

CHARACTERIZATION OF FUNCTIONAL GLUTEN-FREE BREADSTICKS WITH CUMIN IMPROVED BY ADDITION OF CRUCIFEROUS EXTRACTS

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Abstract

People suffering from celiac disease must exclude gluten products from their diet. The lack of gluten in bakery products causes both technological problems for processors and nutritional deficiencies for consumers. The purpose of this paper is to obtain functional gluten-free breadsticks with cumin improved by the addition of cruciferous extracts. The 3xBiotics commercial extracts was used for the experiments, which is a mixture of fermented cruciferous powders. In addition to the gluten-free breadsticks with cruciferous extracts, two control samples were made: gluten-free breadsticks with cumin without cruciferous extracts and breadsticks with gluten and cumin improved by the addition of cruciferous extracts. All the samples were evaluated from microbiological point of view to determine the shelf life, from physico-chemical point of view to determine the nutritional value and from sensory point of view, using a panel of consumers, to characterize the sensorial attributes. Following the comparison with the control samples, it was found that the energy value for functional gluten-free breadsticks with cumin and cruciferous extracts was higher compared to the control samples.

Key words: bakery products, technological process, shelf life, nutritional values, sensory analysis.

INTRODUCTION

Gluten is a protein made up of gliadin and glutenin that form disulfide bonds. It is found in wheat, barley, rye and oats (Abedi, 2021). Glutenin gives elastic properties while gliadin gives viscosity. Therefore, gluten is a viscous-elastic mass. In some predisposed individuals, gluten consumption triggers the activation of an immune-mediated enteropathy called celiac disease (CD).

Celiac disease is thought to affect 1% of consumers. The effects of gluten consumption are an inflammatory response that causes the destruction of the villi of the small intestine by reducing the absorption surface and the amount of secreted enzymes. These effects are caused by gliadin (Thompson, 2017).

Because the gluten matrix, which also contains starch granules and fiber fragments determines the properties of the dough such as extensibility, gas retention capacity, mixing tolerance and tensile strength, the elimination of gluten results in poor nutritional and sensory qualities for gluten-free products (Arendt & Dal, 2008).

It is considered that gluten-free products have a higher price compared to variants with gluten and also have lower nutritional values and sensory properties (Xhakollari et al., 2019), being caused problems during the technological process (Matos, 2014).

For people with celiac disease, a gluten-free diet is mandatory. It was also found that 20% of the population follow this gluten-free diet without a medical diagnosis, but as a lifestyle chosen from a civic, cultural, historical, ecological and ethnic point of view (Foschia, 2016).

However, the gluten-free diet also has the disadvantage of a deficiency in nutritional compounds. For this reason, it is very important to expand the market by introducing new products, fortified with food matrices rich in micronutrients that fulfill the needs of the consumer (Polo et al., 2020).

Thus, functional foods are developed by adding ingredients with antioxidant, anti-inflammatory, immunomodulatory or antitoxic effects. These foods are very important for the prevention of health problems, including chronic diseases (Vattem, 2016).

The leaven is very important in the technological process because it improves the aroma, texture, taste, shelf life and nutritional value by the presence of lactic bacteria (*Lactobacillus fermentum*, *Lactobacillus graminis*, *Lactobacillus plantarum*, *Lactobacillus sakei*, *Lactobacillus gallinarum* and *Pediococcus pentosaceus*) (Gobbetti, 2018).

The leaven is also important in the process of gluten-free breadsticks because the lack of gluten causes technological problems. Breadsticks are bakery products with a stick shape and are very well known for their taste and long shelf life.

The main purpose of this study is to obtain functional gluten-free breadsticks. In order to be improved from a nutritional point of view, a variant is the addition of 3 x Biotics cruciferous extracts (products manufactured by Pro Natura factory) which represent a mixture of cabbage, broccoli, cauliflower, Maca root and fermented polyfloral pollen in the form of powder. These powders were obtained by fermentation in symbiotic cultures of bacteria and yeast and dried on a bed of maltodextrin.

MATERIALS AND METHODS

The raw materials were microbiologically and physico-chemically analyzed, while the finished products were analyzed from both a microbiological and physico-chemical point of view, as well as sensory.

Microbiological analysis of raw materials

The raw materials that were analyzed from a microbiological point of view are wheat flour, rice flour and brown sugar.

Method that was used for determination of yeasts and molds number was according to SR ISO 21527-2:2009 - Microbiology - General guidelines for counting yeasts and molds. In order to have a greater specificity it was used the technique for counting colonies in products with water activity less than 0.95.

Enterobacteriaceae enumeration method was performed according to SR EN ISO 21528-2/2017- Food chain microbiology, respectively horizontal method for detecting and counting Enterobacteriaceae, namey part 2 - Colony counting method.

The determination of yeasts and molds number per gram of product (N) and Enterobacteriaceae number, after reading the colonies grown on selective media, was calculated by applying the following formula:

$$N = \frac{\Sigma C}{(n_1 + 0.1n_2) \times d}$$

where:

ΣC = the sum of the colonies counted in all retained plates;

n_1 = the number of plates retained at first dilution;

n_2 = the number of plates retained at the second dilution;

d = the dilution from which the first counts were made.

The results obtained are mentioned in Table 1.

Table 1. Microbiological analysis results for raw materials

Sample	Microbiological indicators	
	Yeasts and molds (cfu/g)	Enterobacteriaceae (cfu/g)
Wheat flour	1.4×10^2	-
Rice flour	< 10	-
Brown sugar	< 10	-

Physico-chemical analysis

The raw materials used to make breadsticks, respectively wheat flour, rice flour and brown sugar, were initially analyzed from a physico-chemical point of view. Moisture, ash, protein and fat content along with the acidity of the product were determined, according to the methods given below.

Sugar moisture determination was performed according to SR 110-3:1995 method.

Determination of moisture in cereal flours was performed according to SR 90:2007 point 11 with reference to SR EN 712:2010.

Determination of ash was performed according to SR ISO 2171:2009. The results calculation method was applied as follows:

$$wad = (m_2 - m_1) \times \frac{100}{m_0} \times \frac{100}{100 - Wm},$$

where:

m_0 = the work sample mass (g);

m_1 = the calcination crucible mass (g);

m_2 = the mass of the calcination crucible and calcined residue (g);

Wm = the moisture content of the sample as a mass percentage.

Determination of fat was carried out according to the Soxhlet method, where the results have been calculated as follows:

$$w = \frac{m_2 - m_1}{m} \times 100,$$

where:

m_1 = the extraction flask mass;

m_2 = the mass of the extraction flask with fat;

m = the mass of the sample taken for drying.

Determination of protein content was performed according to the Kjeldahl method.

Raw materials acidity determination was done according to SR 90:2007 point 12 and the results calculation method is presented below:

$$\text{Acidity} = \frac{V \times 0.1}{m} \text{ (degrees),}$$

where:

V = the volume of 0.1 N NaOH solution (mL);

m = the work sample mass (g);

0.1 = the normality of the NaOH solution.

Determination of crude fiber (cellulose) content was achieved according to SR EN ISO 91:2007. In order to calculate the results, the following formula was used:

$$wf = \frac{m_3 - m_1 - m_4 - m_5}{m_2} \times 100,$$

where:

$m_5 = m_7 - m_6$;

W_f = the crude fiber content, %;

m_1 = the FiberBag mass, g;

m_2 = the initial sample mass, g;

m_3 = the calcination crucible mass with dried FiberBag, g;

m_4 = the mass of calcination crucible and residue obtained after calcination, g;

m_5 = the empty FiberBag blank mass, g;

m_6 = the calcination crucible mass, g;

m_7 = the mass of calcination crucible and ash content of empty FiberBag, g.

The results obtained from physico-chemical analysis of raw materials, are mentioned in Table 2.

Table 2. Physico-chemical analysis results for raw materials

Sample	Acidity (°)	Moisture (%)	Fat (%)	Ash (%)	Protein (%)	Raw fiber (%)
Wheat flour	3.5	13.58	1.08	0.65	10.83	1.17
Rice flour	1.6	13.42	0.39	0.39	8.58	0.51
Brown sugar	-	0.16	-	0.09	-	-

Formulation of products

3xBiotics (product manufactured by Pro Natura) cruciferous extracts consists of a mix of Cabbage powder (*Brassica oleracea* var. *capitata*), Cauliflower powder (*Brassica oleracea* var. *botrytis*), Maca root powder (*Lepidium meyenii*) and Broccoli sprout powder (*Brassica oleracea* var. *italica*), this ingredients being fermented in synbiotic cultures of bacteria and yeast and dried on a maltodextrin bed.

Three experimental breadsticks variants were obtained, as follows: functional gluten-free breadsticks with cumin enhanced by the addition of cruciferous extracts (Figure 2), gluten-free breadsticks with cumin and without cruciferous extracts (Figure 3) and breadsticks with gluten and cumin enhanced by the addition of cruciferous extracts (Figure 4).

The recipe for **functional gluten-free breadsticks with cumin enhanced by the addition of cruciferous extracts** with a net mass of 0.100 kg includes the following ingredients:

- Leaven which was obtained from: 0.0242 l water; 0.0157 kg rice flour; 0.0024 kg brown sugar; 0.0024 kg dry yeast.

- Dough which involved the mixing of the following ingredients: 0.058 kg rice flour; 0.012 kg eggs; 0.009 l olive oil; 0.007 l water; 0.007 kg cruciferous extracts; 0.0024 kg starch; 0.0014 kg cumin; 0.0012 kg chia; 0.0012 kg salt; 0.0007 kg carboxymethyl cellulose (CMC); 0.0002 kg Xanthan gum.

The recipe for **gluten-free breadsticks with cumin and without cruciferous extracts** with a net mass of 0.100 kg includes:

- Leaven obtained by mixing: 0.0286 l water; 0.0185 kg rice flour; 0.0028 kg brown sugar; 0.0028 kg dry yeast.

- Dough that was obtained from: 0.068 kg rice flour; 0.012 kg eggs; 0.011 l olive oil; 0.011 l water; 0.0028 kg starch; 0.0014 kg chia; 0.0014 kg salt; 0.0012 kg cumin; 0.0008 kg carboxymethyl cellulose (CMC); 0.0002 kg Xanthan gum.

The recipe for **breadsticks with gluten and cumin enhanced by the addition of cruciferous extracts** with a net weight of 0.100 kg includes:

- Leaven made of the ingredients such as: 0.0213 l water; 0.0138 kg white flour; 0.0021 kg brown sugar; 0.0021 kg dry yeast.

- Dough obtained by mixing the following ingredients: 0.051 kg white flour; 0.012 kg eggs; 0.0085 l olive oil; 0.0064 kg cruciferous extracts; 0.0053 l water; 0.0021 kg starch; 0.0012 kg cumin; 0.001 kg chia; 0.001 kg salt; 0.0006 kg carboxymethyl cellulose (CMC); 0.0002 kg Xanthan gum.

The technological process for obtaining the three experimental variants of breadsticks described above, involved the performance of a series of unitary operations, which are described below.

All raw materials are dosed according to the manufacturing recipe, using a scale.

The water is slightly heated using a stove or oven to facilitate the dissolution operation. Dissolution is the operation by which a homogeneous liquid mixture is formed and involves mixing water with salt in order to uniformly disperse the salt. At the same time, the yeast is dissolved in water to facilitate its activation.

The eggs are beaten with a mixer. Mixing is the technological operation that involves the uniform incorporation of raw materials. In the first phase, the ingredients for the leaven are mixed, followed by the incorporation of the remaining ingredients into the leaven.

The leaven is fermented in a bowl at room temperature for 60 minutes, meanwhile the bowl being covered.

The kneading is done at room temperature for 10 minutes in a one-arm mixer to form the dough. The dough is shaped using a grinder with funnel, the shape of the by-products obtained being cylindrical and the cutting to the desired lengths is done with a knife.

The fermentation of the by-products takes place into the leavener for 20 minutes.

The baking process is performed at 190°C for 38 minutes, in a hearth oven with the by-products placed on a tray.

The cooling is realised with the trays placed on the work tables, for 2 hours, at ambient temperature.

The final products are packed in a normal atmosphere, in bags made of biaxially oriented polypropylene which is a highly valued material in the food industry, at different weights depending on consumer requirements, using the Impulse Bag Sealer equipment.

The products labeling shall be in accordance with Regulation (Eu) No 1169/2011 Of The European Parliament And Of The Council.

Breadsticks are stored at room temperature, in air-conditioned spaces, with controlled temperature, humidity and ventilation, for 7 weeks. Because the lack of gluten causes technological problems, Xanthan gum and carboxymethyl cellulose (CMC) were added in order to bind the dough components.

The technological operations are shown in Figure 1.

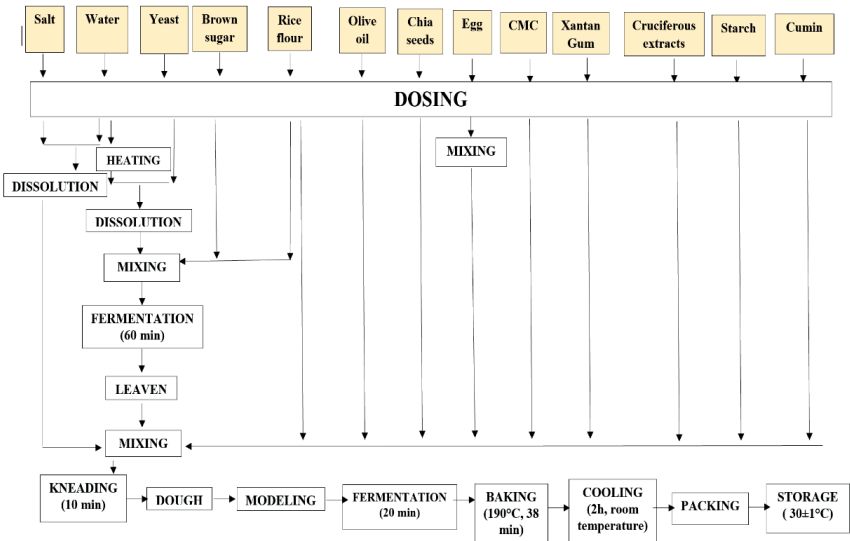


Figure 1. Technological diagram for functional gluten-free breadsticks with cumin enhanced by the addition of cruciferous extracts

Microbiological analysis of finished product
use the same methods for yeasts and molds cfu/g and Enterobacteriaceae cfu/g, as previously described for the raw materials. The results are mentioned in Table 3.

Table 3. Microbiological analysis results for finished products

Sample	Microbiological and stability indicators	
	Yeasts and molds (cfu/g)	Enterobacteriaceae (cfu/g)
Initial analysis		
Functional gluten-free breadsticks with cumin and cruciferous extracts	< 10	< 10
Gluten-free breadsticks with cumin, without cruciferous extracts	< 10	< 10
Breadsticks with gluten, cumin and cruciferous extracts	< 10	< 10
Analysis at three weeks		
Functional gluten-free breadsticks with cumin and cruciferous extracts	< 10	< 10
Gluten-free breadsticks with cumin, without cruciferous extracts	< 10	< 10
Breadsticks with gluten, cumin and cruciferous extracts	< 10	< 10
Analysis at six weeks		
Functional gluten-free breadsticks with cumin and cruciferous extracts	< 10	< 10
Gluten-free breadsticks with cumin, without cruciferous extracts	< 10	< 10
Breadsticks with gluten, cumin and cruciferous extracts	< 10	< 10
Analysis at seven weeks		
Functional gluten-free breadsticks with cumin and cruciferous extracts	< 10	< 10
Gluten-free breadsticks with cumin, without cruciferous extracts	< 10	< 10
Breadsticks with gluten, cumin and cruciferous extracts	< 10	< 10

Determination of water activity is based on the formula: $aw = \text{relative humidity (\%)} / 100$. The results are mentioned in Table 4.

Table 4. Results for water activity

Sample	Water activity
Initial analysis	
Functional gluten-free breadsticks with cumin and cruciferous extracts	0.750
Gluten-free breadsticks with cumin, without cruciferous extracts	0.752
Breadsticks with gluten, cumin and cruciferous extracts	0.751
Analysis at three weeks	
Functional gluten-free breadsticks with cumin and cruciferous extracts	0.751
Gluten-free breadsticks with cumin, without cruciferous extracts	0.753
Breadsticks with gluten, cumin and cruciferous extracts	0.755
Analysis at six weeks	
Functional gluten-free breadsticks with cumin and cruciferous extracts	0.755
Gluten-free breadsticks with cumin, without cruciferous extracts	0.756
Breadsticks with gluten, cumin and cruciferous extracts	0.758
Analysis at seven weeks	
Functional gluten-free breadsticks with cumin and cruciferous extracts	0.755
Gluten-free breadsticks with cumin, without cruciferous extracts	0.756
Breadsticks with gluten, cumin and cruciferous extracts	0.758

Physico-chemical analysis of finished products use the same methods for moisture, ash and fat, as previously described for the raw materials. Determination of proteins is based on the Kjeldahl method.

Determination of total carbohydrates is based on the formula:

$$\text{Total carbohydrates} = 100 - (\text{Moisture} + \text{Protein} + \text{Fat} + \text{Ash})$$

The energy value measured in kilocalories is based on the formula:

$$\text{E.V. (kcal)/sample} = (4 \times \text{protein/sample}) + (4 \times \text{total carbohydrates/sample}) + (9 \times \text{fat/sample})$$

The energy value measured in kilojoules is based on the formula:

$$\text{E.V. (kJ) / sample} = (17 \times \text{protein/sample}) + (17 \times \text{total carbohydrates/sample}) + (37 \times \text{fat/sample})$$

The results are mentioned in Table 5.

Table 5. Physico-chemical analysis results for finished products

Sample	Moisture (%)	Ash (%)	Protein (%)	Fats (%)	Total carbohydrates (%)	Energy value (kcal/ 100 g)
Functional gluten-free breadsticks with cumin and cruciferous extracts / 100 g	7.93	1.42	9.84	9.85	70.96	411.85
Gluten-free breadsticks with cumin and without cruciferous extracts / 92.74 g	7.24	1.50	9.68	10.24	64.08	387.20
Breadsticks with gluten, cumin and cruciferous extracts / 100 g	9.9	1.78	12.18	9.95	66.19	403.03

Sensory analysis of finished products

A questionnaire, which includes the following attributes, was completed by a panel of consumers: appearance (shape), surface color, inside color, smell, texture / chewing sensation. Following the tasting, the panel of consumers completed a questionnaire and chose the answer by giving notes according to the individual assessment from: I dislike it extremely (1)/I dislike it a lot (2)/I dislike it moderately (3)/I

dislike it lightly (4)/I don't care (5)/I like it lightly (6)/I like it moderately (7)/I like it very much (8)/I like it extremely (9).

The results were interpreted as a percentage and mentioned in Table 6. Sensory analysis results for functional gluten-free breadsticks with cumin and cruciferous extracts and Table 7. Sensory analysis results for gluten-free breadsticks with cumin, without cruciferous extracts.

Table 6. Sensory analysis results for functional gluten-free breadsticks with cumin and cruciferous extracts

Appearance (form)	I dislike it moderately (3)	I don't care (5)	I like it lightly (6)	I like it moderately (7)	I like it very much (8)
	16.67 %	8.33 %	16.67 %	33.33 %	16.67 %
Surface colour	I dislike it moderately (3)	I don't care (5)	I like it lightly (6)	I like it moderately (7)	I like it very much (8)
	16.67 %	8.33 %	8.33 %	41.67 %	25.00 %
Inside colour	I dislike it moderately (3)	I don't care (5)	I like it lightly (6)	I like it moderately (7)	I like it very much (8)
	-	16.67 %	8.33 %	41.67 %	33.33 %
Smell	I dislike it moderately (3)	I dislike it lightly (4)	I like it lightly (6)	I like it moderately (7)	I like it very much (8)
	8.33 %	8.33 %	25.00 %	41.67 %	16.67 %
Texture / chewing sensation	I dislike it moderately (3)	I don't care (5)	I like it lightly (6)	I like it moderately (7)	I like it very much (8)
	8.33 %	16.67 %	25.00 %	41.67 %	8.33 %
Aroma / taste	I dislike it a lot (2)	I like it lightly (6)	I like it moderately (7)	I like it very much (8)	I like it extremely (9)
	8.33 %	8.33 %	41.67 %	25.00 %	8.33 %
Sweetness	I don't care (5)	I like it lightly (6)	I like it moderately (7)	I like it very much (8)	I like it extremely (9)
	25.00 %	25.00 %	16.67 %	8.33 %	8.33 %
Acidity	I don't care (5)	I like it lightly (6)	I like it moderately (7)	I like it very much (8)	I like it extremely (9)
	41.67 %	8.33 %	25.00 %	8.33 %	8.33 %
Remaining taste	I dislike it extremely (1)	I dislike it moderately (3)	I like it lightly (6)	I like it moderately (7)	I like it very much (8)
	16.67 %	16.67 %	25.00 %	16.67 %	25.00 %
Total acceptability	I dislike it a lot (2)	I dislike it moderately (3)	I like it lightly (6)	I like it moderately (7)	I like it very much (8)
	8.33 %	8.33 %	16.67 %	50.00 %	16.67 %

Table 7. Sensory analysis results for gluten-free breadsticks with cumin, without cruciferous extracts

Appearance (form)	I don't care (5)	I like it lightly (6)	I like it moderately (7)	I like it very much (8)	-
	30 %	20 %	30 %	20 %	-
Surface colour	I don't care (5)	I like it moderately (7)	I like it very much (8)	-	-
	30 %	40 %	30 %	-	-
Inside colour	I don't care (5)	I like it moderately (7)	I like it very much (8)	-	-
	30 %	50 %	20 %	-	-
Ssmell	I dislike it lightly (4)	I don't care (5)	I like it moderately (7)	I like it very much (8)	-
	10 %	20 %	50 %	20 %	-
Texture / chewing sensation	I dislike it lightly (4)	I don't care (5)	I like it lightly (6)	I like it moderately (7)	I like it very much (8)
	10 %	20 %	20 %	20 %	30 %
Aroma / taste	I dislike it extremely (1)	I don't care (5)	I like it lightly (6)	I like it moderately (7)	-
	10 %	20 %	20 %	50 %	-
Sweetness	I dislike it a lot (2)	I don't care (5)	I like it lightly (6)	I like it moderately (7)	I like it very much (8)
	20 %	30 %	10 %	20 %	20 %
Acidity	I dislike it lightly (4)	I don't care (5)	I like it lightly (6)	I like it moderately (7)	I like it very much (8)
	10 %	30 %	20 %	10 %	20 %
Remaining taste	I dislike it a lot (2)	I dislike it moderately (3)	I like it lightly (6)	I like it moderately (7)	I like it very much (8)
	10 %	20 %	20 %	30 %	10 %
Total acceptability	I dislike it moderately (3)	I dislike it lightly (4)	I like it lightly (6)	I like it moderately (7)	I like it very much (8)
	10 %	20 %	20 %	30 %	10 %

RESULTS AND DISCUSSIONS

Among the raw materials analyzed, only wheat flour exhibited contamination with yeasts and molds at a level of 10^3 cfu/g. According to Order no. 27/2011, issued by ANSVSA, for the product category “flours for bakery” the maximum allowed limit is 10^3 cfu/g, but the analyzed sample shows contamination with yeasts and molds below this limit. The results obtained from the microbiological analyses fall within the accepted limits.

Comparing the physico-chemical analysis results for raw materials by analyzing acidity, moisture, fat, ash, protein and raw fiber, it can be seen that rice flour has lower values than white flour.

From a technological point of view, three experimental variants were obtained, as follows: Variant 1 - Functional gluten-free breadsticks with cumin enhanced by the addition of cruciferous extracts, whose appearance can be seen in Figure 2.



Figure 2: Functional gluten-free breadsticks with cumin enhanced by the addition of cruciferous extracts

Variant 2 - Gluten-free breadsticks with cumin, without cruciferous extracts whose appearance can be seen in Figure 3.



Figure 3: Gluten-free breadsticks with cumin, without cruciferous extracts

Variant 3 - Breadsticks with gluten, cumin and cruciferous extracts, whose appearance can be seen in Figure 4.



Figure 4. Breadsticks with gluten, cumin and cruciferous extracts

Under normal storage conditions, breadstick samples remained stable for seven weeks, showing no microbiological contamination by molds or Enterobacteriaceae during this period. Both aerobic mesophilic bacteria and molds are common spoilage microorganisms that contaminate the technological flow under inadequate hygiene conditions. To prevent contamination of finished products by microorganisms, it is essential to rigorously monitor raw materials, equipment, personnel hygiene, the production environment, and processing methods. It is well known that these are potentially contaminating elements of the technological flow. The results obtained from the microbiological analyses fall within the accepted limits.

Based on the results presented in Table 4, the following conclusions can be drawn:

- after the initial analysis, gluten-free breadsticks with cumin, without cruciferous extracts had the highest water activity and functional gluten-free breadsticks with cumin while cruciferous extracts had the lowest water activity;
- the analysis made after three weeks showed that breadsticks with gluten, cumin and cruciferous extracts had the highest water activity while the functional gluten-free breadsticks with cumin and cruciferous extracts had the lowest water activity;
- at six-week evaluation, breadsticks with gluten, cumin and cruciferous extracts had the highest water activity and the functional gluten-free breadsticks with cumin and cruciferous extracts had the lowest water activity;
- after seven weeks, the analysis revealed that breadsticks with gluten, cumin and cruciferous

extracts had the highest water activity while the functional gluten-free breadsticks with cumin and cruciferous extracts had the lowest water activity.

During the shelf-life monitoring period, the water activity index showed a slight increase but the final values are not significantly different from those obtained during initial testing.

Functional gluten-free breadsticks with cumin and cruciferous extracts, gluten-free breadsticks with cumin and without cruciferous extracts and breadsticks with gluten, cumin and cruciferous extracts were analyzed from a physico-chemical point of view. Comparing the results, we can see that moisture, ash and protein have the highest values for breadsticks with gluten, cumin and cruciferous extracts. Total carbohydrates and energy value have the highest values for functional gluten-free breadsticks with cumin and cruciferous extracts.

For functional gluten-free breadsticks with cumin and cruciferous extracts, the appearance was evaluated as „I like it moderately” by 33% from the panel consumers, the surface colour, inside colour, smell, texture/chewing sensation and aroma/ taste were evaluated as “I like it moderately” by 41.67% from the panel consumers, the sweetness was evaluated as “I don't care ” and “I like it lightly” by 25% from the panel consumers, the acidity was evaluated as “I don't care” by 41.67% from the panel consumers, the remaining taste was evaluated as “I like it lightly” and “I like it very much” by 25% from the panel consumers, the total acceptability was evaluated as “I like it moderately” by 50% from the panel consumers.

For gluten-free breadsticks with cumin, without cruciferous extracts, the appearance was evaluated as “I don't care” and “I like it moderately” by 30% from the panel consumers, the surface colour was evaluated as “I like it moderately” by 40% from the panel consumers, the inside colour was evaluated as “I like it moderately” by 50% from the panel consumers, the smell was evaluated as “I like it moderately” by 50% from the panel consumers, the texture/chewing sensation was evaluated as “I like it very much” by 30% from the panel consumers, the aroma/taste was evaluated as “I like it moderately” by 50% from the panel consumers, the sweetness was evaluated as “I don't care” by 30% from the panel consumers,

the acidity was evaluated as “I don't care” by 30% from the panel consumers, the remaining taste was evaluated as “I like it moderately” by 30% from the panel consumers, the total acceptability was evaluated as “I like it moderately” by 30% from the panel consumers. Functional gluten-free breadsticks with cumin and cruciferous extracts was preferred by consumers.

CONCLUSIONS

The purpose of this paper was to obtain functional gluten-free breadsticks with cumin improved by the addition of cruciferous extracts. The 3xBiotics commercial extracts was used for the experiments, which is a mixture of fermented cruciferous powders. The sulfur compounds naturally present in cruciferous vegetables are known to support liver detoxification at the cellular level. These vegetables strengthen the immune system and absorb free radicals. At the same time, sulfur compounds improve heart health and digestion. From microbiological point of view, the shelf life of the functional gluten-free breadsticks with cumin and cruciferous extracts and the shelf life of the control samples were of seven weeks, all the samples being free of microbiological contamination with mold or Enterobacteriaceae. From physico-chemical point of view, the highest energy value was for functional gluten-free breadsticks with cumin and cruciferous extracts, compared to the control samples.

Following the results of sensory analysis performed, it can be noticed that total acceptability for breadsticks with cumin and cruciferous extracts is appreciated as “I like it moderately” by 50% of consumers and “I like it very much” by 16.67 % of consumers.

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