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ENRICHMENT OF SANGAK BREAD WITH CARROT POMACE POWDER AND ITS EFFECT ON DOUGH RHEOLOGY, BREAD QUALITY, AND SHELF LIFE

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ABSTRACT

The study explores the use of antioxidant dietary fiber (ADF) from vegetable and fruit by-products in bread production to enhance nutritional value and reduce food waste. Specifically focusing on Sangak bread, a popular flatbread in Iran, the research investigates the effects of supplementing soluble fiber from carrot powder on bread quality and shelf life. By adding carrot pomace powder at different levels to the bread dough formulation, improvements in protein levels, reduced carbohydrate content, and enhanced dough strength were observed. The enriched bread samples showed less variation in texture over six days of storage, with the initial firmness attributed to the moisture absorption properties of carrot pomace powder. While the enriched dough exhibited changes in texture and sensory qualities compared to the control sample, the 3% enrichment level was found to be superior in terms of aroma and overall acceptability. The study emphasizes the importance of carefully balancing the incorporation of dietary fiber-rich ingredients in baked products to improve their nutritional profile without compromising sensory qualities. Overall, incorporating carrot pomace powder into Sangak bread at an optimal level of 3% is suggested as a promising approach to create a more nutritious and appealing product for consumers, addressing both health and sustainability concerns in the baking industry.

1.Introduction

Dietary fiber is a widely recognized term that has been defined by the Codex Alimentarius Commission as carbohydrate polymers that resist hydrolysis by endogenous enzymes in the small intestine of humans. In contrast to dietary fiber, antioxidant dietary fiber (ADF) is a novel concept introduced by Saura-Calixto (1998), with its key feature being the association of dietary fiber with natural antioxidants like phenolic compounds. ADF is predominantly found in plant-based foods such as vegetables (e.g., carrots, cabbage, cactus), fruits (e.g., apples, grapes, oranges, mangoes), cereals (e.g., wheat, rye, oats), and seeds (e.g., cocoa beans, coffee beans) (Xu et al., 2021). Utilizing high-fiber wastes such as tomato, beet, apple, and carrot pomaces from processing plants can not only reduce food waste but also enhance the nutritional value of food products, contributing to the development of healthier and more sustainable food options. Vegetable or fruit by-products are abundant sources of ADF and have traditionally been utilized as low-value commodities, primarily for animal feed (Xu et al., 2021; Nawirska and Kwaśniewska, 2005). Bread is a widely consumed staple food in many parts of the world. Unfortunately, most breads are crafted using refined flours that lack essential nutrients like fiber, vitamins, minerals, and antioxidants. This deficiency arises from the extraction of wheat bran and germ during processing (Tebben et al., 2018). Hence, breads made from white wheat flour fail to fulfill the growing nutritional and health requirements of consumers. There are many ways to reduce bread staling today, such as the use of fiber in bread formulation. Sangak bread, because of its good flavor, is one of the most widely used kinds of flat bread in Iran (Khoshakhlagh et al., 2014). Sangak bread has the highest amount of insoluble fiber among traditional bread types in the country, and adding soluble fiber to it, due to differences in physiological responses of these fibers, seems desirable. Most studies have focused on reducing and delaying bread staling using bread improvers.

Carrot)Daucus carota(, is a widely used and valuable vegetable because of its nutritional properties, carotene, and carotenoids content, as well as vitamins B1, B2, B6, B12 and minerals. Carrot contains large amounts of fiber, protein, fat, and carbohydrates (Hernández-Ortega et al., 2013). Carrots have been used in foods such as bread, cakes, pickles, enriched wheat bread, and biscuit to enhance the fiber content of these products (Salehi et al., 2016).

In recent years, Iran has faced increasing bread waste. Approximately 23% of wheat, 7% of flour, and 22% of bread, equivalent to 4 million tons of imported wheat, are converted into waste in Iran each year. Due to the high volume of bread consumption in the country, this figure is very significant (Mohammadi, 2007). Bread shelf life is generally limited by two microbial and staling factors. Bread after baking, due to moisture, is a good environment for the growth of molds and yeasts that cause spoilage of bread (Avital et al., 1990).

Adding fiber sources to the bread formula is often accompanied by problems in the properties of the dough and the quality of the bread. Adding fiber reduces the volume, and increases the firmness and darkness of the bread (Wang et al., 2002). Besides, the resulting doughs have high water absorption which reduces the fermentation tolerance. The negative effects of fiber on bread structure are related to the decrease in gluten content and the increase in bran particles in bread texture (Katina et al., 2006). Turfani et al. (2017) studied the nutritional value of bread enriched with lentil flour. According to the results of this study, protein and fiber of the bread increased significantly. The rheological properties of the dough and the characteristics of the bread were also changed. According to these studies, there is no research on the use of carrot pomace powder fiber in Sangak bread production. This study aims to use carrot pomace waste and extract its fiber to increase the nutritional value of Sangak bread and to prevent bread waste by using new and cost-effective packaging.

2. Materials and methods

2.1. Materials

2.2.1. Material preparation

In this research, wheat flour with a 90% extraction rate, was supplied from the Marianaj-kar factory in Hamedan. Carrot pomace was collected as a juice waste from the local fruit juice shops. For the packaging of bread, silicon Nano-polymer film and lightweight polyethylene film were prepared from Tehran Aitak Nano-polymer and Tehran Plast companies, respectively. The Nano-bags (Zip-Kip) are made of silicone polymers, which allow the entry and exit of oxygen and carbon dioxide to be controlled and minimized. As a result, they prevent the spoilage of food inside these bags, and keep fresh the foods for a long time, and retain their properties until they are punctured or torn.

2.2.2. Extraction and maintenance of carrot pomace fiber

Carrot pomace fiber was prepared using the method developed by Chantaro et al. (2008). At first, the carrot pomace was blanched in hot water at 90 ± 2 °C (1 to 6 pomace ratio to water) for 1 minute. After rinsing, they were dried at 60 °C to 80 °C up to 6% moisture with an Avon from Fan Azemaghostar Company. It was then powdered with a home grind to obtain homogeneous particles. The resulting powder was passed through a 35-degree mesh sieve (500 μm) and stored in aluminum packaging at 4 °C.

2.2.3. Chemical analysis of carrot pomace powder

Moisture content was determined according to the AACC 44-19 standard method. Ash content was analyzed using the electric furnace method as per the AACC 08-01 standard. Crude protein content was determined by the Kjeldahl method using Soxhlet extraction, following the AACC 30-100 standard. Total nitrogen content for protein determination was measured by the Kjeldahl method and converted to protein content using a conversion factor of 6.38, in accordance with the AACC 46-10 standard.

2.2.4. Measuring the amount of total fiber

Fatless and dry samples were used to measure total fiber (AOAC, standard 1995). At first, 2 g of the sample was weighed accurately using model (AND FX-300GD) digital scale. After transferring to a beaker with a volume of 600 ml, the sample was boiled for 30 min in 200 ml of 0.25 normal sulfuric acid and the beaker contents were shaken once every 5 minutes. Subsequently, the content of the beaker was filtered using a filter paper, a Buchner funnel, and a vacuum pump. Then it was transferred to another beaker. Then 200 ml of 0.3 normal NaOH solution was added to the beaker and boiled for 30 min. At this step, the contents of the container were again filtered, and the residual material on the filter paper was transferred into a previously weighed porcelain crucible and placed in an oven at 105 °C for 24 h. Then, the porcelain crucible containing the sample was cooled in the desiccator and reweighed. For removing all organic materials, the porcelain crucible and its contents were placed in the oven for 3 h at a temperature of 550 °C. After this time, the crucible was cooled in the desiccator and reweighed. Finally, Equation (1) was used to calculate the percentage of fiber.

$$F = \frac{W_1 - W_2}{W} \times 100 \quad (1)$$

F: Total fiber content; W1: The weight of the porcelain crucible and sample before burning (g); W2: The weight of the porcelain crucible and sample after burning (g); W: The sample weight (g).

2.2.5. Preparation of dough samples

Wheat flour (1 kg), salt (45 g), and water were used to prepare the dough. Carrot pomace powder was added to the dough at different percentages of 3, 5, and 7 % (w/w based on flour) at the mixing stage. The dough was then rested at 25 ± 2 °C for 1 to 2 hours to complete fermentation (AACC-I, 2000).

2.2.6. Investigation of tissue parameters of dough

To obtain the textural features of the enriched and control dough, the back-extrusion test was carried out by a food texture analyzer (Zwick / Roell model BT1_FR0.5TH.D14) made in Germany with a load cell capacity of 500 N. In this test, the diameters of the retaining container and the probe were 45.92 mm and 40 mm, respectively. The test was defined in three cycles and in three repetitions so that in each cycle, loading and unloading last 30 and 10 seconds, respectively. The test speed was 40 mm / min, and the displacement rate after loading was 5 mm. Textural features such as elasticity, adhesion, chewiness, and cohesion were plotted in the form of a force-displacement curve using (Test Xpert) software (Fig. 1).

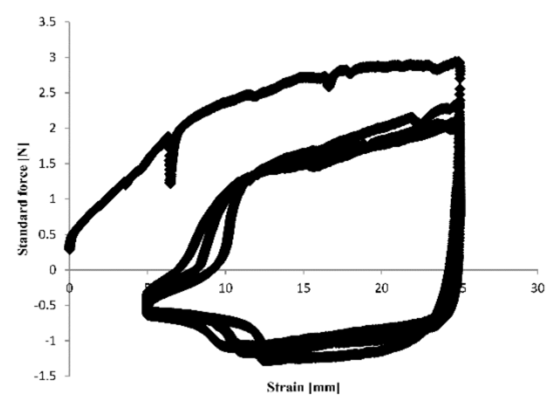

Figure 1. An example of a food texture analyzer graph

2.2.7. Sangak bread preparation method

Wheat flour (3 kg), salt (45 g), and water (as needed) were used to prepare the dough. Then, the sourdough (20%) was added, and the dough stirred for half an hour with the stirrer. The fiber was added to the dough at various levels during the mixing process. The dough was then transferred to a large container and was rested for 1-2 hours, at 25 ± 2 °C to complete fermentation. It was then baked in the oven for 4 min at about 400 °C. To convert direct heat to indirect heat, a wall of fireproof brick at an approximate height of 50 cm was installed in front of the direct furnace flame.

2.2.8. Bread packaging

The bread was cooled to 20 °C and transferred to the laboratory for sensory and mechanical analysis. The bread was cut into 15 × 15 cm with a sterilized knife and packaged in two kinds of package form including silicon Nano-polymer film and polyethylene film with a thickness of 100 µm and dimensions of 25 × 35 cm using a special stitching machine (Dookht Plast). The samples were kept at 6 °C (refrigerator) and 20 °C (ambient) until the mold was observed.

2.2.9. Determination of mechanical properties of bread texture

Tensile test is a destructive test in which a sample is studied under uniaxial tension until failure. This test was determined using a food texture analyzer (Zwick/Roell model BT1_FR0.5TH.D14 load cell x force hp) made in Germany with a capacity of 500 N according to standard ASTM 882-02 (2002). (Fig. 2). For this test, two fixed and movable jaws with adjustable jaw opening were used. The distance between the two jaws was calibrated at 50 mm at a speed of 25 mm/min. First, bread was cut (3 x 10 cm). Then its thickness was measured by caliper and recorded in machine software. When the machine started working, the specimen was stretched and the textural features such as maximum force required to tear the bread, breaking force (Fbreak), the amount of rupture energy were plotted by machine software (Test Xpert), in the form of force (N) - displacement (mm) curve (Fig. 2).

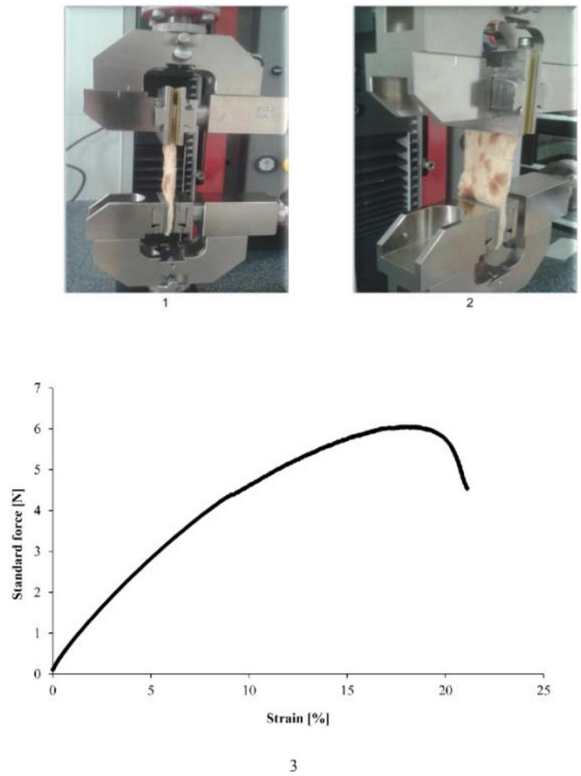

Figure 2. Material Texture Machine, tensile test. 1- Front view, 2- Side view. 3- An example of a food texture analyzer graph

2.2.10. Sensory evaluation of bread

The aroma, taste, color, chewiness, and acceptability of the produced bread sample and the control sample were determined by the sensory evaluator group, using the Consumer Desire Test (5-point hedonic test). The samples were evaluated by eight students of Bu Ali University who were familiar with the principles of sensory evaluation. Enriched and control bread was prepared and given to the evaluators with a special form. The evaluators completed the forms according to their tastes. For this purpose, the scores of 5 and 1 were assigned for the high-quality and low-quality types of bread, respectively.

2.2.11. Experimental design and statistical analysis

In this study, all stages and experiments were performed in three replications. The results of the experiments were analyzed by factorial test in a completely randomized design after normalization using SPSS 23 software. The mean treatments were compared with Duncan's method at a 95% confidence level. EXCEL 2016 software was used to draw charts.

3.Results and discussions

3.1. Chemical analysis

Table 1 shows the amounts of protein, fat, ash, moisture, fiber, and carbohydrates of wheat flour and carrot pomace powder as follows. According to Table 1, the protein content of the flour is 78.8%. Protein content increased by 11.87% by adding carrot pomace powder at the level of 3% (w/w based on the flour). Scanlon et al. (2000) in their study on the textural features of bread made from weak and strong flour, showed that increasing the quantity and quality of protein in flours, made the dough stronger. The protein content of carrot pomace powder was 9.62%. Kohajdová et al. (2012) reported the protein content of carrot pomace powder 6.86%, and Chau et al. (2004) reported it 8.44%. According to the results, flour fat content was 0.83%, which was increased to 0.85% by the addition of carrot pomace powder, which was not a significant increase. According to National Standard No. 11136, the amount of flour fat was reported to be 1.2%. Flour ash content is significantly higher than carrot pomace powder. Flour ash was 5.55%, but carrot pomace powder was 1.15%, indicating higher mineral content in flour. This rate for enriched flour was 4.13%. Bread is high in carbohydrates, and carbohydrates are major contributors to obesity and overweight (Nandini et al., 2001). According to Table (1), carbohydrate content is 83.13% for flour and 86.73% for carrot pomace powder. But for enriched flour with carrot pomace powder, the carbohydrate content is 68.58%. Thus, the effect of carrot pomace powder is significant because it reduces the carbohydrate content, which is a major contributor to overweight in bread consumption. Kim et al. (2012) investigated the physical and chemical properties of cactus-enriched sponge cake. Their results showed that with the addition of cactus fiber, the amount of carbohydrates decreased, which was consistent with the results of this study. Reducing the moisture content of flour and carrot pomace powder means keeping them in the right place. According to the results, the moisture content of flour was 2.61%, which was reduced to 2.53% by the addition of carrot pomace powder. So, the carrot pomace powder has been able to reduce the moisture content of the flour.

When grinding wheat grains, a large percentage of the fiber in the wheat shell is removed. By decreasing extraction rate, the amount of minerals and fibers in flour decreases and subsequently, the nutritional value of flour is reduced. According to Table 1, with the addition of carrot pomace powder to wheat flour at a ratio of 1:3, the total fiber content also increased, so that the total fiber content of flour increased from 1.49% to 6.74%. Ateş and Elmacı (2018) showed that by adding coffee to one kind of cupcake formulation the fiber content increased, which was consistent with the results of this study. In a study conducted by Hussein et al. (2013), it was reported that the ash and crude fiber contents of the baked pan bread increased with higher levels of carrot powder (CP). The authors suggested that this increase could be linked to the elevated ash and fiber contents present in CP when compared to fine wheat flour. These results align with previous studies by Doweidar (2001), Gopulan et al. (1991), and Chantaro et al. (2008) (Body text TNR 12 normal, ident first line 0.66 cm, line spacing Single).

Table 1. Chemical analysis of wheat flour and carrot pomace powder

Treatment	Moisture (%)	Fiber (%)	Carbohydrate (%)	Ash (%)	Fat (%)	Protein (%)
Flour	2.61 ± 0.04	1.49 ± 0.03	83.18 ± 0.01	5.55 ± 0.06	0.83 ± 0.04	7.87 ± 0.09
CPP	2.47 ± 0.09	11.05 ± 0.04	86.73 ± 0.05	1.15 ± 0.07	0.24 ± 0.03	9.62 ± 0.07

3.2. The evaluation results of the dough texture

3.2.1. Gumminess

Gumminess is the amount of force needed to break down a semi-solid product into a form that is ready to be eaten (Mousavi et al., 2019). According to Table 2, the results for the gumminess of enriched dough show that by adding carrot pomace powder to the dough, the dough gumminess has increased from 1.87 N/mm2 to 5.57 N/mm2. Meanwhile, the dough with 3% carrot pomace powder has changed less than the control sample, but doughs with 5% and 7% carrot pomace powder have high gumminess which, has increased the volume of the dough. The Maillard reaction, which requires low activation energy, produces carbon dioxide, which can contribute to increasing the volume of the dough. Dietary fiber plays a significant role in influencing bread dough gumminess. Research indicates that incorporating dietary fiber into dough alters its rheological properties, impacting bread quality. Fiber can disrupt the gluten network, delay gluten hydration, and compete for water molecules in the dough (He, 2023; Lu et al., 2018), potentially leading to increased bread hardness and gumminess (Shiau et al., 2015). Moreover, dietary fibers, such as insoluble arabin oxylans, can increase water absorption during bread making, further affecting dough gumminess (Iraqui et al., 2013). The interaction between fiber and gluten influences dough rheology and bread quality (Liu et al., 2017), with fiber addition potentially causing bread hardening due to gluten dilution (Sivam et al., 2010). The results of this study is in agreement with those of Majzoobi et al. (2016) and Lebesi and Tzia (2011). Monthe et al. (2019), in a study on the rheological properties of gluten-free bread and its enrichment with sorghum and potatoes, showed that increased gumminess was a negative parameter in bread preparation, which was consistent with our results.

3.2.2. Elasticity

Elasticity refers to how quickly a material, like food, returns to its original shape after being deformed (Garrido et al., 2015). The results show that adding carrot pomace powder to Sangak dough reduces its elasticity. Specifically, the addition of carrot pulp powder decreased the elasticity from 0.66 N in the control sample to 0.60 N in the sample at the 7% level (Table 2). The incorporation of dietary fibers into bread formulations has been found to reduce the elasticity of bread while enhancing its mechanical properties (Culețu et al., 2020). In a study by Wu and Shiau (2015), it was reported that adding pineapple peel fiber (PPF) at levels of 0%, 5%, 10%, and 15% with particle sizes of 250-420 micrometers resulted in a decrease in the elasticity of the dough, which was attributed to the increase in PPF particle size in the dough.

3.2.3. Cohesiveness

Cohesiveness refers to the internal strength of food structures and the capacity to bind together the components of a product (Nourmohammadi et al., 2021). The results show that the addition of carrot pomace powder decreases the cohesiveness of the dough compared to the control sample and a significant decrease is observed in the levels. The highest and lowest amount of cohesion were observed in the control dough (0.94 N) and in the enriched dough at the level of 7% (0.77 N), respectively. Among the levels, the level of 3% with the cohesion of 0.88 N has better cohesion in the dough structure than other levels (Table 2). In the study by Wu and Shiau (2015), the effect of pineapple peel fiber (PPF) on the cohesiveness of bread dough was also investigated. It was reported that increasing the level of PPF in the dough led to a decrease in cohesiveness. Specifically, the cohesiveness decreased from 0.75 N in the control sample to 0.68 N, 0.62 N, and 0.58 N in samples with PPF levels of 5%, 10%, and 15%, respectively. This decrease in cohesiveness was attributed to the presence of PPF particles in the dough, which may have disrupted the structure and cohesiveness of the dough.

3.2.4. Chewiness

The chewiness is a property of being chewy. Dietary fiber, particularly insoluble fiber, can increase the water-holding capacity of the dough, leading to improved texture and chewiness. Additionally, dietary fiber can also strengthen the gluten network in the dough, resulting in a more elastic and chewier crumb. There was no significant difference between the level of 3% (2.73 N) and the control sample (1.87 N). But among the levels, the level of 7% (5.53 N) had the highest rate of chewiness (Table 2). Gómez et al. (2010) found that by replacing wheat bran percentages and increasing fiber, the dough flow behavior index decreased. The high fiber content and a large number of hydroxyl groups present in the fiber structure, react with water molecules through hydrogen bonds, and by absorbing the water present in the dough formulation, increases the chewiness and reduces the flow behavior of the dough (Horstmann et al., 2018). Studies have demonstrated that incorporating fiber-rich ingredients such as whole grains, bran, or seeds into bread formulations can enhance the chewiness of the final product. However, the type and amount of fiber added can also influence the overall texture and mouthfeel of the bread.

Regarding the texture parameters of the dough, the results showed that the level of 3% had the best performance compared to the other levels for baking Sangak bread. Thus, this level was used for baking Sangak bread and packing it with films.

Table 2. The results of the comparison table of average evaluation of dough texture

Variations sources	Cohesiveness	Chewiness	Gumminess	Springiness
Dough control	$0.94^{a} \pm 0.02$	$1.87^{b} \pm 0.02$	$1.87^{c} \pm 0.01$	$0.66^{a} \pm 0.06$
Enriched dough 3%	$0.88^{ab} \pm 0.03$	$2.73^{b} \pm 0.03$	$2.73^{b} \pm 0.04$	$0.63^{a} \pm 0.03$
Enriched dough 5%	$0.81^{ab} \pm 0.05$	$5.72^{a} \pm 0.07$	$5.53^{a} \pm 0.03$	$0.61^{a} \pm 0.09$
Enriched dough 7%	$0.77^{b} \pm 0.01$	$5.53^{a} \pm 0.08$	$5.57^{a} \pm 0.06$	$0.60^{a} \pm 0.08$

3.2.5. Investigation of textural changes in bread by tensile test during storage at 6°C and 20 °C

In spite of the common use of the compressive force and the penetration test to examine the texture of bread, there have been few studies on the use of the tensile test for this purpose. The most important reason for not using this method is the difficulty of obtaining a sample with a uniform geometric shape (Pavinee et al., 2018). After preparing the sample by geometric method, the parameters of the maximum tensile force (Fmax) and maximum breaking force (Fbreak) were measured. According to the results in (Table3), the interaction effect of bread × day × film × temperature is significant at the 0.05 level for maximum tensile force (Fmax), Fbreak, and tensile strength. Changes in Fmax, Fbreak, and tensile strength of enriched and control bread samples after 6 days showed an increasing trend, but enriched bread samples exhibited less variation compared to control samples. The reason for the increased firmness of enriched stone bread on the first day compared to control bread is the fiber property present in carrot pomace powder (Kumar et al., 2011). Moisture absorption by fiber prevented mold spoilage in bread but led to initial firmness compared to the control sample. These results are consistent with the study by Sharoba et al. (2013), where using carrot pomace powder in cake increased the firmness of the cake structure due to the water and oil absorption ability of the fibers in carrot pomace powder. Moreover, Majzoobi et al. (2016) reported an increase in cake structure firmness by using soy isolate in the cake. Nikzadeh et al. (1390) examined the effect of adding two different types of sourdough on the rheological properties and sensory evaluation of bread. Tensile test results showed that the required force for stretching oat-containing bread dough decreased after 48 hours but increased after 72 hours.

Table 3. Variance analysis table of the effects of day, bread, film, atmosphere and temperature on the stretch ability parameters of Sangak bread

Variations sources	Degrees of freedom	F_{max} (N)	F_{Break} (N)
Day (A)	2	1.64^{**}	1.47^{**}
Bread (B)	1	5.64^{**}	4.07^{**}
Film (C)	1	0.00^{ns}	0.00^{ns}
Temperature (D)	1	4.00^{**}	2.92^{**}
A×B	2	1.01^{**}	0.80^{*}
A×C	2	2.21^{ns}	0.32^{*}
C×D	1	0.66^{ns}	0.33^{*}
A×B×D	2	0.77^{*}	0.45^{*}
A×C×D	2	1.24^{**}	0.76^{**}
A×B×C×D	2	0.64^{*}	0.49^{*}
Error	96	0.16	0.11

Notes: * Significant at $p \leq 0.05$, ** Significant at $p \leq 0.01$, and ns not significant.

3.2.6. Sensory analysis results

The results showed that the addition of carrot pomace powder decreased satisfaction with the taste of enriched bread. Enriched Sangak sample at a 3% level, was not significantly different from the control sample, and the addition of carrot pomace powder did not change bread taste. The worst taste was related to the enriched bread at the level of 7% with a score of 1.37, and the best taste was related to the enriched bread at the level of 3% with a score of 3.75 (Fig. 3).

According to the sensory test results, the enriched Sangak bread at the level of 3% had the highest score in terms of aroma, and the enriched bread at the level of 7% had the lowest score compared to the control sample.

Color is one of the most important sensory properties of the food, and the consumer first evaluates the quality of the food by this property. Color is one of the best quality attributes of food and at the same time, it conveys the texture and taste of the product. According to the sensory analysis of bread, it was found that adding carrot pomace powder had a significant effect on the color of bread. This was due to the presence of carotenoids in the bread. Enriched bread at the level of 7%, with a score of 4.61, had the highest score among the other levels compared to the control sample.

Chewing is a mechanical aspect of eating and refers to crushing the food between teeth. According to Figure 3, with the addition of carrot pomace powder, the chewiness of the bread was reduced, so that according to the reports of evaluators, the enriched bread had a stiffer texture than the control sample. The results also showed that the control sample with a score of 3.66 was the best one in terms of chewiness. The worst score was related to the enriched bread at the level of 7% with a score of 1.5. Also, according to the mean comparison, enriched bread at the level of 3% was not significantly different from the control sample.

In terms of overall acceptability, two kinds of enriched bread (levels of 3% and 7%) with the total scores of 4.32 and 2.89, respectively, were the best and the worst kinds of bread compared to the control sample. Kohajuvada et al. (2012), found that using carrot pulp powder (up to 10%), increased the acceptability of the product, but at higher levels, due to negative effects on color, aroma, texture, and taste, the overall acceptability of the product was reduced. Sharuba et al. (2013) also reported a decline in cake acceptability by adding carrot pomace at high levels. Turksoy and Ozkaya (2011) also reported that the use of carrot pomace powder by more than 15% in a kind of pancake decreased its acceptability by the evaluator group.

According to the rheology of the dough and the overall acceptability of the bread by the evaluators, the enriched bread at the level of 3%, was selected for packaging.

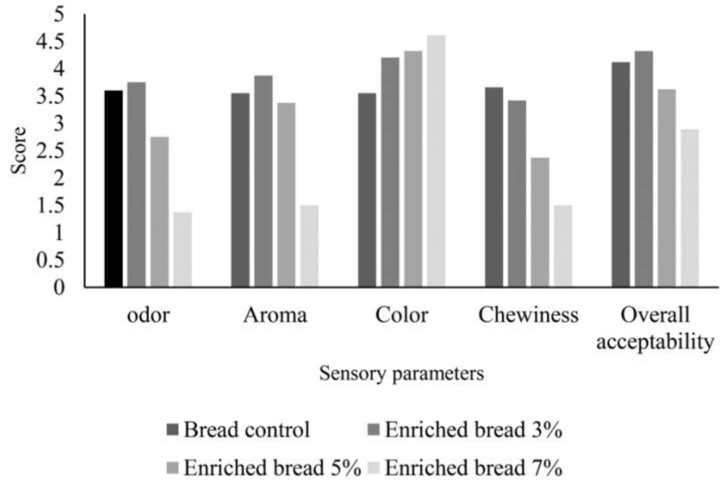

Figure 3. Sensory analysis chart

4. Conclusions

The overall results showed that with the addition of carrot pomace to flour, the protein, fat, and fiber contents increased but the carbohydrate content decreased. Thus, the carrot pomace powder had a significant effect on Sangak bread. The texture indices of the dough showed that the addition of carrot pomace powder decreased the cohesion, chewiness, and elasticity of the dough but increased its adhesion. The second step of this study was to investigate the sensory analysis of enriched bread at three levels of 3%, 5%, and 7% compared to the control sample. These results showed that the addition of carrot pomace decreased the chewiness of bread, but increased the color of enriched bread compared to the control sample. Evaluators found the taste, aroma, and overall acceptability of the enriched bread at the level of 3% better than the control sample. According to the results of texture and sensory analyses, the dough at the level of 3% had the best performance compared to the control sample and was therefore selected for baking and packaging Sangak bread. The third stage of the study was to determine the mechanical properties of enriched and control Sangak bread at 6 and 20 °C with two types of silicon Nano-polymer film and light polyethylene film. The texture results of the tensile test showed that the addition of carrot pomace to the bread reduced the staling process of bread, but the enriched bread had more stiff texture on the first day than the control sample. Investigation of two types of films shows that silicon Nano-polymer film acts better than polyethylene film in increasing the shelf life of the Sangak bread. Finally, it is worth noting that extracting carrot pomace fiber and its use in bread industry products, considering its economical and high nutritional value, can be a good option.

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