POSSIBILITY OF USING BLACK OLIVE SEED POWDER IN FORMULATIONS TO FUNCTIONALIZE BREAD

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***Abstract*— This paper aims to evaluate the potential use of black olive seed powder (BOP), a by-product of the olive oil industry, as a functional raw material. Physicochemical, rheological and bioactive properties and consumer acceptance preferences of bread produced by adding 1%, 2.5%, 5% and 7.5% BOP to wheat flour were examined in the study. It has been determined that BOP is rich in minerals. An increase in BOP addition in both the crumb and the crust led to enhanced phenolic and antioxidant activity. As for sensory evaluation, BOP-added bread samples scored higher than the control bread samples in terms of color, structure, hardness, and overall acceptability. High BOP addition resulted in the formation of firmer dark low volume bread, while low proportional BOP additives provided better rheological properties, bioactive additives and higher consumer appreciation. For this reason, BOP appears to be a good choice for enriching bread on an industrial scale.**

***Keywords*— Black olive seed powder, Bread, Rheological properties, bioactive content**

I. INTRODUCTION

Bread, which has high popularity in human nutrition from the past to the present, is a product that is open to enrichment with bioactive and nutritionally high components. Currently, increasing demands by consumers for products with high nutritional value containing dietary fibers, vitamins, minerals and phytochemicals have resulted in a paradigm shift in the bakery sector (Dapčević-Hadnađev *et al*., 2022; Dini *et al*., 2012; Hadnađev *et al*., 2011; Koletta *et al*., 2014; Rosell, 2011). As a result, researchers have turned their attention (De Lamo and Gómez, 2018; Lazaridou *et al.*, 2007; Pojić *et al*., 2015; Sciarini *et al*., 2012; Zdybel *et al*., 2019) to increase the quality of flavor and nutritional value of bread (Alam *et al*., 2013; Sayed-Ahmad *et al*., 2017).

With this aim, different flours with high nutritional value, and seeds and wastes obtained after extraction have emerged as flour-substitute materials (Cakir *et al*., 2021a; Cakir *et al*., 2021b; Koletta *et al*., 2014; Korus *et al*., 2017; Pojić *et al.*, 2015; Torbica *et al.*, 2019). Studies show that seed wastes from oil production are valuable food additives. Seeds, skins, seed cake, and residual oil forming in significant amounts during global olive oil production are wastes that are rich in terms of polyphenols, proteins, and fibers.

As by-products containing valuable compounds, they have strategic importance for producing healthy and value-added new foods and developing functional features for micro-nutrient deficiencies in production (Oreopoulou and Tzia, 2007; Parry *et al*., 2008; Pojić *et al*., 2015; Rabrenović *et al*., 2012).

These products emerge as important resources to improve the nutritional and technological properties of bakery products (Kaur *et al*., 2019; Wirkijowska *et al*., 2020). For this reason, in this study, different levels of BOP replaced wheat flour to analyze the effects on quality, physicochemical, rheological, and bioactive properties, and consumer acceptance of wheat bread.

II. METHODS

A. Materials

All-purpose wheat flour, instant dry yeast, and salt were provided from a local market (Istanbul, Turkey). BOP which is produced from olive stone was donated by Kale Naturel Limited Company (Balıkesir, Turkey). Folin-Ciocalteu's phenol reagent, methanol, gallic acid, Na2CO3, DPPH, and Trolox were obtained from Merck (Darmstadt, Germany). All chemicals used in this research were analytical grade.

B. Bread making method

AACC standard method No: 10-11 (AACC, 1990) was used with some modifications according to Turkish bread formulation. In this formulation, flour mixtures containing BOP (0%, 1.0%, 2.5%, 5%, and 7.5%) were prepared. 25 mL 8% yeast solution and 25 mL 6% NaCl solution were added in this flour mixture. All ingredients were mixed (Kitchen aid, USA) until optimum dough development. After complete mixing, dough was placed in the fermentation cabinet (Nuve TK 252, Turkey) at 30 °C and 85% relative humidity. The total duration of the fermentation was 115 min. The dough was taken out of the fermentation cabinet after initial 30 min, punched and placed in fermentation cabinet again. A second punch was also given 30 min later. The dough was then shaped and placed in the fermentation cabinet for the last 55 min. Baking was performed at 235 °C for 25 min in an electric oven (Maksan MKF-4P, Turkey). Afterwards the bread was taken out of the oven and cooled to room temperature for 2 h before analyses.

C. Chemical analyses of BOP samples (for moisture, ash, protein, fat and crude fiber

The compositions of bread and BOP samples, including moisture, ash, protein, and fat were determined according to the AACC 44-15A, AACC 08-01, AACC 46-11A and AOAC 14.093 methods respectively (AACC, 2000; AOAC, 1990a; 1990b; 1990c). Crude fiber was determined according to the AOAC 14.111 method (AOAC, 1990d). Total carbohydrates different from crude fiber were calculated by subtracting from 100%.

D. Determination of mineral contents

The Fe, Mg, Mn, Zn and Cu mineral contents of black olive seed powder were examined with a flame-assisted atomic absorption spectrophotometer (Analytics Jena ContrA 700, Germany) using an air-acetylene flame. Samples were weighed in Teflon balloon flasks (nearly 0.5 g) and mixed with 6 mL HNO_3 (65%) and 2 ml H_2O_2 (35%) before being digested in a microwave degradation device (Milestone, Sorisole, Italy) at 300 °C for 20 minutes.

E. Determination of total phenolic content

The crust and crumb of the bread samples were removed and then dried at 40 °C in vacuum oven. 10 grams of dried samples were extracted in 80% methanol for 2 h in the mechanical shaker.Total phenolic content of the samples was determined using the Folin–Ciocalteu phenol reagent according to the procedure described by Singleton and Rossi (1965). The samples were diluted as 1:10 with distilled water and 0.5 mL of diluted extracts were put into a tube. 2.5 mL Folin–Ciocalteu phenol reagent (diluted as 1:10 with distilled water) was added into the tube and after 3 minutes 2 mL of 2% (w/v) Na_2CO_3 was added. Then the prepared mixture was stored for 30 min in a dark place at room temperature. At the end of this period, the absorbance of the samples was measured at 760 nm (Shimadzu UV-1800 spectrophoto-meter, Japan). The total phenolic content of the samples was calculated as milligram gallic acid equivalent per 1 kg samples using calibration curve prepared with gallic acid standard. After bread samples removed from crust and crumb were dried in a vacuum oven at 40 °C, dry samples weighed to 10 g were dissolved in 80% methanol for 2 hours. The absorbance value of total phenolic content of the obtained extract was measured at 760 nm (Shimadzu UV-1800 spectrophotometer, Japan) using the Folin-Ciocalteu phenol reactive according to the procedure explained by Brand-Williams *et al*., (1995). The total phenolic content of samples was calculated as milligram gallic acid equivalent per 1 kg sample using a calibration curve prepared with gallic acid standard.

F. Determination of antiradical efficiency

In order to determine antiradical efficacy, 0.1 mL of sample was mixed with 5 mL DPPH solution (2,2-diphenyl-1-pikrilhydrasyl (DPPH) free radical within methanol solution (0.1 mM) (Singh *et al*., 2002) and incubated at 27 °C for 20 minutes. Abs_{sample} was measured at 517 nm (Shimadzu UV-1800 spectrophoto-meter, Japan) at the end of the incubation period. Percent inhibition values of the samples were calculated using

$$\%inhibition = \frac{Abs_{control} - Abs_{sample}}{Abs_{control}} \times 100$$

The results were expressed as mg Trolox equivalent/L sample.

G. Dynamic rheological measurements of dough

The prepared bread doughs were loaded on stress/strain-controlled rheometer (Anton Paar MCR 302, Australia) using a PP25 probe and a 2 mm gap at 25°C. The values of storage modulus (G'), loss mod- ulus (G''), and complex viscosity (η*) were obtained as a function of frequency and regression was subjected to the plots of angular frequency versus G' and G'' data to compute magnitudes of intercepts (K' , K'' , and K*), slopes (n', n'',and n*), and regression coefficient (R^2). Furthermore, loss or damping factor (tan δ) was determined based on the G''/G' ratio.

H. Specific volume, texture and color properties of bread

Bread volume was determined according to the AACC 10-05 method (AACC, 1998) with some modification of the rapeseed replacement method and Specific volume was calculated as volume/weight ratio (cm^3/g). Texture profile analysis was completed using a TA.XT2 Plus Texture Analysis device (SMS, UK) according to the AACC method 74-09.0 (AACC, 1999). The crust and crumb color of bread samples were measured using Chromameter CR-100 (Konica Minolta, Japan) by recording the L*(lightness), a*(redness) and b*(yellowness) values

I. Sensory evaluation

Bread samples were rated using descriptive profile analyses with a 15-point hedonic scale (1: strongly disliked, 15: strongly liked) completed (Haglund *et al*., 1998; Kihlberg *et al*., 2006). Sensory analysis was carried out by the students of the Department of Food Engineering. They trained in sensory analysis.

J. Statistical analysis

One-way ANOVA was performed to carry out statistical analysis and Duncan test was preferred for measuring the means of the results with significant differences ($p < 0.05$). Data analysis was conducted using the software package (SPSS statistics 23, IBM.2015).

III. RESULTS

A. Chemical properties of BOP

The obtained chemical composition of BOP is shown in Table 1. The amount of carbohydrates different from fiber was 71.4%. It was found that the chemical composition includes valuable nutrients such as, 9.8% protein, 2.1% fiber, 607.34 ppm magnesium, 25.55 ppm zinc, 9.18 ppm manganese and 4.65 ppm cupper. In a previous study, it was determined that commercial olives contain Cu, Fe, Mn, Zn, Ca, Mg, Na, K and P minerals (López *et* *al*., 2008). The high amount of ash content (Table 1) also indicates that the composition is rich in minerals.

B. Total phenolic content (TPC) of bread

The TPC of the bread is shown in Table 2. The obtained TPCs of the crust and crumb ranged between 261.27-1141.73 mg GAE/g and 79.45 – 1087.18 mg GAE/g, respectively. Additionally, the impact of the BOP amount on the TPC content of bread shows that as the BOP ratio increased from 1% to 7.5% in samples, the TPC content of both bread crust and crumb increased significantly (P< 0.05). Our results agree with the previous studies which reported that the phenolic contents of biscuits produced using olive seed powder at the levels of 0%, 5%, 10% and 15% increased from 148.08 mg GAE/100 g to 260.32 mg GAE/100g.

C. Determination of radikal scavenging activity of bread

DPPH is a stable free radical. This assay is generally used to specify the antioxidant power of olive oil pomace (Aliakbarian *et al*., 2012; Lavelli, 2002; Sánchez *et al*., 2007). The results of the radical scavenging activity are presented in Table 2. Each value is expressed as mean ± SD (n = 3) in the obtained antioxidant activity of the crust and crumb. Here, mean values having different letter superscripts within the same column are significantly different (P<0.05) (%0 control bread) with 243.34 - 1890.94 mg TE/L and 147.86 – 2593.56 mg TE/L, respectively. Besides, the impact of the concentration of BOP on the radical scavenging activity revealed that increasing the amount of BOP from 1% to 7.5% in bread developed antioxidant activity significantly (P < 0.05). It supports antioxidant activity in studies. In a study by Bolek, (2020), it was determined that the phenolic contents of biscuits produced using olive seed powder at the levels of 0%, 5%, 10%, and 15% increased from 148.08 mg GAE/100 g to 260.32 mg GAE/100 g (Bolek, 2020)

D. Volume, Specific Volume of bread

Besides the taste and color, the volume of bread is an important factor, which strongly influences consumer acceptance (Mamat *et al*., 2014). The volume and specific volume of loaves were determined between 240 – 360 cm^3, and 1.79 - 2.64 cm^3/g, respectively (Table 2). As the BOP percentage increased, the volume and specific volume of bread decreased significantly (P<0.05). Bread containing 7.5% BOP showed minimum specific volume, while bread with 1% BOP did not present significant differences in specific volume compared to control sample (Fig. 1). The volume of the bread samples decreased due to the increasing BOP level. It has been determined that the addition of phenolic compounds not only improves the antioxidant capacity of bread, but also affects the physicochemical properties and quality of dough due to various interactions with flour components. It has been determined that components rich in phenolic content reduce the volume as a result of weakening the bread dough by affecting the disulfide bonds of bread gluten (Han and Koh, 2011). This study, it was determined that the increase in BOP from 1% to 7.5% in bread decreased in volume due to the increase in the amount of phenolics.

E. Dynamic rheological properties of dough

A frequency sweep test was performed to understand how the viscoelastic properties of the pulp of BOP change with the stress or strain rate at constant amplitude of the signal, and the results are shown in Figure 2. The values of all moduli increased with an increase in ω for all samples. As frequency increased the G', G" and G*

Table 1. Physicochemical composition of BOP

Physicochemical Parameters	Black olive seed powder (BOP)
Moisture (%)	5.9±0.1
Protein (%)	9.8±0.2
Oil (%)	3.4±0.1
Crude fiber (%)	2.1±0.2
Ash (%)	9.7±0.0
Mg (ppm)	607.34±32.78
Zn (ppm)	25.55±1.17
Mn (ppm)	9.18±0.81
Cu (ppm)	4.65±0.05

a) b) c) d) e)

Figure 1. Bread with black olive seed powder (BOP) addition. a) Control, b) 1%BOP, c) 2.5%BOP, d)5% BOP e)7.5%BOP/

Table 2. Effect of different level of black oil pulp powder addition on the total polyphenol content, radical scavenging activity, and specific volume of bread

Substitution Level (%)	Total polyphenol Content (mg GAE/g)		Radical scavenging Activity (mg TE/L)		Weight (g)	Volume mL	Specific volume (mL/g)
	Crust	Crumb	Crust	Crumb			
0	261.27±1.93[e]	79.45±0.64[e]	243.34±103.87[e]	147.86±107.33[a]	136.42±1.41[a]	360±7.07[a]	2.64±0.02[a]
1.0	306.73±9.64[d]	189.45±19.93[d]	311.88±0.00[d]	561.59±27.70[b]	135.78±1.63[a]	360±14.14[a]	2.65±0.07[a]
2.5	674.45±1.29[c]	416.73±22.50[c]	730.52±65.78[c]	958.19±20.77[c]	136.93±1.41[a]	350±21.21[a]	2.56±0.13[a]
5.0	722.64±11.57[b]	864.45±5.14[b]	1281.35±69.24[b]	1974.18±10.39[d]	136.05±1.58[a]	295±7.07[b]	2.17±0.03[b]
7.5	1141.73±38.57[a]	1087.18±1.29[a]	1890.94±93.48[a]	2593.56±110.79[e]	134.17±1.51[a]	240±14.14[c]	1.79±0.13[c]

Each value is expressed as mean ± SD (n = 3) and means having different letter superscripts within the same columnare significantly different (P < 0.05) (%0 control bread)

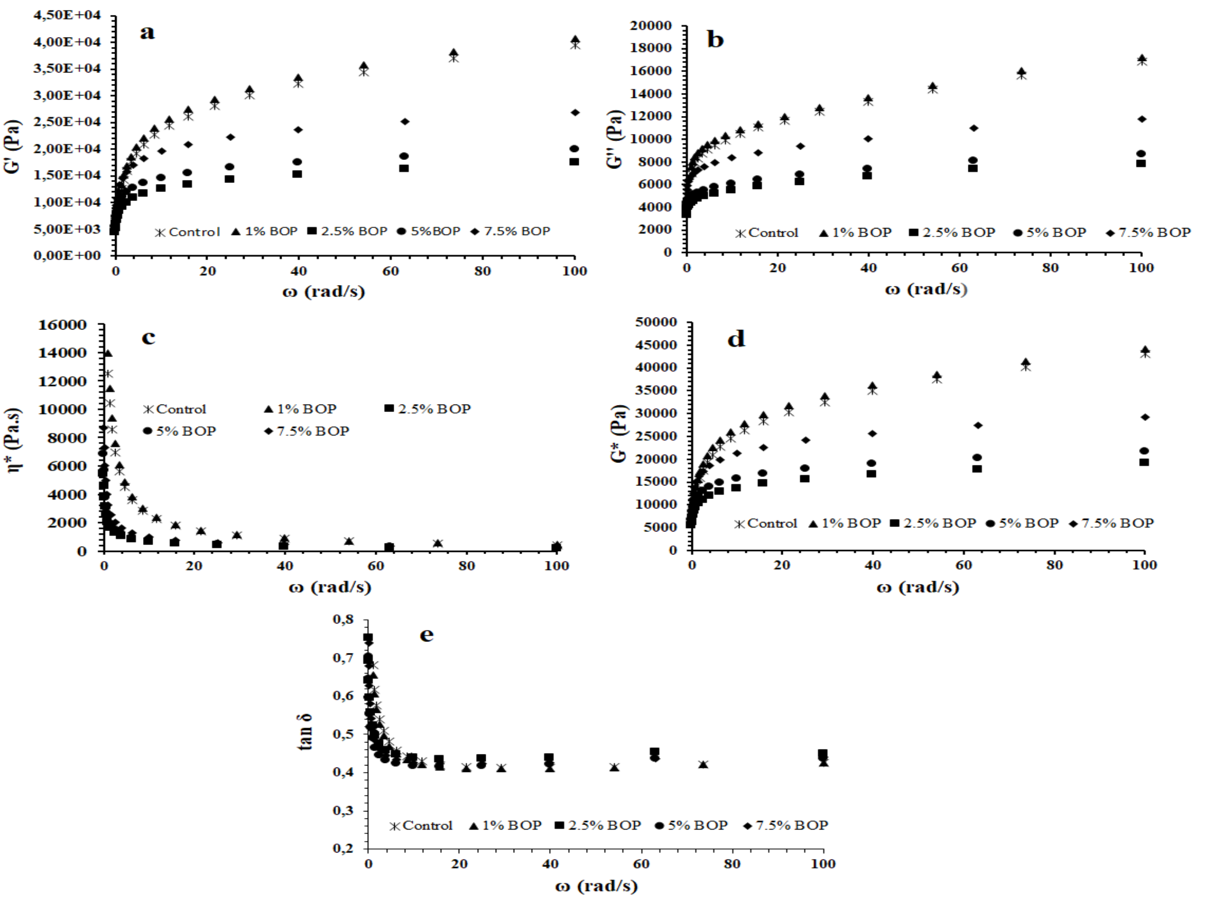

Figure 2. Frequency sweep curves of dough. a: storage modulus G′(Pa), b: loss modulus G″ (Pa),c: complex viscosity η* (Pa.s), d: complex modulus G* (Pa), e: loss factor.

Table 3. Mathematical modeling of experimental data from frequency sweep test.

Sample	$G'=K'\ \omega^{n'}$			$G''=K''\ \omega^{n''}$			$G^*=K^*\ \omega^{n^*}$		
(% BOP)	**K'(Pa)**	**n'**	**R^2**	**K''(Pa)**	**n''**	**R^2**	**K*(Pa)**	**n***	**R^2**
0	12590 ± 680^{c}	0.258 ± 0.014^{a}	0.9905	6895 ± 356^{c}	0.185 ± 0.012^{a}	0.9860	14297 ± 655^{c}	0.245 ± 0.012^{a}	0.9951
1	13661 ± 2706^{c}	0.244 ± 0.016^{a}	0.9905	7228 ± 891^{c}	0.179 ± 0.005^{a}	0.9814	15426 ± 2825^{c}	0.232 ± 0.013^{a}	0.9956
2.5	5462 ± 539^{a}	0.259 ± 0.111^{a}	0.9845	3268 ± 299^{a}	0.182 ± 0.007^{a}	0.9854	6340 ± 602^{a}	0.244 ± 0.009^{a}	0.9769
5	6754 ± 290^{ab}	0.241 ± 0.006^{a}	0.9858	3777 ± 125^{a}	0.170 ± 0.001^{a}	0.9750	7723 ± 302^{ab}	0.228 ± 0.005^{a}	0.9930
7.5	8769 ± 771^{b}	0.251 ± 0.008^{a}	0.9826	5144 ± 305^{b}	0.171 ± 0.004^{a}	0.9830	10119 ± 816^{b}	0.236 ± 0.007^{a}	0.9906

Each value is expressed as mean ± SD (n = 3) and means having different letter superscripts within a same column are significantly different ($P < 0.05$).

values increased, while the η* values decreased. Also, for all formulations, G' was greater than G", which demonstrated the predominant elastic behavior of the dough. The rheological properties of sample with 1% BOP were similar to those of the control sample which was related to low concentration of BOP. However, as BOP concentration increased from 2.5 to 5.0% the G', G" and G* significantly decreased. When the addition level of BOP increased to 7.5%, an increase for G', G" and G* values was observed again (Fig. 2). From a rheological viewpoint, dough with 1% BOP had more usage potential compared to control samples for bread production. Furthermore, adding BOP to the formulation caused slight increases in the tanδ of the samples. The addition of 1% BOP in dough caused the highest storage modulus and lowest tan δ values as it led to more rigidity. The R^2 value of the samples was between 0.97 and 0.99, as shown in Table 3, which indicates that the power-law model is suitable for describing the relation between ω and the moduli (G', G" and G*). The K' values were higher than K" values for all samples which demonstrated that the dough had an elastic-like character (Table 3). The highest and lowest values of K', K" and K* (consistency index) belonged to the doughs containing 1% BOP and 2.5% BOP, respectively. The flow behavior index (n', n", and n*) are slopes of the curves, which give information about the strength of the dough. No significant differences were observed for the flow behavior index value (n', n", and n*) of the samples (Table 3). The n' and n" values ranged from 0.241 to 0.259 and from 0.170 to 0.185, respectively. Higher flow behavior index value demonstrates that the structure is more dependent on strain (Mariotti *et al*., 2009). Samples with 5% BOP had minimum flow behavior index values which means they are less sensitive and more stable compared to other samples. Therefore, BOP-added formulations would be good candidates to make new bakery products with acceptable rheological properties.

Table 4. Textural characteristics of bread samples prepared by black oil pulp powder addition

Substitution Level (%)	Hardness (g)	Springiness	Cohesiveness	Gumminess (g)	Chewiness (g)	Resilience
0.0	397.76±10.69^{d}	2.12±0.02^{a}	0.88±0.004^{a}	413.22±132.49^{b}	607.31±198.62^{d}	0.55±0.01^{b}
1.0	503.35±133.14^{cd}	1.65±0.11^{b}	0.90±0.015^{a}	450.13±95.57^{b}	619.47±164.15^{d}	0.56±0.01^{b}
2.5	663.43±153.39^{ba}	0.96±0.02^{c}	0.87±0.020^{a}	580.34±169.33^{ab}	560.26±166.05^{c}	0.52±0.03^{c}
5.0	793.20±20.58^{ab}	0.95±0.04^{c}	0.86±0.017^{a}	712.58±50.78^{a}	677.53±46.34^{b}	0.54±0.01^{bc}
7.5	935.19±3.49^{a}	0.98±0.02^{c}	0.87±0.009^{a}	818.24±11.72^{a}	802.95±7.89^{a}	0.59±0.01^{a}

Each value is expressed as mean ± SD (n = 3) and means having different letter superscripts within a same column are significantly different (P < 0.05) (%0 control bread)

Table 5. Colour characteristics of bread prepared by black oil pulp powder addition.

Substitution Level (%)	Crust color L*	Crust color a*	Crust color b*	Brown index	Crumb color L*	Crumb color a*	Crumb color b*	Brown index
0	69.10 ±1.65^{a}	11.21±0.69^{b}	26.39±1.69^{a}	30.90^{b}	71.70 ±0.97^{a}	5.54±0.14^{d}	11.54±0.35^{c}	28.30^{e}
1	68.75±1.84^{a}	10.62±0.97^{b}	24.43±1.78^{a}	31.25^{b}	66.39 ±1.28^{b}	5.30± 0.01^{d}	11.66± 0.29^{c}	33.61^{d}
2.5	66.58±1.27^{ab}	12.06±1.43^{b}	25.70±2.46^{a}	33.42^{b}	60.73±2.24^{c}	6.55±0.19^{c}	13.50±0.62^{b}	39.27^{c}
5	60.72±4.12^{b}	12.53±1.83^{ab}	26.54±2.18^{a}	37.78^{ab}	57.33±0.76^{d}	7.89±0.12^{b}	15.04±0.29^{a}	42.67^{b}
7.5	62.22±5.58^{b}	14.70±1.22^{a}	21.26±4.5^{b}	39.28^{a}	50.89±1.10^{e}	8.87±0.13^{a}	14.94±0.28^{a}	49.11^{a}

Each value is expressed as mean ± SD (n = 2) and means having different letter superscripts within a same column are significantly different (P < 0.05).

Table 6. Sensory evaluation of bread prepared by black oil pulp powder addition

Substitution level (%)	Crust Colour	Crust Structure	Crumb Colour	Crumb Structure	Elasticity	Taste	Hardness	Overall
0	3.3±1.87^{d}	4.90±3.47^{c}	3.7±2.58^{c}	4.33±3.12^{c}	10.3±3.8^{a}	6.53±0.28^{b}	6.4±1.43^{b}	4±3.94^{b}
1	5.2±2.3^{cd}	4.90±2.88^{c}	5.5±2.46^{c}	4.8±1.58^{c}	8.9±3.96^{b}	8.08±1.33^{b}	7.8±2.49^{ab}	4.8±4.34^{b}
2.5	7.2±1.81^{bc}	5.44+2.88^{b}	7.6±2.37^{bc}	6.9±2.06^{b}	8.8±2.49^{b}	10.73±0.48^{ab}	7.3±2.91^{ab}	4.2±3.49^{b}
5	10.4±1.65^{ab}	8.22+3.07^{a}	9.9±2.13^{ab}	7.3±3.33^{ab}	8.4±4.3^{b}	10.43±0.18^{ab}	8.5±2.95^{a}	4.5±3.5^{b}
7.5	12.7±1.7^{a}	8.20±3.77^{a}	12.4±2.01^{a}	8.6±2.83^{a}	9.3±4.4^{ab}	13.78±1.03^{a}	7.8±4.34^{ab}	6.9±3.57^{a}

Fifteen-point hedonic scale with 0 and 15 representing extremely dislike, neither like nor dislike, and extremely like, respectively. Means with different letter superscripts within the same column are significantly different (P < 0.05).

F. Textural properties of bread

The effect of substitution of BOP on the textural parameters (hardness, springiness, cohesiveness, gumminess, chewiness, and resilience) of bread is shown in Table 4. The hardness value of bread samples ranged between 397.76 and 935.19 g. Significant effects were observed for the bread containing 2.5%, 5.0% and 7.5% BOP when compared to control (p<0.05) in terms of hardness, springiness and chewiness. This may be related to the dilution of gluten content of bread samples due to replacement with BOP, which is a non-gluten and fiber containing ingredient (Van Hung *et al*., 2007). Incorporation of BOP up to 1.0% didn’t affect the hardness value significantly (p>0.05).

Springiness is measured as the amount of recovery between the first and second compression and is related to food elasticity. The bread can be exposed to different forces until consumption ; therefore, high elasticity of it play a critical role in maintaining the quality of end products (Hsieh *et al.,* 2017). Lower springiness value was observed with the inclusion of BOP into bread (p<0.05) when compared to control. Springiness value wasn’t affected by the BOP addition at the levels of 2.5%, 5.0% and 7.5% (p>0.05,Table 4). The cohesiveness values of the bread ranged from 0.86 to 0.90. There was no statistically significant difference compared to the control sample(p>0.05, Table 4).

Gumminess value varied from 413.22 g with 818.24 g (Table 4). An increase in gumminess value with BOP addition for the bread containing 5.0% and 7.5%. This can be due to higher incorporation levels. No significant effect was observed for the bread containing 1% and 2.5% BOP compared to the control. The chewiness of all samples was not significantly different from that of the control sample, except for bread with 7.5% BOP content (Table 4).

Chewiness is the required energy for the mastication of bread and can be considered during bread production for the elderly consumer (Pehlivanoglu *et al*., 2018). Resilience is another important property of bread and measures the energy stored by the material after the first compression (Altuna *et al*., 2015). The addition of BOP at the level of 7.5% produced the bread with the highest resilience value (p<0.05, Table 4).

G. Color and Sensory Characteristic of Bread

The color properties of the crumb and crust of bread are detailed in Table 5. The substitution of BOP in the bread formulations creates differences in the color of both the crust and crumb of bread. The brown index was determined as 100- *L** (Liu *et al*., 2018).The results show that (Table 5) the crust brown indices vary from 28.30 to 49.11, while the crumb brown indices range between 30.90 and 39.28. As expected, crust brown indices were generally higher than the crumb brown indices. Additionally, the use of BOP in bread results in a product with darker color compared to the control sample (Fig. 1), as the increase in BOP increases in the brown index. The effects of BOP on the sensory attributes of bread are shown in Fig. 3.

The highest score from the panelists in terms of the structure and color of the crust and the crumb were belonged to the 7.5% BOP samples, followed by 5% BOP sample (Table 6). As can be seen from Fig. 1, this situation is more attractive to consumers due to the darker colors of the crust and crumb. In terms of hardness, 5% BOP added bread was the most appreciated, while control bread was the most preferred in terms of elasticity. As for general taste, the highest score was given to the 7.5% BOP added bread, while the lowest score was received by the control sample. All BOP-added bread samples were scored higher than the control bread in terms of crust.

V. CONCLUSIONS

This paper aims to evaluate the potential use of black olive seed powder (BOP) as a functional raw material. The functional and technological properties of breads were affected with the addition of BOP. It has been determined that low level addition of BOP (up to 1%) is more appropriate in terms of rheological and textural properties of bread. Bread samples formulated with BOP addition received higher scores general acceptance compared to control samples, which resulted in consumer preference and appreciation. As a result of the addition of BOP to bread formulation appears to be a promising application for producing more functionally enriched bread. The use of this important by-product would generate an economic benefit for the olive industry.

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