Chemical Composition and Sensory Properties of Gluten-Free Crackers with Buckwheat Sourdough

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ABSTRACT

In this paper, the influence of biological acid dough with a strain of lactic acid bacteria (Lactobacillus plantarum) on the properties of the dough and the addition of sourdough on the quality of crackers was investigated. Changes in total titratable acidity and pH were monitored during the fermentation of the sourdough (24 hours). In the dough for the production of gluten-free crackers, the influence of the addition of sourdough on the total titratable acidity and pH value was examined. The content of water, protein, fat, starch, crude fiber, pH value and total titratable acidity was determined by flour samples for the production of gluten-free crackers and gluten-free crackers. The influence of sourdough on the sensory properties of crackers was examined. The mineral composition of zinc was determined and the contribution of the daily recommended intake was assessed. In samples of crackers subjected to storage for 5, 10, 20 and 30 days, a change in water content was monitored. The length of fermentation had a significant impact on the dynamics of pH change and on the total titratable acidity during the fermentation of sourdough. The results of the study showed that the control sample has a higher pH value than the samples with sourdough. The reason for that is the development of acetic acid during fermentation. The change in water content in the crackers over 30 days was significantly higher in the control sample compared to the samples with sourdough. Crackers with sourdough contain a significantly higher percentage of protein, ash, fiber, zinc at the expense of reducing carbohydrates.

Keywords: Gluten-free Crackers, pH, Sourdough, Total Titratable Acidity.

I. INTRODUCTION

Gluten is a complex mixture of proteins comprising the gliadins and glutenins in wheat and equivalent proteins in barley and rye, representing 80% of total grain proteins [1]. In the bakery industry, gluten is usually related to the protein that makes the dough both cohesive and extensible, easily sheeted and shaped, as well as capable of retaining the gases produced during fermentation and proofing [2]. The gluten-free diet can help in treatment of disorder such as celiac patient, autism, chronic fatigue, schizophrenia, attention deficit disorder, multiple sclerosis, migraine, and fertility problem [3]. The only effective treatment for celiac disease is keeping a strict gluten-free diet throughout the patient’s lifetime [4]. Baking with gluten-free doughs is a big challenge for all bakers and cereal researchers. Gluten-free foods are low quality, more expensive, not widely available, lack variety with lower palatability [5] and bad cooking quality when compared to products based on the wheat flour [6]. In fact, these gluten-free doughs are often called batters instead of dough [7]. Due to, the main focus of food technologist is on development of gluten-free bakery products with good nutritional quality and high fiber content to deal with the health problems [8]. During the last years many researchers have focused on another pseudocereals such as buckwheat, using of various combinations of hydrocolloids and modifying the interaction between gluten-free proteins and starch [9]. Buckwheat is a rich source of starch, proteins are constituted of well-balanced amino acid composition, antioxidant substances, fibre, mineral contents and they are also gluten-free which makes them useful for people suffering from celiac disease [10]. Additionally, buckwheat flour had a favorable fatty acid composition, being prevalent the oleic and linoleic acids, and are high in protein and folate than other pseudocereals [11]. Therefore, a number of gluten-free bakery products containing buckwheat have been developed, such as gluten-free bread, biscuits spaghetti and crackers [12]. Availability of these products in the market is still quite limited. Crackers are manufactured mainly from flour and water with relatively small quantities of shortening. Usually they come in different flavors, shapes, and sizes [13]. They are ready to eat, convenient and inexpensive food product,
containing digestive and dietary principles of vital importance [14].

The aim of this study was to examine the influence of strains *Lactobacillus plantarum* and the content of buckwheat flour on chemical composition and sensory evaluation gluten-free crackers with buckwheat sourdough. According to [15] starter cultures and process parameters have started to be exploited in buckwheat sourdough. The application of the strains *Lactobacillus fermentum* AB 15, *Lactobacillus plantarum* AB 16, *Lactobacillus vaginalis* AB 17 and *Lactobacillus crispatus* AB 19 improved the quality of the product.

Freshly prepared sourdough strain of *Lactobacillus plantarum* was used as a biological acidification agent. The process of acidification the dough with the addition of starter cultures of lactic acid bacteria affects the nutritional profile, organoleptic properties of the finished product and is considered one of the important steps in production, which in addition to improving texture, smell and taste, also affects the extended shelf life of the finished product. The content of water, ash, protein, fat and mineral content were determined.

### II. EXPERIMENTAL PART

#### 2.1. Material

The basic materials for making crackers were commercially available products gluten-free flour was purchased from “Schar”, Austria, corn flour was purchased from “KLAS”, Bosnia and Herzegovina, buckwheat flour was purchased from "Heljdeko", Bosnia and Herzegovina, baking powder was purchased from “VIPAK”, Bosnia and Herzegovina, powdered sugar was purchased from “MASTERS, AS Jelah, Bosnia and Herzegovina salt was purchased from “SOLANA”, Bosnia and Herzegovina, vegetable fat was purchased from "VITAL", Bosnia and Herzegovina, flax seed was purchased from “GAMUS”, Bosnia and Herzegovina.

#### 2.2. Preparation of Sourdough with *L. plantarum*

Sourdough was prepared by adding 0.01% lyophilized starter culture to the amount of flour [16]. Starter culture was added in equal parts water and flour (flour: water = 1:1), to obtain a yield of sourdough of 200%. The lyophilized starter culture is dispersed in a little water, subtracted from the total amount of water required and added to the flour with the remaining water with stirring. The vessel with the dough thus prepared is placed on fermentation at 30 °C for 24 hours. Fermentation of buckwheat had a major impact on the biochemical, rheological and baking properties of the flour [17]. Buckwheat flour was used to make sourdough.

#### 2.3. Cracker Preparation

Recipes for the preparation of mixes for cracker baking trials are shown in Table 1.

| Table 1: Crackers formulations |
|-------------------------------|
| **Ingredients**              | **W** | **W+20% BF** | **W+10% BFSD** | **W+20% BFSD** |
|-------------------------------|-------|--------------|----------------|----------------|
| Gluten-free flour            | 70    | 50           | 60             | 50             |
| Integral buckwheat flour     | 0     | 20           | 0              | 0              |
| Sourdough                     | 0     | 0            | 20             | 40             |
| Corn flour                   | 30    | 30           | 30             | 30             |
| Baking powder                | 1     | 1            | 1              | 1              |
| Powdered sugar               | 3     | 3            | 3              | 3              |
| Salt                          | 3     | 3            | 3              | 3              |
| Vegetable fat                | 30    | 30           | 30             | 30             |
| Seeds of flax                | 10    | 10           | 10             | 10             |
| Water                         | 50    | 50           | 40             | 30             |

| (W- wheat gluten-free crackers; W+20%BF – wheat gluten-free crackers with addition od 20% buckwheat flour; W+10%BFSD – crackers from gluten-free flour with addition of 10% buckwheat sourdough; W+20% BFSD – crackers from gluten-free flour with 20% buckwheat sourdough) |

Direct kneading was used to make the cracker dough. The ingredients were measured according to the formulation given in Table 1. The pre-fermented sourdough was weighed in the amount given in Table 1. After that, all the ingredients were mixed by hand. The dough was left to stand for one hour at room temperature, after which it was rolled out by hand and cut into rectangles. Baking was carried out at a temperature of 200 °C for 15 minutes. After baking, the crackers were left on a baking sheet to cool, packed in aluminum foil and then in plastic bowls with lids. Samples were crushed with a mortar and pestle before each test, except for the sensory ones.

#### 2.4. Methods

Determination of the amount of water was performed by the method [18] according to (Pravilnik,
“Sl. list RBiH, br. 2/92” was determined content of ash, the Kjedhal method was used to determined the nitrogen content. The nitrogen to protein conversion factor was 5.7 for wheat; 5.83 for rye and 6.25 for buckwheat flour, determination of the amount of total fat was performed by the Weibull-Stoldt. The method is based on treatment of the sample with hydrochloric acid and fat extraction of organic solvents, in Soxlet devices, determination of crude fibers it was done after acid-base digestion of the sample [19], starch content was proven by Ewers method, by polarimetric determination of the optical activities of glucose, they are formed by the decomposition of starch, total titratable acidity was performed by the Schulerud method.

The zinc content was determined by atomic absorption spectrometry, where the sample was digested in a mixture of HNO₃ / HClO₄ before measurement. To determine the minerals extractable in HCl acid, 1 g of the sample was extracted into 10 mL of 0.03 M HCl acid by stirring at 37 °C for 3 hours. The extract was filtered and heated to 100 °C. The obtained dry extract was digested with a mixture of HNO₃: HClO₄ acids (5:1, v / v), and the content of minerals extractable in HCl acid was determined according to the previously described procedure for the determination of total minerals. The extractability of minerals in HCl acid was calculated based on the expression [20].

Statistical processing of results all experiments were performed in at least three replicates, unless otherwise noted. Results are expressed as mean ± standard deviation (SD). The data were processed using the Microsoft Excel 2010 for Windows example.

2.5. Sensory Evaluation

Sensory evaluation of crackers was performed 24 hours after baking. Representative properties of crackers were evaluated using a hedonistic scale, with a score range of 1 to 9 (1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much, and 9 = like extremely). For methodologically correct and successful application of this method, before the evaluation, the evaluator conducted a selection of representative properties of crackers (quality factors). Each quality factor, expressed by the corresponding point, was precisely defined [21].

III. RESULTS AND DISCUSSION

Table 2 shows the chemical composition of the flour for cracker production.

| Flour samples            | Parameters (% na s.t.) |          |          |          |          |          |          |
|--------------------------|------------------------|----------|----------|----------|----------|----------|----------|
|                          | Moisture               | Proteins | Ash      | Fat      | Starch   | Crude fiber |          |
| Wheat gluten-free flour  | 11.61 ± 0.13           | 3.70 ± 0.55 | 0.49 ± 0.05 | 1.1 ± 0.16 | 77.00 ± 0.24 | 6.10 ± 0.07 |
| Buckwheat flour          | 12.37 ± 0.04           | 12.40 ± 0.22 | 1.82 ± 0.02 | 2.50 ± 0.01 | 72.52 ± 0.26 | 8.55 ± 0.50 |

Table 3: pH value and total titratable acidity of crackers

| Cracker samples          | W                      | W+20% BF  | P+10% BFSD | P+20% BFSD |
|--------------------------|------------------------|-----------|------------|------------|
| pH                       | 7.11 ± 0.06            | 6.73 ± 0.04 | 6.53 ± 0.01 | 6.19 ± 0.06 |
| total titratable acidity (mL 0.1M NaOH) | 0.45 ± 0.07 | 1.5 ± 0.00 | 2.15 ± 0.0 | 2.48 ± 0.04 |

Results are presented as mean ± standard deviation

During the first 6 hours of fermentation, changes in pH and total titratable acidity were minimal. After 12 hours of fermentation, there was a slight decrease in pH from the initial 6.2 to 5.14. Total titratable acidity after the same time interval also increased significantly. Similar results got [22] where the titratable acidity values increased over time with the highest levels of acidity found for dough and bread with yeast. 24 hours after the start of fermentation, the pH value was about 3.9, while the total titratable acidity rose sharply to 16.1. Table 3 shows that the pH value is lower in samples with sourdough due to the fact that acetic acid develops during fermentation. Similar results got [23] where pH reduced consistently from 7.3 to 4.8 during 72 h of fermentation. Also, Table 3 shows that the consumption of NaOH or the total titratable acidity is higher for samples with sourdough.
Table 4: Sensory evaluation of crackers

| Cracker samples | Sensory evaluation |      |      |      |      |
|-----------------|-------------------|------|------|------|------|
|                 | Color             | Taste| Crispness | Total acceptability |
| W               | 8.1 ± 0.74        | 5.4 ± 1.96 | 4.0 ± 1.83 | 6.4 ± 1.35 |
| W+20% BF        | 8.2 ± 0.63        | 7.7 ± 1.49 | 7.3 ± 1.77 | 7.7 ± 1.25 |
| W+10% BFSD      | 8.1 ± 0.88        | 6.9 ± 1.66 | 5.6 ± 1.78 | 6.9 ± 1.73 |
| W+20% BFSD      | 8.2 ± 0.63        | 6.4 ± 1.90 | 5.4 ± 1.90 | 6.8 ± 1.55 |

Results are presented as mean ± standard deviation.

Sensory evaluation of the representative properties of crackers shows that the best quality was achieved with crackers with 20% buckwheat flour, as well as with crackers with 10% buckwheat sourdough, which were rated as a product of very good quality. Ratings for individual properties show very good quality of all tested crackers. If compare the ratings for all sensory properties of crackers, it is noticed that the ratings are higher in crackers with starter culture *L. plantarum* than crackers produced only from wheat gluten-free flour. Also, the analysis of the results showed the difference between the ratings for taste and crunchiness in crackers without starter culture and with starter culture, while for color there is no significant difference. The taste and crunchiness of gluten-free wheat flour control crackers were the worst, while the taste and crunchiness of the buckwheat flour sample were best rated. The scores for total acceptability and color in all samples are relatively high. This fact indicates that buckwheat flour can be used as a basic ingredient for the production of crackers and crackers obtained by inoculation. *L. plantarum* can only have a positive effect on the sensory quality of crackers. The preliminary sensory evaluation of gluten-free breads with 30% of buckwheat flour showed significant improvement of the sensory quality in comparison with control breads which obtained very low notes in total score [24].

Table 5: Chemical composition of gluten-free crackers

| Cracker samples | Water (%) | Proteins (%) | Fat (%) | Ash (%) | Crude fiber (%) | CH* (%) |
|-----------------|-----------|--------------|---------|---------|-----------------|--------|
| W               | 10.50 ± 0.32 | 4.04 ± 0.27 | 19.26 ± 0.2 | 1.81 ± 0.01 | 2.37 ± 0.02 | 62.03 |
| W+20% BF        | 9.18 ± 0.10 | 5.25 ± 0.30 | 21.49 ± 0.55 | 2.60 ± 0.02 | 3.30 ± 0.01 | 58.18 |
| W+10% BFSD      | 9.88 ± 0.31 | 4.17 ± 0.05 | 20.22 ± 0.01 | 2.40 ± 0.02 | 3.00 ± 0.03 | 60.33 |
| W+20% BFSD      | 8.55 ± 0.21 | 5.14 ± 0.08 | 21.07 ± 0.09 | 2.55 ± 0.05 | 4.33 ± 0.07 | 58.36 |

Results are presented as mean ± standard deviation.

* carbohydrates = 100 – water – proteins – fat – ash – crude fiber

Based on the results from Table 5., it can be concluded that the sample of crackers with 20% buckwheat flour and the sample with 20% sour buckwheat dough contains the highest percentage of protein, fat, fiber and ash at the expense of reducing carbohydrates. They are followed by a sample with 10% sour buckwheat dough, while the lowest content of fat, protein, ash and fiber has a control sample, ie a sample of gluten-free wheat flour, which has an increased carbohydrate content. Thus, crackers with sourdough have an increased protein content compared to the control sample, so they are adaptable to people who have a need for increased protein intake, and also contain a higher content of ash (minerals) and fiber. Similar observations got [22] where the highest content of soluble proteins was found in water biscuits made of buckwheat flour fermented by *L. plantarum*. Since they contain a higher proportion of ash, they are recommended for people suffering from celiac disease, because minerals are lost very quickly in their body.
The highest zinc content was found in the sample with 20% buckwheat flour as well as in the sample with 20% buckwheat sourdough. In terms of bioavailability, the highest percentage of bioavailability is shown by samples with 10% and 20% buckwheat sourdough. Zinc is found in buckwheat flour, so that the sample with buckwheat flour also contains the highest zinc content. The bioavailability is higher in the samples with sourdough than in the control sample, it is also higher than in the sample with buckwheat flour. The recommended daily intake of zinc is 11 mg for men and 8 mg for women. The attached results show that by consuming 100 g of buckwheat flour crackers we meet our daily needs for zinc. Also, good results were shown in the sample with sourdough, and its intake (100 g) meets the daily needs for zinc.

### IV. CONCLUSION

In this paper was demonstrated that the addition of buckwheat flour further increases the nutritional properties of crackers. The control sample and the buckwheat flour sample have sufficient data on the total titration acidity of the starter culture samples, while the total titratable acidity in the buckwheat flour sample is higher than the control sample, which is the last higher buckwheat acidity (3.8) in relative to wheat (1.8).

Considering the obtained values of the dry matter and water content in the dough and crackers, it seems that the added starter culture has the effect of reducing the amount of water during the baking of the crackers. Addition of buckwheat sourdough also extended the shelf life of wheat crackers due to less water. Sensory evaluation of representative properties of crackers, performed by the scoring method, showed that the best quality was achieved with crackers with 20% buckwheat flour, as well as crackers with 10% buckwheat sourdough, which were rated as a product of very good quality.

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