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THE EFFECT OF ADDITION OF INULIN AND JERUSALEM ARTICHOKE POWDER ON THE NUTRITIONAL AND SENSORY PROPERTIES OF BREAD

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ABSTRACT

The study aimed to compare the nutritional and sensory properties of bread types. In this study, 5 bread types were examined, including standard (STD) and inulin added breads with 5% (I-5) and 10% (I-10) powdered inulin, 5% (J-5) and 10% (J-10) Jerusalem artichoke powder form. Volume, crust colour and texture the difference between 5 different types of bread is found to be statistically significant ($p<0,05$). According to multiple comparisons, for sensory parameters volume, crust colour and texture breads with J-10 and I-5 were statistically differ from other three types of bread. There were not statistically significantly different between 5 type breads in terms of the General Appreciation Preference parameter. The total score of J-5, I-10 and STD breads were not differ statistically significantly. Two-dimensional multidimensional scaling resulted with a strong correlation (RSQ=0,82). J-10 and I-5 plotted in the same quadrant, they were found to be close to each other. Considering its positive effects on health and acceptable sensory analysis results, the addition of inulin as a functional food is remarkable.

KEYWORDS: Inulin, bread, sensory analysis, functional food.

INTRODUCTION

Hydrocolloids are long-chain polymers of different structures that are easily dispersed in water, completely or partially soluble, and have a tendency to swell. Inulin is a plant-derived hydrocolloid with a fructan structure.[1] It is a carbohydrate polymer composed of fructose molecules linked by β-(2-1) glycosidic bonds and a single glucose unit linked by an α-(1-2) bond to the outermost fructose. It was first obtained from the roots of a plant called Inula helenum in the 1800s.[2-5] Inulin, which is considered a fructan compound, is found in fruits and vegetables.[6] Its natural sources are chicory, Jerusalem artichoke, asparagus, leek, onion, banana, wheat, and garlic.[5]

Due to its structure, inulin is resistant to enzymatic digestion inside the upper gastrointestinal tract by showing prebiotic properties. It cannot be broken down by enzymes such as maltase, saccharase or alpha amylase. Thus, it reaches the large intestine without being digested, where it can be fermented by the endogenous microflora.[7,8] While preventing constipation by increasing intestinal movements, it also prevents diarrhea due to its promotion of the development of bifidobacteria and inhibition of the proliferation of Gram-negative and Gram-positive bacteria among bifidobacteria.[9] Besides, inulin improves mineral absorption, is effective in appetite management, regulates lipid metabolism, regulates blood sugar, supports the immune system, and has antimutagenic and anticarcinogenic properties.[10,11] The usage of inulin as a functional food is quite common. Its addition as a fiber component in foods often provides better organoleptic properties. Inulin has a slightly neutral taste and does not adversely alter the sensory properties of the foods it is included in. It is also used to improve the stability of formulas and emulsions. Inulin-type fructans are successfully utilized in dairy products, baked goods and grain products, desserts, processed meat products, baby foods, beverages and meal replacement products, thereby improving the nutritional profile of processed foods.[10,12]

Inulin affects the quality characteristics of bread. By the addition of inulin, dough stability and mixing time are reduced. It contributes to the general elasticity and strength of the dough.[13] Brennan and Tudorica.[14]

proposed the idea that inulin shows its effects either by competing with starch for water or through starch gelatinization, thereby leading to lower hydrolysis levels. Another study carried out in Poland demonstrated that inulin strengthened the dough by positively affecting its rheological properties and improved its porous structure.[15]

The aim of this study was to compare the nutritional and sensory properties of breads with added inulin and Jerusalem artichoke powder.

MATERIALS AND METHODS

Samples

In this study, 5 types of bread were produced. Among the analyzed breads, the standard bread (STD) contained 500 g bread flour (söke), 20 g dry yeast (Dr. Oetker), 10 g sugar (Torku), 10 g salt (Billur) and 300 ml water. For the bread to which inulin would be added, 5% (I-5) or 10% (I-10) (25-50 g) inulin in powder form (Proteinocean) was added in addition to the standard bread content. For the bread to which Jerusalem artichoke would be added, 5% (J-5) or 10% (J-10) (25-50 g) of Jerusalem artichoke (Siberian Wellness) in powder form was added to the standard bread content.

Baking Protocol

The dough that was manually kneaded was shaped and transferred to molds after resting for 1 hour at room temperature. The samples were baked in a convection oven at 180°C for 45 minutes and kept at room temperature for 1 hour to cool. Bread weights were determined in grams on an analytical precision scale (Tefal BC5004V1 KS Optiss).

Sensory Analysis

The sensory analyses were performed by 10 trained panelists 2 hours after cooking. Before starting the analyses, the panelists were informed about the sensory evaluation criteria of the bread samples. The panelists evaluated the bread samples over 9 points according to the Aroma, Volume, Crust Color, Shape and Symmetry, Crust Characteristics, Crumb Color, Porosity, Texture, Flavor, Smell and General Appreciation Preference properties. Samples taken from the produced breads at equal amounts (25 g) were presented on plates of the same size and color. These plates were given codes consisting of 3 random numbers. The samples were presented separately to the panelists, and cold drinking water was given as they passed from one bread sample to the next.

Nutritional analyses

The nutritional analyzes of the prepared breads were carried out using the 'BEBIS Package Program version 8.2'. As a result of the analyses, the macronutrient and micronutrients values of 100 grams of bread for each sample were obtained.

Statistical Analysis

The mean values and standard deviations of the scores of the examined parameter were calculated with descriptive analysis. As the data were not found to be normally distributed, nonparametric statistical analyses were. The comparison of the five different breads by sensory parameters was made using Kruskal Wallis tests. The significance level was set to 0.05.

Table 1: Weight, energy, macro and micronutrients of breads.

	STD	J-5	J-10	I-5	I-10
Weight (g)	740	761	799	754	788
Energy (kkal)	245,33	242,23	234,21	245,74	239,89
Protein (g)	7,75	7,82	7,72	7,60	7,27
Fat (g)	0,70	0,73	0,74	0,69	0,66
Carbohydrate (g)	51,09	50,16	48,22	53,26	53,95
Dietary Fiber (g)	2,43	3,79	4,97	5,19	7,65
Vitamin A (mcg)	0,00	0,24	0,45	0,00	0,00
Vitamin E (eq.) (mg)	0,13	0,15	0,16	0,12	0,12
Thiamine (mg)	0,13	0,15	0,17	0,13	0,13
Riboflavin (mg)	0,13	0,13	0,13	0,13	0,13
Niacin (mg)	2,84	2,98	3,05	2,79	2,66
Vitamin B_6 (mg)	0,08	0,09	,10	0,08	0,08
Folate (mcg)	114,86	115,83	114,27	112,73	107,87
Vitamine C (mg)	0,00	0,47	0,90	0,00	0,00
Sodium (mg)	527,84	513,63	489,54	518,04	495,69
Potassium (mg)	167,65	219,55	262,95	164,54	157,44
Calcium (mg)	11,77	12,63	13,15	11,55	11,05
Magnesium (mg)	17,70	19,58	20,90	17,37	16,62
Phosphorus (mg)	78,78	85,83	90,54	77,32	73,98
Iron (mg)	0,93	1,34	1,69	0,91	0,95
Zinc (mg)	0,56	0,56	0,54	0,55	0,53

Table 2: Descriptive statistics of scores assigned to sensorial attributes of breads.

Sensory Parameters	STD	J-5	J-10	I-5	I-10	p-value
	Mean ± S.D.	Mean± S.D.	Mean± S.D.	Mean ± S.D.	Mean ± S.D.	
Aroma	7,1A ± 1,595	7,3A ± 0,948	5,8A ± 1,813	6,3A ± 1,636	7,1A ± 0,994	0,094
Volume	7,8A ± 0,788	7,6 A ± 0,699	5,9 B ± 1,595	6,8B ± 1,813	7,6 A ± 1,264	0,028*
Crust Color	8,1A ± 0,994	7,2 A ± 1,398	6,2B ± 1,135	6,0B ± 1,763	7,7 A ± 0,948	0,002*
Shape and Symmetry	7,7 A ± 0,948	7,5 A ± 1,269	6,8A ± 1,032	6,5 A ± 1,840	7,6 A ± 1,264	0,278
Crust Characteristics	7,6 A ± 1,264	7,3 A ± 1,159	6,7A ± 1,159	6,2 A ± 1,398	7,5A ± 1,269	0,095
Crumb Color	7,5 A ± 1,354	6,9 A ± 1,370	6,5 A ± 1,433	7,5 A ± 1,269	7,6 A ± 1,264	0,336
Porosity	7,2 A ± 1,475	6,7 A ± 1,251	6,3 A ± 1,418	6,3 A ± 1,766	7,2 A ± 1,398	0,392
Texture	7,4 A ± 1,349	7,6 A ± 0,843	6,1B ± 0,994	6,5 B ± 1,509	7,4 A ± 1,074	0,014*
Flavor	6,9 A ± 2,330	7,4 A ± 1,074	6,2 A ± 1,619	6,0 A ± 2,108	7,0 A ± 0,942	0,208
Smell	7,3A ± 1,702	7,6 A ± 0,966	6,3A ± 1,946	6,5 A ± 1,354	7,4 A ± 1,173	0,205
General Appreciation Preference	7,3A ± 1,702	7,3 A ± 0,948	6,1A ± 1,286	6,2 A ± 1,686	7,3 A ± 0,674	0,063
Total Score	74,6 A ± 11,663	73,1 A ± 7,385	62,8B ± 9,784	64,6B ± 14,485	74,1 A ± 9,374	0,040*

S.D: Standard Deviation, *: p-value significant at 0,05

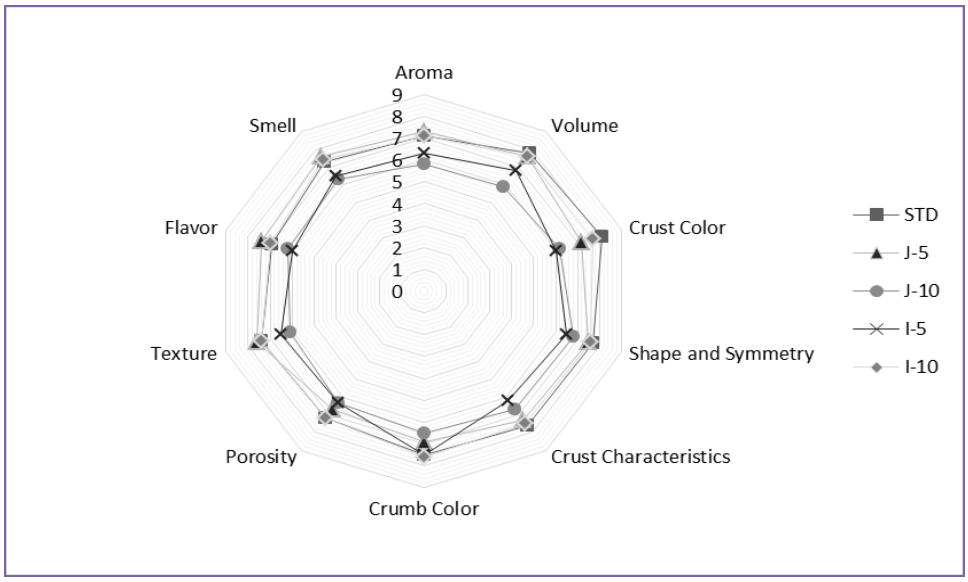

Figure 1: Sensory attributes of breads.

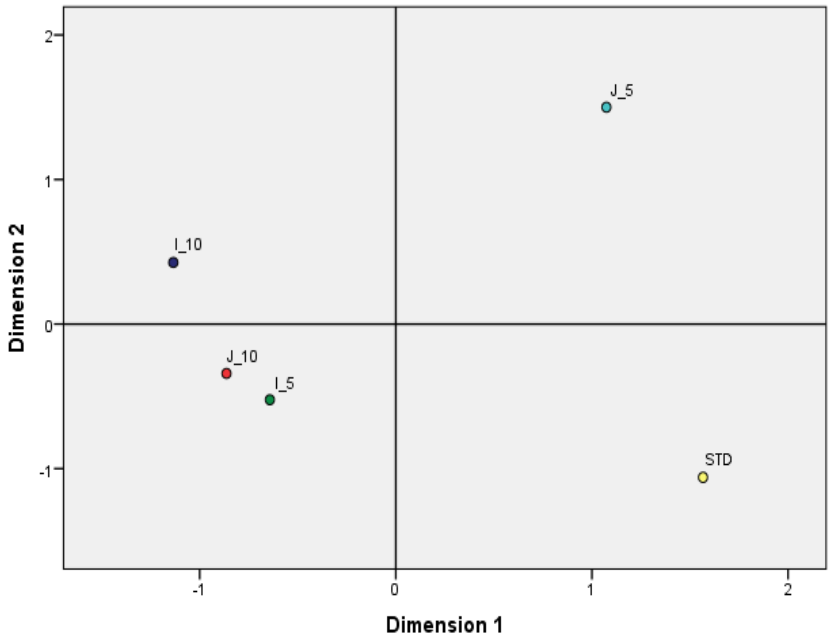

Figure 2: Multidimensional sensory profile.

RESULTS AND DISCUSSIONS

The weights, energy values, macronutrients and micronutrients of the 5 bread types are given in Table 1. Accordingly, the bread type with the highest fiber content was I-10.

The descriptive statistics of the bread samples and the results of their comparisons are summarized in Table 2. The bread types coded with the same letters were not significantly different. It is shown in Table 2 that for the sensory parameters that were examined, the differences in the volume, crust color and texture values between the 5 different types of bread were found to be statistically significant ($p<0.05$). According to multiple comparisons, for the sensory parameters of volume, crust color and texture, the J-10 and I-5 samples significantly differed from the other three samples. The mean volume, crust color and texture scores of J-10 and I-5 were lower than those of the others. There were no statistically significant differences between the 5 types of bread in terms of the General Appreciation Preference parameter.

Figure 1 shows the sensory attributes of the five different types of bread. The multidimensional sensory profile of each type of bread was analyzed by multidimensional scaling based on the Euclidean distance model. The derived stimulus configuration is presented in Figure 2. Two-dimensional multidimensional scaling resulted in a strong correlation (RSQ=0.82). As seen in Figure 2, the two breads plotted in the same quadrant, J-10 and I-5, were close to each other.

Since grain-based functional foods have a positive effect on human health, grains have an important place in the development of new products.[16] In addition to their nutritional properties, the economical nature of grains also affects the fact that they are the main food category consumed by the world's population.[17]

According to the 1999-2000 data of the National Health and Nutrition Examination Survey (NHANES), which was conducted to evaluate the health, dietary practices and nutritional status of the US population, the top 10 food groups contributing to energy intake were determined. As a result of the study, the cumulative contribution of "bread, rolls, crackers" to the total energy intake of individuals was stated as 31.0%.[18] In the 2003-2006 NHANES study, foods were examined in more than 20 groups. The top two foods were yeast breads/rolls and cake/cookies/quick bread/pastry/pie, and their contribution to total energy intake was 7.2% for both groups.[19] According to the 2007-2012 NHANES data, the most frequently consumed grains in all age groups participating in the research were determined as soft white rolls and white bread.[20]

According to the Turkey Nutrition and Health Survey,[21] 39.5% of the daily energy intake of the general population is provided from bread and grains. Moreover, the among of daily fiber intake with diet was determined as 21.8 g. According to the data of the aforementioned study, white bread is consumed by 72.1% of the population, whole grain bread, rye bread, whole wheat bread and other breads are consumed by 15%, and homemade unleavened breads (e.g., phyllo dough) are consumed by 9.4% every day in Turkish society.[21] Filipiak-Florkiewicz and Cieślik,[22] showed that inulin-supplemented bread had a higher nutritional value than standard bread. In this study, which was planned considering the important role of grain consumption in daily nutrition, it was aimed to compare the nutritional and sensory properties of bread with the addition of inulin and Jerusalem artichoke powder. It was aimed to increase the functional properties of bread by adding prebiotic nutrients to bread that was made from white flour.

Interest in the usage of hydrocolloids in making bread is increasing due to their properties such as increasing the water absorption of bread dough, improving the bread volume, pore structure and texture of the bread crumb, and increasing the shelf life by delaying staling.[1] In our study, the bread with the lower ratio of Jerusalem artichoke powder (I-5), that with the higher ratio of inulin (I-10) and the standard bread were significantly different from the bread with the higher ratio of Jerusalem artichoke powder and that with the lower ratio of inulin in terms of the volume, crumb color and texture properties ($p<0.05$). Between the inulin-supplemented samples (I-5 and I-10), it was found that the I-10 sample had a higher total score. Bojnanska et al.[13] reported that adding 10% inulin into bread provided "satisfactory sensory acceptance", but adding higher amounts was not satisfactory.

Wang et al.[23] performed a sensory analysis of breads with added carob fiber, chicory inulin and pea fiber and stated that the softest bread crumb belonged to the inulin-added bread. In another study that was carried out to evaluate the effects of inulin addition on the sensory, nutritional and physical parameters of white bread, formulations containing 0%, 6% and 10% inulin were compared, and the test sample containing inulin by 6% was rated to have good sensory qualities.[24] In the study by Rubel et al.,[4] different doses (2.5 and 5.0 g) of inulin-rich carbohydrate powder extracted from Jerusalem artichoke and commercial dandelion inulin powder were used in making bread, and the breads that were made were compared to bread prepared without inulin. It was shown that adding the lower amount of inulin was more acceptable according to the results of their sensory analysis, and there was no significant difference between the inulin-added and control samples in terms of other features.[4] In a study comparing bread samples by adding artichoke fiber at different ratios, it was determined that the addition of more than 9% in formulations significantly changed the texture of the bread.[25] In this study, we aimed to conduct a sensory evaluation using different doses of 2 different products and observed that the total score of the J-5 sample was

significantly higher than that of the J-10 sample ($p<0.05$). We also determined that the I-10 sample had a higher total score than the I-5 sample. The fact that the commercial form of inulin has a neutral taste, that it provides similar crust and inner color as in standard bread made from white flour as a result of its addition to bread and that the sharp aroma and odor of the Jerusalem artichoke powder might have affected the preferences of the panelists in our study.

In a previous study comparing the sensory profiles and acceptability of breads to which inulin and oligofructose-inulin were added to a standard bread, the bread samples made with fructan addition were preferred to the standard bread in terms of aroma, texture, taste and general acceptability.[26] Considering the consumption frequency of types of bread made with white flour on a social scale, research results on the acceptability of products added to this bread type is limited. In this study, it was determined that the J-5 and I-10 samples had similar total scores to that of the STD sample in the sensory analysis.

In addition to the effect of some hydrocolloids such as inulin on rheological and physical properties, it was determined that they showed a dietary fiber structure and were effective in reducing the risk of osteoporosis, preventing coronary heart diseases, type 2 diabetes and colon cancer associated with the consumption of foods to which they were added.[27] The recommended dose of inulin for its different physiological benefits ranges from 10 g to 15 g.[8] Radovanovic et al.[28] stated that leavened bread consisting of 75% wheat flour and 25% Jerusalem artichoke powder had optimal nutrition and caloric values, as well as low GI and GL values. In this study, it was aimed to enrich the fiber content of bread by adding different forms of inulin to bread at different rates. In the study by Brasil et al.[24] a bread containing 10% (g/100g) inulin was compared to a standard recipe, and a statistically significant difference was found in terms of fiber content, but no significant increase in fiber content was observed with the addition ratio of 6%. In our study, the highest fiber content was found in the I-10 sample.

For years, the positive effect of inulin on mineral absorption has been emphasized. Studies showed that rats fed inulin and/or oligofructose absorbed more calcium and magnesium than the control group.[29,30] The positive effects of inulin and oligofructose on mineral absorption are associated with lowering the pH of the small and large intestines and increasing the concentration of volatile fatty acids.[31] The results of the study by Matt et al.[32] suggested that an increase in butyrate with additional soluble fiber such as inulin may balance age-related microbiota dysbiosis and potentially provide neurological benefits. On the other hand, the 'bifidogenic' nature or prebiotic effect of inulin-type fructans causes increased concentrations of Bifidobacteria in the colon lumen, providing protection against colon cancer and improving the blood lipid profile.[33,34]

It should be taken into account that the excessive use of inulin may cause absorption-related and digestive problems. Moreover, data on the potential allergenicity of inulin are very limited.[8]

CONCLUSIONS

In conclusion, the finding that there was no significant difference between the "General Appreciation Preference" scores of the samples suggested that the addition of inulin may be quality-increasing option for bread in comparison to conventional preferences. This may contribute to a balanced diet by having many beneficial effects on human health and nutrition by increasing the fiber content and types of products turned into functional foods by the addition of inulin to foods. In line with this information, the development of functional foods with the addition of inulin is noteworthy, and it is thought that it will have positive effects on health.

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Conflict of interests: There are no conflicts to declare.

Ethics committee approval: This study was approved by Baskent University Institutional Review Board and Ethics Committee (Project no: KA21/241).

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