. Conclusion
The paper has presented the use of whey as the basis to produce dairy beverage. It was proposed to use a combination of thermophilic streptococcus and acidophilus bacillus in a ratio of 4: 1 without the use of yeast as a starter culture.

Calculation of the biological value of the protein component of the beverage showed that the combination of the milk base and the plant component increases the biological value of the beverage due to the balanced amino acid composition. Barley's limiting amino acid, lysine, can be replenished in the beverage with whey proteins. It was founded that the provision level of the daily requirement of the body in dietary fiber reaches 26% when a portion of the drink is consumed in an amount of 250 g.

In this study, germination of grain was used to extract more extractives and a heat treatment mode was selected to provide a higher organoleptic rating.

The production of a dessert based on whey using a plant component with a dose of 60–70% by weight of the finished product can be proposed to expand the range of sour-milk products.

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