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Effect of Inulin and Resistant Starch on Some of Qualitative Properties of Baguette Bread

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ABSTRACT: Bread is a particularly important staple food. It can be thus improved using different prebiotics like inulin and resistant starch. Food diets with sufficient prebiotic content can trigger the growth of the remaining microorganisms in the digestive system. These microorganisms are essential for human health. In this study, the effect of different levels of inulin and resistant starch (at levels of 2.5 and 5%) was investigated on a number of qualitative properties of baguette breads. A completely randomized design with three replications was used to analyze experimental data (except for staleness data which were analyzed using factorial experiment with a completely randomized design). Means were compared by Duncan's multiple-range test (α = 5%). The results showed that moisture, ash and fiber contents of bread samples were higher than control samples, whereas protein, fat, and pH were lower in the former. In addition, these additives improved sensory analysis scores, instrumental staleness, color analysis and volumetric analysis of samples. According to the results, the treatment that contained 5% inulin and 5% resistant starch was selected as the best treatment.

Keywords: *Baguette Bread, Inulin, Prebiotics, Resistant Starch*.

Introduction

Bread is a staple food for most of the Iranian population as it is considered a substantial supply of protein and energy. Undoubtedly, production and supply of health breads are highly effective in public health. The quality of yeast breads depends on the baking capability of flour, fermentation time, protein content, and type of additives. Moreover, the baking capability of flour generally is a function of flour properties, industrial processes, production methods, and dough preparation stages. The general formulation of yeast breads includes flour, water, salt, dry yeast, sugar, oil, additives, and improvers, which their type and quantity vary with the bread type and purpose (Movahhed *et al.,* 2011). Food diets with sufficient prebiotic content can trigger the growth of the remaining microorganisms in the digestive system. These microorganisms are essential for human health (Fahey, 2010). Inulin-type diet fibers have prebiotic functions in the human body.

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They are not digestible due to B1 and B2 glycoside bonds, whereas they can be used by the micro flora of the large intestine. Digestion-resistant starch is another prebiotic that acts as a food fiber and improves nutritional value. Currently, it is widely used in the food industry and can also improve the texture of the final product. Digestion-resistant starch (also known as resistant starch) is a suitable substrate for intestine micro flora and produces metabolites like short-chain fatty acids (SCFAs), particularly acetic acid, propionic acid, and butyric acid. Butyric acid can be metabolized by intestinal bacteria and plays an important role in supplying food and energy for intestinal cells. In recent years, the rise in consumer awareness about health benefits of prebiotics has increased interests in functional foods particularly in bakery products. In other words, enrichment of breads with prebiotics, which turn them into functional foods, can have a significant role in achieving health benefits (Brites *et al.*, 2011). Hager *et al.* (2011) focused on the effect of inulin solution fibers and beta-glucan on dough and bread quality. The results showed that beta-glucan increases dough elasticity whereas inulin showed no substantial effect on dough structure. Moreover, by increasing inulin and beta-glucan levels, the volume of gluten-free breads shrank. Additionally, it was indicated that both compounds reduced the specific volume of gluten-free breads, however their effects on sensory profile, hardness and staleness of breads were different. Aravind *et al*. (2012) focused on optimization of second and third resistant starch levels in durum wheat used in pastas in a bid to reduce digestibility under laboratory conditions while conserving productivity and sensory profile. The consumption levels were 10, 20 and 50% for semolina with type 2 resistant starches and 10 and 20% for replacement with type 3 resistant starches. According to the results, no significant effects on cooking loss, texture and sensory profile of the samples were observed, except for a slightly lighter yellow color for pastas. The addition of resistant starch to pasta also reduced experimental starch digestion compared to durum wheat. Iranshahi *et al*. (2014) studied the effects of inulin and beta-glucan on the staling rate of Barbari breads. The addition levels were 1.5 and 3%. Their results showed that beta-glucan absorbs more water than starch, which in turn reduces hardness of breads. At the same time, inulin HPX is more efficient in increasing volume and improving bread quality. Moreover, inulin-enriched breads have better flavor and texture and less staleness. Against this background, the present study aimed to analyze the effect of inulin and resistant starch prebiotics on a number of qualitative properties of baguette breads.

Materials and Methods

- *Materials*

The raw materials included wheat flour (Ettehad Karaj Co., Iran), long-chain inulin (Beneo, Germany), Hi-Maize 260 resistant starch (National Starch Food Innovation, Germany), active dry yeast (Iran Mellas Co., Iran), improver (Nan Sahar Co., Iran), salt (Sefid Daneh Co., Iran) and sugar (Pardis Co., Iran). Based on the number of treatments, about 20 kg wheat flour, 1 kg resistant starch and 1 kg inulin were purchased. In the following, Table 1 presents the study treatments.

- *The process of Baguette production*

In order to produce baguette, raw materials including Setareh flour, long-chain inulin, Hi-maize 260 starch resistant to digestion, active dry yeast, improver, salt, sugar, and water were prepared and weighed. Then, powdered materials were mixed in the mixer tank without water for 2 min and about 0.5 l of water was added. In the next stage, the mixture was stirred in a mixer tank with low speed for 3-4 min and then stirred in a mixer tank with medium speed for another 3 min.

Table 1. Treatments of study

Treatments	Code
Control treatment	C
Treatment containing 2.5% inulin	D1
Treatment containing 5% inulin	D2
Treatment containing 2.5% resistant starch	D3
Treatment containing 5% resistant starch	D4
Treatment containing 2.5% inulin + 2.5% resistant starch	D5
Treatment containing 2.5% inulin + 5% resistant starch	D6
Treatment containing 5% inulin + 2.5% resistant starch	D7
Treatment containing 5% inulin + 5% resistant starch	D8

Finally, the mixture was stirred in a fast speed mixer for 4 min. After complete mixing of the material with water and forming a formable mass, the sample was given a 7-min rest period. Then, pieces of dough were chopped and rounded and accordingly, the mid rest was given to the sample for 5 min. After the mid fermentation was performed, the dough chops entered the rolling machine and the special rolls of each treatment were placed on the tray. The trays carrying the treatment were transferred to the fermentation chamber for performing final fermentation and kept at a temperature of 37 °C and relative humidity of 80% for 45 min. Then, the bread trays were placed in a storey oven at a temperature of 220 °C for 15 min and finally, packed in polyethylene bags after cooking and cooling (Rajabzadeh, 2013).

- *Physicochemical properties*

The chemical properties of flour and baguette breads included measurements for moisture (AACC Method 44-16), ash (AACC Method 08-01), protein (AACC Method 46-12), fat (AACC Method 30-10), wet gluten (only flour) (AACC Method 38-12A), fiber (AACC Method 32-10), and pH (AACC Method 02-52). Baguette breads also received sensory (AACC Method 74-30), color (AACC Method 14-22), and volumetric analysis (AACC Method 72-10) (Anonymous, 2000; Anonymous, 2003). Breads were baked in Sahar Bakery Co and all the physicochemical properties on the flour and breads were conducted in the Cereal Research Center in Tehran, Iran.

- *Colorimetric test for Baguette bread*

In order to determine the color of the specimens, the Hunter Lab instruments (D25-9000 made in Germany) was used. The analysis of the bread color was performed by evaluating three indicators of $L*$, $a*$ and $b*$. The $L*$ indicator measures the brightness of specimens and varies between zero (pure black) and 100 (pure white). On the other hand, the $a*$ indicator represents the proximity of specimens color to green and red, while the $b*$ indicator indicates the proximity of specimens color to blue and yellow. It is worth noting that the range of these two variables varies between (-120) and (+120) (Anonymous, 2000).

- *Examining the staling of Baguette bread by the instrumental method*

In order to examine the staling (tissue metric) of bread specimens, the instrument of Testometric M350-10CT, Germany, was used by the instrumental method. The test was performed at periods of 24, 48 and 72 hours after cooking. Initially, the specimens were kept individually in plastic bags at ambient temperature. Then, the cuts of the specimen with dimensions of 2 cm × 2 cm were separated from their cores in order to evaluate by Instron instrument. The applied compression rate was equivalent to 50% of the thickness of the specimen as mentioned in the standard method (Anonymous, 2000).

- *Evaluating the sensory properties of Baguettes*

In order to evaluate the sensory properties of bread specimens, their properties were analyzed by using five senses. Bread specimens were coded after cooling and cutting and evaluated by 10 trained evaluators. On the first day of baking, the evaluation was conducted based on the properties of bread such as color, shell, fit, chewing ability, tissue, perfume and odor, taste and flavor, and the like, each of which has a special point based on the importance. The referees determined specific points for the bread specimens with respect to the maximum points specified in the evaluation forms (Anonymous, 2000).

- Statistical analysis

A completely randomized design with three replications was used to analyze experimental data (except for staleness data which were analyzed using factorial experiment with a completely randomized design). Means were compared by Duncan's multiple-range test ($\alpha = 5\%$) in SPSS 16.

Results and Discussion

- Physicochemical testing of wheat flour

The physicochemical profile of wheat flour samples was determined including moisture content (13.02%), ash (0.680%), protein (11.93%), fat (1.25%), pH (5.9), wet gluten (29.65%) and fiber (0.63%). By comparing the results against the standard recommendations, the wheat flour was suitable for producing baguette breads.

- Physicochemical tests on Baguette breads

Mean comparison results for the effect of different levels of prebiotics (inulin and resistant starch) on the chemical profile of baguette breads are given in Table 2.

According to Table 2, D8 (5% inulin+5% resistant starch) had the highest amount of moisture content (MC), ash, fiber and volume whereas C (control) had the lowest than other treatments. There was a significant difference between all treatments ($p<0.05$). The reason for the results of moisture content is due to the presence of inulin and other oligosaccharides in dough samples that maintain the moisture and freshness of breads compared to the control samples for a longer period (Franck, 2002). In other words, breads containing inulin and resistant starch lose water slower than the control treatment

Table 2. Mean comparison of chemical properties of bread samples

Treatment	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Fiber (%)	pH	Volume (cm^3)
C	25.33±0.29^{e}*	0.84±0.01^{e}	12.86±0.15^{a}	6.01±0.05^{a}	0.48±0.07^{g}	6.55±0.01^{a}	535±5.01^{h}
D1	26.37±0.75^{d}	0.90±0.09^{d}	12.47±0.23^{b}	5.65±0.09^{b}	0.55±0.03^{f}	6.54±0.01^{b}	542.2±4.18^{g}
D2	27.07±0.23^{d}	1.01±0.15^{d}	12.13±0.18^{c}	0.92±0.06^{d}	0.74±0.05^{e}	6.53±0.02^{b}	594.8±3.43^{e}
D3	26.77±0.06^{d}	0.93±0.01^{d}	12.39±0.1^{b}	1.21±0.08^{c}	0.71±0.03^{e}	6.53±0.02^{b}	574±6.25^{f}
D4	27.50±0.35^{c}	1.20±0.14^{c}	12.1±0.08^{c}	0.74±0.05^{e}	1.18±0.06^{c}	6.5±0.02^{b}	601.1±4.70^{d}
D5	27.33±0.29^{c}	1.08±0.24^{c}	12.12±0.04^{c}	0.80±0.02^{e}	0.89±0.05^{d}	6.51±0.02^{b}	598.2±4.37^{de}
D6	28.60±0.35^{b}	1.383±0.03^{b}	11.53±0.12^{d}	0.54±0.01^{f}	1.29±0.13^{ab}	6.42±0.01^{c}	677.7±5.41^{b}
D7	27.63±0.12^{c}	1.27±0.5^{b}	11.58±0.10^{d}	0.56±0.01^{f}	1.20±0.03^{bc}	6.43±0.01^{c}	638.2±6.30^{c}
D8	30.27±0.06^{a}	2.007±0.16^{a}	11.50±0.09^{e}	0.45±0.04^{g}	1.32±0.09^{a}	6.41±0.01^{c}	699.7±4.69^{a}

[*] Mean ± standard deviation; In each column, means with at least one common letter have no significant difference ($p < 0.05$). Control treatment (C), treatment containing 2.5% inulin (D1), treatment containing 5% inulin (D2), treatment containing 2.5% resistant starch (D3), treatment containing 5% resistant starch (D4), treatment containing 2.5% inulin + 2.5% resistant starch (D5), treatment containing 2.5% inulin + 5% resistant starch (D6), treatment containing 5% inulin + 2.5% resistant starch (D7), and treatment containing 5% inulin + 5% resistant starch (D8).

during their shelf-life. Their behavior is similar to hydrocolloids which are effective in increasing the water absorption of dough samples. Resistant starch has a more substantial effect on increased MC and shelf life of baguette breads due to its higher water holding capacity (Skendi *et al.,* 2010). The study results were in agreement with those reported by Devereux *et al.* (2003), who suggested that low-fat cookies containing inulin had a higher MC than control samples (without inulin). Based on the results, addition of different levels of inulin and resistant starch (RS) caused significant differences between ash of baguette samples and that of control ($p<0.05$). It can be caused by the higher mineral content of these prebiotics, which in turn shows the nutritional value of inulin and resistant starch in breads (Škrbic *et al.,* 2009). Škrbic *et al.* (2009) suggested that prebiotics of husk-less barley flour as a source of fiber can be effective in increasing the ash content of samples. On the other hand, the high fiber content of prebiotics-containing samples than control samples can be due to the nature of inulin and RS as they have a fiber nature and can increase product fiber content. Škrbic *et al.* (2009) showed that husk-less barley flour as a source of fiber can be effective in increasing the fiber content of samples. Kirshnan *et al*. (1987) also reported that the increase in the fiber content of bran-containing oat breads was higher in the NDF than the ADF method, and these fibers had high hemicellulose content. The results about volume can be explained by the fact that inulin and RS increased baguette volumes by positively contributing to the formation of a gluten lattice and increasing stability and CO_2 production (Movahhed *et al.,* 2011). Rodriguez-Cabezas *et al.* (2010) showed that inulin, as a fat replacement, can entrain more air in dough by developing higher viscosity, and can thus produce larger breads. According to Table 2, the control treatment had the highest amount of protein, fat and pH whereas D8 (5% inulin+5% resistant starch) had the lowest and there were significant differences between the said treatments ($p<0.05$). The results that obtained about protein can be due to the high protein content of C thanks to the higher gluten content in wheat, which was lower, other treatments. At the same time, since flour samples containing inulin and RS had lower protein content than wheat flour (C), the decrease in protein content of other treatments with increasing prebiotic levels can be supported (Movahhed *et al.,* 2014a). The results were in agreement with those reported by Movahhed *et al*. (2014b). They suggested that addition of brown rice flour prebiotics and mono- and diglyceride emulsifiers can reduce the protein content of Sangak breads (an Iranian flat bread) compared to control samples. On the other hands the lower fat content of prebiotics-containing samples than control samples can be due to the nature of inulin and RS as they have a polysaccharide and fiber nature and can function as a fat substitute to reduce product fat. At the same time, both prebiotics can bond with water and form a molecular gel, which in turn increases the product consistency (Movahhed *et al*., 2014b). Similarly, Mohebbi *et al.* (2014) reported that addition of inulin as a fat substitute can reduce the fat content of samples compared to control. Based on the results, the control treatment had the highest pH. In other words, addition of inulin and RS caused significant differences between pH of baguette breads and that of control. This can be due to the fact that inulin and RS have neutral pH, which reduced the pH of the final product compared to the control treatment. In other words, these compounds reduced the bread pH, which is caused by their effect at the beginning of the fermentation by lactic bacteria and yeasts (Akin *et al.,* 2007). Akin *et al.* (2007) reported that increased levels of inulin in ice-cream are effective in reducing pH. That is, addition of inulin to samples formed a gel-like state and delayed starters when kept in a refrigerator.

- *Sensory analysis results for Baguette samples containing different levels of inulin and resistant starch*

Mean comparison results for the effect of different levels of prebiotics on the sensory profile of baguette breads are given in Table 3.

According to Table 3, D8 had the highest aroma, taste, chewiness and texture whereas C (control) had the lowest value than other treatments. There were significant differences between the treatments ($p< 0.05$). The reason about aroma and taste are due to the presence of proteolytic enzymes in sourdough that decompose some of the dough proteins and produce free amino acids. These acids in turn are effective in the flavor of products despite the fact that amino acids alone have no role in good aroma, rather some aldehydes and ketones are also effective. In other words, sourdough breads have more volatile compounds giving them a higher sensory analysis score. In general, lactic bacteria can produce different aromatic compounds as their main characteristics (sourdough flavor and proper metabolite production) are a function of the microbial species, raw materials, access to carbohydrates, and the process. Moreover, the taste-producing acetic and lactic acids are the other by-products of sourdough. It seems that acetic acid intensifies the effect of other aromatic substances (Gobbetti *et al.*, 2005). Mohamed *et al.* (2011) reported that bread enrichment with banana prebiotics and RS can improve the flavor of breads. The results about chewiness are directly related to dough elasticity. At the same time, elasticity is a function of dough structure and porosity, whereas the stability of pore walls in turn depends on starch swelling. Finally, starch swelling is related to enzymatic activities. In general, dough with insufficient fermentation usually produces non-elastic breads. In the present study, inulin and resistant starch improved dough elasticity and bread chewiness. Also Peyghambardoust *et al.* (2013) suggested that increased levels of common flax seed flour in bread ingredients can improve dough elasticity and chewiness of samples compared to the control treatment. Tissue recovery can be caused by the effect of prebiotics on starch structure that contributes to the better distribution and holding of water, which improve bread texture resistance. Moreover, these

Table3. Mean comparison of sensory properties of bread samples

Sensory profile	C	D1	D2	D3	D4	D5	D6	D7	D8
Aroma	8.7±0.1^{e}	9±0.1^{d}	9.2±0.1^{c}	9.2±0.1^{c}	9.6±0.01^{b}	9.2±0.1^{c}	9.6±0.01^{b}	9.6±0.01^{b}	9.8±0.01^{a}
Taste	12.3±0.2^{d}	12.9±0.1^{c}	13.1±0.1^{bc}	13±0.1^{c}	13.3±0.1^{b}	13.2±0.1^{b}	13.5±0.1^{a}	13.4±0.1^{ab}	13.6±0.1^{a}
Chewiness	8.2±0.1^{f}	8.8±0.2^{e}	9.2±0.2^{de}	8.9±0.2^{e}	9.6±0.2^{bc}	9.4±0.2^{cd}	9.8±0.1^{ab}	9.7±0.1^{b}	10±0.1^{a}
Texture	12.4±0.2^{g}	12.8±0.2^{f}	13.1±0.2^{e}	13±0.1^{e}	13.4±0.1^{c}	13.2±0.1^{d}	13.7±0.1^{a}	13.6±0.2^{b}	13.8±0.1^{a}
Color	7±0.1^{e}	7.4±0.1^{cd}	7.8±0.1^{bc}	7.6±0.1^{cd}	7.8±0.1^{bc}	7.8±0.1^{bc}	8±0.1^{a}	7.8±0.1^{bc}	8±0.1^{a}
Back uniformity	2±0.1^{c}	2.4±0.1^{b}	2.4±0.1^{b}	2.4±0.1^{b}	2.7±0.2^{a}	2.4±0.1^{b}	2.8±0.2^{a}	2.8±0.2^{a}	3±0.2^{a}
Rupture	2±0.1^{d}	2.2±0.1^{c}	2.2±0.1^{c}	2.2±0.1^{c}	2.4±0.1^{b}	2.2±0.1^{c}	2.6±0.1^{a}	2.4±0.1^{b}	2.6±0.1^{a}
Crust properties	2±0.1^{e}	2.3±0.1^{d}	2.4±0.1^{cd}	2.3±0.1^{d}	2.4±0.1^{cd}	2.4±0.1^{cd}	2.8±0.1^{ab}	2.6±0.1^{bc}	3±0.1^{a}
Volume	8.1±0.1^{e}	9±0.1^{d}	9.2±0.1^{cd}	9.1±0.1^{d}	9.6±0.1^{b}	9.3±0.1^{c}	9.8±0.1^{a}	9.6±0.1^{b}	10±0.1^{a}

In each column, means with at least one common letter have no significant difference ($p < 0.05$). Control treatment (C), treatment containing 2.5% inulin (D1), treatment containing 5% inulin (D2), treatment containing 2.5% resistant starch (D3), treatment containing 5% resistant starch (D4), treatment containing 2.5% inulin + 2.5% resistant starch (D5), treatment containing 2.5% inulin + 5% resistant starch (D6), treatment containing 5% inulin + 2.5% resistant starch (D7), and treatment containing 5% inulin + 5% resistant starch (D8).

compounds improved the texture of baguette samples through their positive effect on formation of a gluten lattices and increased resistance. The results were in agreement with a study where hydrocolloids, fibers and prebiotics generally improved the texture of samples compared to the control (Aravind *et al.,* 2012). Based on the results, D8 and D6 (2.5% inulin+5% RS) had equally the highest crust color whereas C (control) had the lowest value than other treatments. In other words, addition of inulin and RS caused significant differences between this sensory attribute, *i.e.* crust color of baguette breads, and that of control ($p< 0.05$). This is because the crust color is a function of maillard (browning) reaction. During the maillard reaction, a large amount of ingredients responsible for color changes and effective in flavor and texture profile are formed. The interaction of prebiotics (inulin and RS) with amylose of bread starch improved the crust color. Accordingly, as the prebiotic addition level increased from D1 to D8, crust color became more pronounced (Movahhed *et al.*, 2014a).

Based on Table 3, D8 had the highest back uniformity, breakage and rupture, crust properties and volume whereas C (control) had the lowest value than other treatments. There were significant differences between the said treatments ($p < 0.05$). Based on the results, inulin and RS increased bread back uniformity through their positive effect on formation of gluten lattices and increased resistance (Movahhed *et al.*, 2011). These results were in agreement with those reported by Movahhed *et al.* (2014b) who suggested that addition of banana flour to toast breads can improve back uniformity of the final products. According to results, the presence of strong complexes between gluten and these prebiotics improved bread resistance against breakage and rupture. In other words, inulin and RS act as reinforcement for breads (Mayer and peters, 2009). Wang *et al*. (2002) shown that higher inulin levels is effective in increasing resistance against breakage and rupture in bread samples compared to the control samples. On the other hand, addition of prebiotics increases water uptake of bread crumb due to their OH groups and other hydrophilic groups of bread texture. This in turn improves the crust profile of breads (Angioloni and Collar, 2008). Angioloni and Collar, (2000) showed that RS can increase water absorption in bread crumbs, which improves sensory profile of samples compared to the control treatment. As mentioned, inulin and RS improved the sensory score for volume of baguette breads compared to the control. That is, these compounds increased bread volume through their positive effect on formation of gluten lattices and increased resistance (Movahhed *et al.*, 2011).

- *Instrumental analysis results of interaction (Treatment × Time) on staleness of Baguette samples containing different levels of inulin and RS (24, 48 and 72 h after baking)*

Mean comparison results for interaction (Treatment × Time) on staleness of baguette breads from the instrumental method are given in Table 4.

According to Table 4, the control treatment had the highest staleness score whereas D8 (5% inulin+5% resistant starch) had the lowest than other treatments within all three time intervals. In other hand, addition of these prebiotics reduced and delayed the hardening process of breads. This can be due to the presence of prebiotics and their increased levels in reducing staleness in baguette samples. These results were in line with those reported for increased dough water uptake, water maintenance, and bread texture. In other words, reduced staleness was expected. Swollen starch in the dough at the beginning of the baking process is decomposed enzymatically, thus uses the released water for advancing the gelatinization process. The dough water content and inner bread texture became swollen as a result of added RS. It also increased dough efficiency thus giving a moist inner texture to the baked products, which in turn postponed staleness. Another reason is that gluten formed a strong complex with inulin and resistant starch prebiotics and enhanced dough stability and water absorption (Movahhed *et al.*, 2011). Baixauli *et al.* (2008) suggested that increasing fiber and prebiotics contents reduces staleness as its lowest score occurred for the highest RS content.

- Sample color results for Baguette samples containing different levels of inulin and resistant starch

Table 5 lists mean comparison results for the effect of inulin and resistant starch on the color of baguette bread samples.

According to Table 5, D8 had the highest *L** whereas C (control) had the lowest value than other treatments. This is because *L** is a function of maillard (browning) reaction. The interaction of prebiotics (inulin and RS) with amylose of bread starch improved color parameters. Therefore, as the prebiotic addition level increased from D1 to D8, this parameter became more pronounced (Movahhed *et al.*, 2014a). The results suggested that higher RS content increased lightness (*L**). The white color of RS was the main cause of lighter-colored breads (Movahhed *et al.*, 2011). Based on Table 5, the control treatment had the highest *a** and *b** parameters whereas D8 had the lowest

Table 4. Mean comparison of interaction between (Treatment × Time) on staleness of baguette samples (Instrument method) (N)

Treatment	Time (hour) 24	48	72
C	4.67 ± 0.1^{e}	8.72 ± 0.1^{b}	12.43 ± 0.2^{a}
D1	3.01 ± 0.1^{g}	6.88 ± 0.1^{c}	8.68 ± 0.1^{b}
D2	2.79 ± 0.1^{h}	5.52 ± 0.1^{d}	5.74 ± 0.2^{d}
D3	2.82 ± 0.1^{h}	6.75 ± 0.1^{c}	6.91 ± 0.1^{c}
D4	2.08 ± 0.1^{i}	4.63 ± 0.1^{e}	4.63 ± 0.1^{e}
D5	2.16 ± 0.1^{i}	4.72 ± 0.1^{e}	5.64 ± 0.1^{d}
D6	1.50 ± 0.2^{j}	2.89 ± 0.1^{h}	3.11 ± 0.1^{g}
D7	1.55 ± 0.2^{j}	4.14 ± 0.1^{f}	4.64 ± 0.1^{e}
D8	1.41 ± 0.2^{j}	2.8 ± 0.1^{h}	2.84 ± 0.1^{h}

In each column, means with at least one common letter have no significant difference ($p < 0.05$). Control treatment (C), treatment containing 2.5% inulin (D1), treatment containing 5% inulin (D2), treatment containing 2.5% resistant starch (D3), treatment containing 5% resistant starch (D4), treatment containing 2.5% inulin + 2.5% resistant starch (D5), treatment containing 2.5% inulin + 5% resistant starch (D6), treatment containing 5% inulin + 2.5% resistant starch (D7), and treatment containing 5% inulin + 5% resistant starch (D8).

Table 5. Mean comparison of inulin and resistant starch effects on the color of baguette samples

Treatment	L*	a*	b*
C	55.27 ± 0.21^{g}	4.49 ± 0.04^{a}	28.66 ± 0.05^{a}
D1	59.49 ± 0.47^{fg}	3.85 ± 0.01^{b}	26.65 ± 0.03^{b}
D2	59.61 ± 0.33^{e}	3.17 ± 0.07^{c}	24.25 ± 0.01^{c}
D3	59.53 ± 0.15^{ef}	3.41 ± 0.09^{bc}	24.26 ± 0.08^{c}
D4	60.19 ± 0.2^{d}	2.69 ± 0.08^{d}	23.72 ± 0.04^{d}
D5	59.83 ± 0.29^{e}	2.77 ± 0.03^{d}	23.89 ± 0.08^{d}
D6	61.80 ± 0.73^{b}	2.14 ± 0.09^{f}	23.13 ± 0.02^{e}
D7	60.89 ± 0.5^{c}	2.40 ± 0.06^{e}	23.35 ± 0.01^{de}
D8	61.96 ± 0.75^{a}	1.67 ± 0.04^{g}	21.67 ± 0.09^{f}

In each column, means with at least one common letter have no significant difference ($p < 0.05$). Control treatment (C), treatment containing 2.5% inulin (D1), treatment containing 5% inulin (D2), treatment containing 2.5% resistant starch (D3), treatment containing 5% resistant starch (D4), treatment containing 2.5% inulin + 2.5% resistant starch (D5), treatment containing 2.5% inulin + 5% resistant starch (D6), treatment containing 5% inulin + 2.5% resistant starch (D7), and treatment containing 5% inulin + 5% resistant starch (D8).

values for both parameters than other treatments. These results can be caused by maillard and caramelization reactions, which produced light-brown pigments and reduced red and yellow colors in bread crusts during the baking process (Movahhed *et al.*, 2014a).

Conclusion

The present study qualitatively analyzed the effect of inulin and resistant starch prebiotics on baguette breads. The results showed that moisture, addition of inulin and resistant starch can increase ash and fiber contents of bread samples compared to control samples, while reducing protein, fat, and pH in the former. In addition, these additives improved sensory (organoleptic) analysis scores, instrumental staleness and color analysis of samples. From the other side, the D8 treatment that contained 5% inulin and 5% resistant starch was selected as the best treatment.

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