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Dried and Powdered Leaves of Parsley as a Functional Additive to Wheat Bread

Dariusz Dziki [1], Waleed H. Hassoon [2], Beata Biernacka [1] and Urszula Gawlik-Dziki [3,*]

[1] Department of Thermal Technology and Food Process Engineering, University of Life Sciences in Lublin, 31 Głęboka St, 20-612 Lublin, Poland
[2] Department of Animal Production, Faculty of Agriculture, University of Al-Qasim Green, Babylon 964, Iraq
[3] Department of Biochemistry and Food Chemistry, University of Life Sciences in Lublin, 8 Skromna Street, 20-704 Lublin, Poland
* Correspondence: urszula.gawlik@up.lublin.pl

Abstract: Parsley leaves (PL) are a rich source of many bioactive compounds and show many health-promoting properties. The aim of this study is to analyze the effect of the addition of PL to wheat flour on the physical, antioxidant, and sensory properties of wheat bread. Wheat flour was partially substituted with 0, 1, 2, 3, 4, and 5% PL. Bread dough was prepared using the direct method. Bread loaves were cooled, and then their volume, texture, color, total phenolic content, and antioxidant activity were evaluated. In addition, a sensory evaluation of bread was performed. Incorporation of PL into wheat decreased the bread volume and increased the crumb moisture but had little influence on the crumb texture. The crumb of the enriched bread was darker and greener compared with the control sample. PL addition increased the redness of the crumb as well. The total color difference for the enriched bread ranged from 9.3 to 21.4. According to the sensory evaluation, the amount of wheat flour added to PL should not exceed 3%. Such a kind of bread showed about a twofold higher level of phenolic compounds and enhanced antioxidant activity compared with the control bread. This study showed that powdered PL can be a valuable nutritional supplement to wheat bread. Future research should focus on the possibilities of fortifying various types of food with this additive.

Keywords: bread quality; texture; antioxidant properties; color; sensory evaluation

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1. Introduction

Parsley (*Petroselinum crispum* Mill.) is a popular vegetable of the Apiaceae family and is native to southwestern Europe and western Asia. Parsley is a medicinal herb and has been used extensively in the Mediterranean for more than 2000 years. Currently, it is grown worldwide as a culinary spice [1]. The average yield of parsley ranges from 74 to 167 $t \cdot ha^{-1}$ [2]. Among several applications of parsley, its pharmacological properties such as antifungal, hepatoprotective, gastroprotective, anticancer, and antibacterial activities are the most important [3,4]. All parts of this plant are useful, including as food, cosmetic, and pharmaceutical ingredients [5]. Parsley leaves (PL) are a rich source of essential oil, vitamins (especially A and C), potassium, iron, and ascorbic acid [6]. Fejes et al. [7] studied the phytochemical profile of PL and reported the presence of flavonoids such as kaempferol and quercetin and glycosylated flavones such as luteolin and apigenin. In addition, PL are rich in ascorbic acid, terpenes, apiin, carotenoids, and tocopherol [4]. Wong and Kitts [8] studied the antioxidant effects of parley leaves in vitro and proposed that essential oil plays a crucial role in the scavenging effect. PL contain 0.04–0.4% of volatile oil, with α-pinene, β-pinene, myrcene, β-phellandrene, 1,3,8-p-menthatriene, and myristicin as major constituents [9]. Consequently, PL show strong diuretic and disinfecting properties [10]. Regular consumption of parsley as food or supplements can reduce the effects of free radical-induced carcinogenesis and cancer [11,12].

To improve the nutritional value and health-promoting properties of food products, wheat flour can be supplemented with functional and nutritional products such as herbs, fruits, and vegetables [13]. In addition to their medical applications, PL are commonly used as food additives both in Poland and worldwide, mostly in salads, sauces, and soups and as an ingredient in herb butter and cheese [14] but also in different dishes [1] and beverages [15,16]. PL can also be used in meat preparation as a natural replacement of sodium nitrite [16], which extends the microbiological spoilage during meat storage [17]. However, there are only a few studies on the fortification of cereal products with parsley. Dirim and Koç [18] studied the properties of homemade Turkish noodles fortified with fresh PL (2, 4, 6, and 8% weight). They reported that the vitamin C, chlorophyll, and carotenoid contents were improved with the addition of fresh PL. The noodles fortified with 2% parsley achieved the highest scores in sensory evaluation. Moreover, they found that PL are a good source of potentially bioaccessible flavonoids. Sęczyk et al. [19,20] reported that fortification of pasta with dried and powdered PL improved the antioxidant capacity of pasta. Most importantly, antioxidant phenolics from the supplemented pasta were highly bioaccessible in vitro. However, no studies on the possibility of bread fortification using PL have been found in the literature. Bread plays an important role in the human diet. Wheat bread is considered a good source of energy and is preferred by most bread consumers. However, wheat bread is a poor source of bioactive compounds because its primary constituent is bran, which is a waste product obtained during white wheat flour milling. The addition of PL to the bakery formulation may result in multiple changes in the nutritional and technological properties and consumer acceptance of wheat bread. Hence, the possibility of the incorporation of active components such as PL into bread has been tested in this study. In particular, this work focused on understanding the influence of the addition of dried and powdered PL on the physical, antioxidant, and sensory properties of wheat bread.

2. Materials and Methods

The course of the research is presented in Figure 1.

2.1. Materials

Sodium salicylate, gallic acid, ferrozine (3-(2-pyridyl)-5,6-bis-(4-phenyl-sulfonic acid)-1,2,4-triazine), and ABTS (2,2′-azino-bis-(3-ethylbenzothiazoline-6-sulfonic acid)) were used in this study. All chemicals were of analytical grade and were purchased from Sigma-Aldrich (Poznan, Poland).

The primary raw material of wheat bread was wheat flour type 650 produced by Młyn Oliwski (Poland) and PL. PL were obtained from the Experimental Station of the University of Life Sciences in Lublin, Poland. The leaves were washed, rinsed, and air-dried at 35 °C using a laboratory dryer (SLW 75, Pol-Eko-Aparatura, Wodzisław Śląski, Poland). A thin layer (about 1 cm thick) of about 0.5 kg of PL was spread on trays, and then the trays were kept in the dryer. The drying process was performed until a constant weight of PL (9.2% wet basis) was obtained, which corresponded to a drying time of about 14 h.

Dried PL were ground using a laboratory knife mill (GRINDOMIX GM-200, Retsch, Haan, Germany) and sifted (AS 200, Retsch, Haan, Germany) according to a previously described procedure [21]. Then, parsley flour (particles that passed through a 0.30-mm sieve) was produced. Ground PL were stored in air-tight plastic boxes until they were needed for bread production. Apart from these materials, salt and instant dry yeasts were also used as ingredients.

2.2. Basic Chemical Composition

The basic chemical composition of wheat flour, PL, and bread was determined according to the AACC methods [22]. The moisture content was determined using the air-oven method (Method 44-15.02). The ash content was determined using Method 08-01.01, protein content was determined using Method 46-09.01, fat content was determined using Method 30-10.01, and total dietary fiber content was determined using Method 32-05.01.

The carbohydrate content was determined by calculating the difference between 100 and the sum of water, protein, fat ash, and fiber [23].

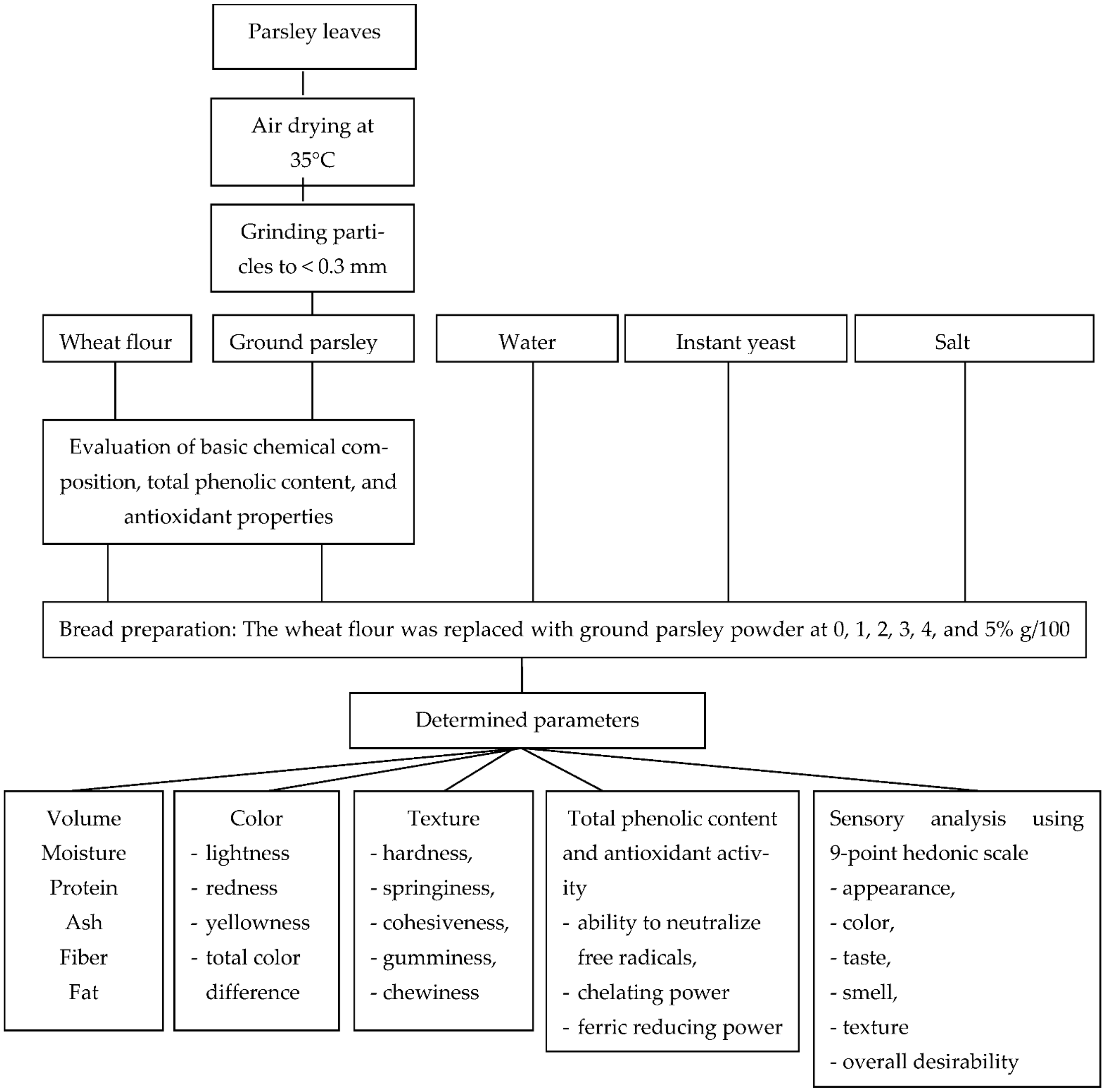

Figure 1. Properties of raw materials and bread.

2.3. Bread Preparation

The bread dough was prepared according to the straight-dough method [24]. The ingredients used for bread preparation were as follows: 100 g of wheat flour, 2 g of salt, 1 g of instant yeast, and the appropriate amount of water (according to flour-water absorption data). The wheat flour was replaced with ground parsley powder at 0, 1, 2, 3, 4, and 5 g/100 g, respectively, and the obtained bread was named control bread (CB), PB1, PB2, PB3, PB4, and PB5, respectively. Because the moisture content of PL was different from that of wheat flour, the amount of PL required was calculated, and the same was added. The dough components were mixed in a spiral kneading machine (QTMP20, Poland) for

5 min at 250 rpm of speed and transferred to the climatic chamber (ICH 256, Memmert, Dusseldorf, Germany) at 30 °C with a relative humidity of 75% for 60 min. After 30 min of fermentation, the dough was transfixed for 1 min using a kneading machine. After fermentation, the dough was divided into pieces (250 g), molded by hand, and put in molds. The molds were transferred to the climatic chamber. After proofing, the bread was baked in an electric oven (Rational, CMP 61, Landsberg am Lech, Germany) at 230 °C for 30 min. After baking and removing from the molds, the loaves were weighted. After 2 h of cooling, the bread was used for further analysis.

2.4. Bread Volume and Crumb Color

The volume of bread was assessed using the seed displacement method [25]. Crumb color was determined using a Chromameter Minolta (CR-200, Japan). This method was based on a system of L*, a*, and b*, where L* denotes lightness. The +a*, −a*, +b*, and −b* values represent red, green, yellow, and blue colors, respectively. The total crumb color difference (TCD) between the control bread crumb and crumb samples with PL addition was calculated using the following formula [26]:

$$TCD = \sqrt{(L_0^* - L^*)^2 + (a_0^* - a^*)^2 + (b_0^* - b^*)^2}, \quad (1)$$

where L_0^*, a_0^*, and b_0^* are the compositional crumb color of the control bread, and L^*, a^*, and b^* are the compositional crumb color of bread with PL.

2.5. Texture of the Crumb

The texture of the crumb was determined after 2 h of storage of the cooled bread at 21 °C using the texture analyzer (type TA.XT2i, Stable Microsystems, Surrey, UK). The method used relied on the dual compression of the crumb cylindrical samples (25 mm thickness and 22 mm diameter) from the center of the slices. The speed test was conducted at 1 mm/s. A cylindrical mandrel (25 mm diameter) was used to measure the crumb texture; 40% penetration of the crumb sample with a 30-s break between the first and second compression was set. Based on the obtained curves, the following texture parameters of the crumb were evaluated: hardness, springiness, cohesiveness, gumminess, and chewiness [27].

2.6. Total Phenolic Content and Antioxidant Activity

For the determination of the total phenolic content (TPC) and antioxidant activity (AA) of wheat flour, PL, and bread, phosphate-buffered saline extracts (PBS) of pH 7.4 were prepared. Of each sample, 0.5 g was extracted for 1 h with 20 mL of PBS. The samples were shaken for 40 min and centrifuged according to the procedure described by Lisiecka et al. [28]. The collected supernatants were used for the determination of TPC and AA.

The TPC was determined according to the Folin–Ciocalteu method with some modifications [29]. In brief, 2 mL of the Folin–Ciocalteu reagent (1:5 H_2O), 0.5 mL of H_2O, and 0.5 mL extract of the sample were mixed. After 3 min, 10 mL of 10% Na_2CO_3 was added. The absorbance of the sample was read at 725 nm after 30 min using a UV–Vis spectrophotometer (UV-1900 UV-VIS, Shimadzu, Osaka, Japan). Then, the TPC was determined based on the standard curve for gallic acid and expressed in milligrams of gallic acid equivalent (GAE) per gram DM.

The antioxidant activity of the samples was determined using the following parameters: the ability to neutralize ABTS radicals, chelating power (CHEL), and ferric reducing power (RED).

The ABTS●+ radical cation was generated by the oxidation of 7 mmol/L stock solution of ABTS using 2.45 mmol/L potassium persulfate as the oxidizing agent [30]. The obtained solution was diluted with distilled H_2O until an absorbance of 0.7 ± 0.05 at 734 nm was achieved. Then, 40 μL of the extract was added to 1.8 mL of ABTS solution, and the absorbance was measured at 5-min intervals. The ability of the extracts to neutralize the ABTS•+ radical (AN) was calculated as follows:

$$AN = \frac{A_{CO} - A_{SA}}{A_{CO}} \cdot 100\% \quad (2)$$

where A_{CO} represents the absorbance of the control, and A_{SA} is the absorbance of the sample.

CHEL was determined using a previously reported method as follows [31]:

$$CHEL = \frac{A_{SA}}{A_{CO}} \cdot 100\% \quad (3)$$

where A_{SA} and A_{CO} are the absorbance of the sample and the control, respectively.

RED was determined according to the method described in [32]. In brief, 500 μL of PBS extract, 500 μL of 200 mM sodium phosphate buffer (pH 6.9), and 1% solution of potassium ferricyanide (500 μL) were mixed. The mixture was kept at 50 °C for 20 min. Then, 500 μL of 10% trichloroacetic acid was added, and the mixture was allowed to rest for 5 min. Then, 1 mL of the mixture was mixed with 1 mL of deionized water and 0.2 mL of 1% iron (II) chloride. Absorbance was measured at 700 nm and was considered RED.

Antioxidant activities were determined as the extract concentration corresponding to 0.5 absorbance value (EC_{50} in the case of RED assay) or 50% of activity (EC_{50} in the case of ABTS and CHEL assays) based on a dose-dependent mode of action [33]. EC_{50} indices were obtained by interpolation from linear regression analysis.

2.7. Sensory Evaluation of Bread

A blinded team of 48 individuals conducted the sensory evaluation of bread. The analysis was performed at the University of Life Sciences in Lublin, Poland, under stable temperature and light conditions. The bread was cut into slices. The samples were scored using a 9-point hedonic scale according to their appearance, color, taste, smell, texture, and overall desirability, as described by García-Gómez et al. [34].

2.8. Statistical Evaluation of Data

Experimental data were subjected to analysis of variance. The significance of the differences between the means was determined using Tukey's test. All tests were performed at a significance level of $\alpha = 0.05$. The STATISTICA (StatSoft, Inc., Tulsa, OK, USA) computer program was used for data evaluation.

3. Results and Discussion

3.1. Basic Chemical Analysis

The basic chemical composition of wheat flours, PL, and bread is presented in Table 1. Wheat flour contained 11.2% moisture, 10.1% protein, 1.4% fat, 3.1% fiber, and 73.6% carbohydrates. PL, assuming the same moisture as the moisture of the flour, contained 1.9% protein, 3.4% fat, 8.8% ash, 14.8% fiber, and 50.9% carbohydrates. Fernandes et al. [35] reported a similar composition of PL. Moreover, they found that α-linolenic and linoleic acid were the main fatty acids in PL. Compared with wheat flour, PL were richer in protein, fat, ash, and fiber. Thus, PL significantly increased the mineral and fiber content in the bread samples but had little influence on the protein and fat content. The ash content in CB was 0.75%.

Table 1. Basic chemical composition of wheat flour, PL, and bread. The basic chemical compounds of bread (protein, ash, fat, fiber, and carbohydrates) were expressed as a percentage of dry weight basis.

Sample	Moisture	Protein	Ash	Fat	Fiber	Carbohydrates
WF *	11.2 ± 0.1 A **	10.1 ± 0.13 B	0.64 ± 0.05 A	1.4 ± 0.1 A	3.1 ± 0.1 A	73.6
PL	11.2 ± 0.1 A	10.9 ± 0.02 A	8.8 ± 0.03 B	3.4 ± 0.1 A	14.8 ± 0.2 B	50.9
CB	36.6 ± 0.1 a	10.3 ± 0.1 a	0.74 ± 0.01 a	1.6 ± 0.0 a	3.6 ± 0.2 a	83.76
PB1	37.0 ± 0.1 ab	10.3 ± 0.2 ab	0.96 ± 0.02 b	1.6 ± 0.1 ab	3.9 ± 0.3 a	83.24
PB2	37.3 ± 0.2 bc	10.5 ± 0.2 ab	1.12 ± 0.02 c	1.7 ± 0.2 ab	4.0 ± 0.3 b	82.78
PB3	37.5 ± 0.1 c	10.6 ± 0.2 ab	1.38 ± 0.01 d	1.7 ± 0.2 ab	4.3 ± 0.3 c	82.02
PB4	37.8 ± 0.0 d	10.6 ± 0.1 b	1.42 ± 0.02 e	1.7 ± 0.2 ab	4.6 ± 0.2 d	81.68
PB5	38.0 ± 0.1 e	10.5 ± 0.2 ab	1.56 ± 0.02 f	1.9 ± 0.2 b	4.9 ± 0.3 e	81.14

* WF—wheat flour, PL—parsley leaves, CB—control bread, PB1, PB2, PB3, PB4, PB5—bread with 1, 2, 3, 4 and 5 % of PL, respectively. Data are presented as mean (n = 3) with standard deviation. ** Data values of each parameter with different superscript letters are significantly different at $p < 0.05$.

3.2. Bread Volume

Bread volume is an important bread quality parameter that strongly influences consumer choice. It indirectly informs about the aeration, porosity, and texture of bread [36,37]. The incorporation of PL into the bread recipe resulted in a linear decrease in loaf volume (Figure 2). The highest volume was found for the control bread (354 cm^3/100 g of flour), and the lowest was found for the PB5 sample (299 cm^3/100 g of flour). A significant and negative relationship was found between the bread volume and the amount of parsley powder added ($r = -0.983$, $p < 0.05$). It is evident from these results that powdered parsley weakens the gluten structure, and thus, the sample dough cannot hold as much carbon dioxide as the control bread holds. Only wheat contains appropriate proportions of gliadins and glutenins to form gluten. Gluten retains carbon dioxide, thus influencing the loaf's volume and, consequently, crumb hardness [38]. The decrease in bread volume usually leads to an increase in crumb hardness [39]. As reported in previous studies, the incorporation of many plant materials into bread dough causes gluten dilution and a lower volume of loaf [40,41].

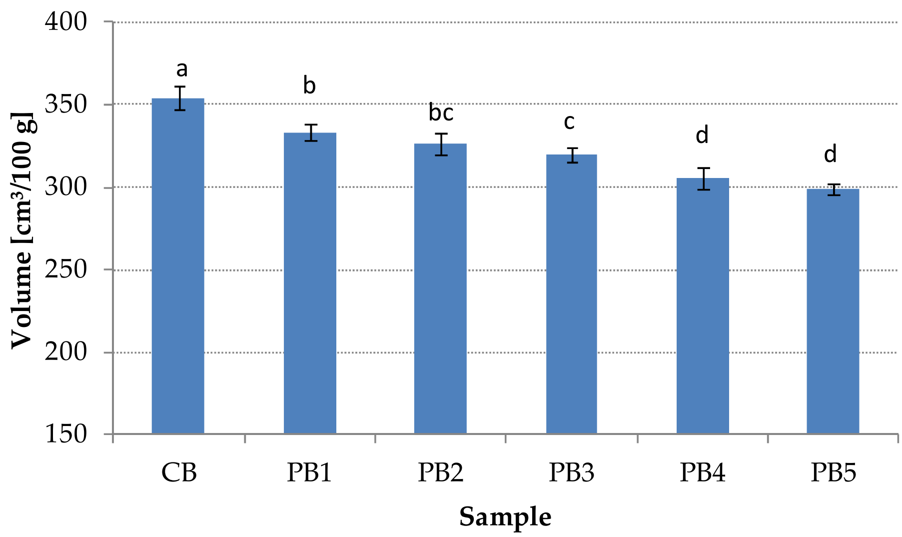

Figure 2. Volume of the control bread (CB) and bread with parsley (PB1, PB2, PB2, PB3, PB4, and PB5: bread with 1, 2, 3, 4, and 5% of parsley powder, respectively). Values followed by the same letter (a–d) are not significantly different ($p < 0.05$), n = 3.

3.3. Color Coordinates

The incorporation of parsley into bread significantly influenced the color coordinates of the crumb (Table 2, Figure 3). Color is one of the most important parameters that affect consumer acceptance [42]. In particular, bread enrichment with PL decreased the lightness of the crumb (from 73.9 (CB) to 53.8 (PB5)). Moreover, crumb greenness and redness were increased by the addition of PL (from 2.83 to −2.33 and from 12.8 to 18.1, respectively). Similar changes were observed in pasta color when dried and powdered PL were incorporated into durum wheat semolina [43]. These changes were effected by parsley pigments. PL, similar to other green parts of plants, contain both chlorophyll a with blue-green color and chlorophyll b with yellow-green color in a ratio of 2:1 [6]. Both these compounds are responsible to the greatest extent for the color change of the bread. Moreover, chlorophylls show strong antioxidant activity [44]. The total color difference (TCD) ranged from 9.1 (PB1) to 21.4 (PB5). TCD could be visually detected by an inexperienced observer when it is higher than 5 [45]. It means that replacing wheat flour with parsley flour already at the level of 1% caused strong visible changes in crumb color. The greatest changes in the pasta color were observed for the incorporation of 3% PL. A higher level of PL had relatively little influence on color coordinates and consequently on the TCD. The kind of additive used has a significant influence on the color of baker products. Usually, the replacement of wheat flour with different plant additives decreases the lightness of the crumb [46]. Plant additives can be used as natural bread colorants and can increase the nutritional value of bread [47–49]. This often increases the consumer acceptance of the products.

Table 2. Color coordinates and total color difference (TCD) of the crumb.

Sample	L*	a*	b*	TCD
CB *	73.9 ± 1.11^{e} **	2.83 ± 0.62^{d}	12.83 ± 0.48^{a}	-
PB1	66.1 ± 1.03^{d}	-0.37 ± 0.27^{a}	16.87 ± 0.32^{b}	9.3
PB2	61.2 ± 0.34^{c}	-1.10 ± 0.19^{b}	17.27 ± 1.02^{b}	14.0
PB3	56.2 ± 0.43^{b}	-1.67 ± 0.52^{c}	19.37 ± 1.23^{c}	19.4
PB4	54.2 ± 1.71^{ab}	-2.63 ± 0.39^{d}	17.90 ± 0.98^{c}	21.1
PB5	53.8 ± 2.30^{a}	2.33 ± 0.22^{cd}	18.13 ± 1.07^{c}	21.4

CB *—control bread, PB1, PB2, PB2, PB3, PB4 and PB5—bread with 1, 2, 3, 4 and 5% of parsley powder, respectively). ** Values followed by the same letter (a–e) are not significantly different ($p < 0.05$), $n = 3$.

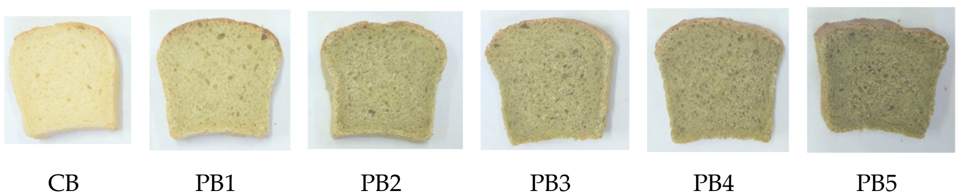

Figure 3. Control bread (CB) and bread with 1, 2, 3, 4, and 5 % of parsley leaves (PB1, PB2, PB3, PB4, and PB5, respectively).

3.4. Bread Texture

The results of the analysis of bread texture and the crumb moisture content are presented in Table 3. The hardness of the crumb is the most studied parameter in bread texture studies, which is described as the maximum force recorded during the first crumb compression [29]. Enrichment of wheat bread with PL had no negative influence on crumb hardness. The highest crumb hardness value was observed for CB (8.2 N), and the lowest was observed for PB4 (6.2 N). When the bread volume decreases due to gluten weakness from different additives, the crumb becomes denser and harder [50]. However, this relationship was not found in the present study. The lack of this relationship can be attributable to the fact that PL increased the water absorption of flour. Consequently, a higher amount of water was added during dough preparation, and the crumb moisture was also higher (Table 1). The crumb with a higher moisture content was characterized by decreased hardness [51]. Moreover, the incorporation of PL into the bread recipe had no significant influence on other texture parameters, such as crumb springiness, cohesiveness, and chewiness. These findings show that, in general, PL had little influence on crumb texture. Recently, Hu et al. [52] studied the effects of the addition of sweet potato leaf powder on steam bread texture and found that crumb hardness increased linearly with the addition of potato leaves. On the other hand, such a relationship was not observed when powdered green leaves of leek were incorporated into wheat bread [53]. This demonstrates that the chemical composition of the additive used has a strong influence on bread texture.

Table 3. Texture parameters and moisture of crumb for control and enriched bread.

Sample	Hardness (N)	Springiness (-)	Gumminess (N)	Chewiness (Nmm)	Cohesiveness (N)
CB *	8.2 ± 0.3 [b] **	0.83 ± 0.06 [a]	3.4 ± 0.2 [b]	2.8 ± 0.3 [a]	0.41 ± 0.01 [a]
PB1	7.6 ± 0.6 [b]	0.81 ± 0.09 [a]	3.2 ± 0.1 [ab]	2.5 ± 0.3 [a]	0.42 ± 0.01 [a]
PB2	6.9 ± 0.5 [ab]	0.82 ± 0.05 [a]	2.7 ± 0.3 [a]	2.2 ± 0.4 [a]	0.43 ± 0.02 [a]
PB3	6.9 ± 0.4 [ab]	0.82 ± 0.08 [a]	3.1 ± 0.2 [ab]	2.5 ± 0.4 [a]	0.45 ± 0.02 [a]
PB4	6.2 ± 0.8 [a]	0.87 ± 0.03 [a]	3.0 ± 0.3 [ab]	2.6 ± 0.3 [a]	0.44 ± 0.03 [a]
PB5	7.8 ± 0.7 [b]	0.85 ± 0.04 [a]	3.7 ± 0.7 [b]	3.1 ± 0.6 [a]	0.42 ± 0.02 [a]

CB *—control bread, PB1, PB2, PB2, PB3, PB4 and PB4—bread with 1, 2, 3, 4 and 5 % of parsley powder, respectively. ** Values followed by the same letter (a–e) are not significantly different (p < 0.05), n = 5.

3.5. Total Phenolic Content and Antioxidant Activity

Phenolic compounds are the widely found secondary metabolites in plants. Phenolic acids and flavonoids are the major phenolic compounds. In general, phenolic compounds play a role in the protection of an organism against the actions of reactive oxygen species [54]. Polyphenols are compounds with antioxidant, anticancer, antiviral, antibacterial, and antimicrobial activities [55]. Recently, de Olivera et al. [56] found that *p*-coumaric acid, *p*-coumaric acid 4-O-hexoside, apigenin 7-glucoside, and quercetin-O-pentosyl-hexoside are the main phenolics in PL. The total phenolic content in wheat flour was 0.35 mg GAE/g DM, whereas PL contained 21 mg GAE/g DM. Antioxidant activity was expressed by the EC_{50} index of PL, which was 6.23, 3.61, and 5.28 mg DM/mL for the ABTS, CHEL, and RED assays, respectively. EC_{50} values for wheat flour were 356.7, 34.1, and 132.8 mg DM/mL, respectively. The incorporation of PL into wheat bread increased the phenolic content in the enriched samples (Figure 4). A significant (p < 0.05) and positive linear relation (r = 0.99) was found between PL and the TPC. PB5 extracts were characterized by about threefold higher content of phenolics (0.84 mg GAE/g DM) compared with the control bread (0.23 mg GAE)/g DM). An increase in the phenolic content enhanced the antioxidant activity of the enriched bread. Various antioxidants show substantially different efficiencies in food due to different molecular structures. Therefore, standardized analytical methods are used in the assessment of the antioxidant activity of food [57]. The results of the present study suggested that PL contain antioxidants with a broad spectrum of action. Furthermore, ABTS, CHEL, and RED assays showed a significant decrease in EC_{50} with an increasing amount of PL in the bread recipe, which shows an increase in the antioxidant activity of bread. The highest decrease in EC_{50} was found for ABTS-neutralizing activity (from 326 mg DM/mL for CB to 112 mg DM/mL for PB5), and the lowest was found for CHEL (from 32.3 mg DM/mL to 23.1 mg DM/mL). Statistically significant correlations (p < 0.05) were observed between the addition of PL and ABTS-neutralizing activity, CHEL, and RED (r = 0.97, 0.98, and 0.97, respectively). Studies also observed that PL increased the TPC and antioxidant activity of different kinds of food, such as pasta [19,43] and beans [58]. Liberal et al. [59] analyzed the phenolic profile and bioactivity of hydroethanolic extracts from PL samples obtained from 25 cultivars and found that apigenin and kaempferol were the most abundant phenolic compounds, demonstrating antioxidant and antimicrobial activity against fungi and bacteria. Moreover, 29 flavonoid glycosides were found in the aqueous extract of PL, and apian, a diglycoside of the flavone apigenin, was the dominant compound responsible for the antioxidant activity of PL [60].

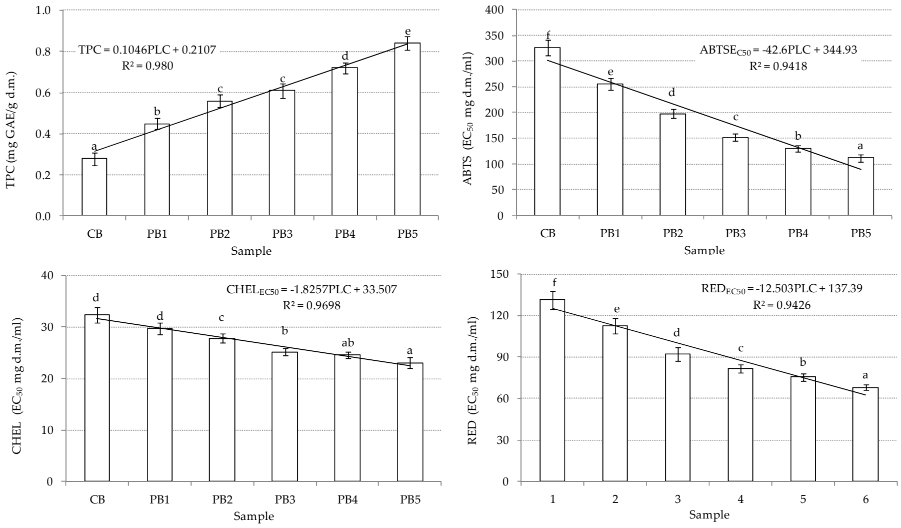

Figure 4. The total phenolic content and antioxidant activity of the control and enriched bread. TPC—total phenolic content; ABTS—ABTS-neutralizing activity; CHEL—chelating power; RED—ferric reducing power; CB—control bread; PB1, PB2, PB3, PB4, and PB5—bread with 1, 2, 3, 4, and 5% of parsley. PLC—content of parsley leaves (%) Different letters on the bars (a–f) denote significant differences between means ($p < 0.05$), $n = 3$.

3.6. Sensory Evaluation of Bread

Sensory characteristics are an important parameter in the evaluation of the quality of food to meet consumer demands. The data presented in Table 4 show that the incorporation of PL into wheat flour had no significant influence on crumb texture. However, with the increased amount of PL in the bread recipe, lower scores for such indicators as appearance, smell, taste, and color of bread were obtained. The highest scores for these indicators were found for the control bread, and the lowest was obtained for PB5. Consequently, more than 3% of parsley in the bread recipe resulted in the overall liking of bread samples with below 4 points (indifferent). In particular, the smell and taste of bread were unacceptable for PB4 and PB5 samples. The smell of bread was nonspecified, too intensive, and, for most of the panelists, poorly accepted. This phenomenon could be due to the high amount of essential oil components in the additive used. The characteristic smell and taste of PL were observed during mechanical damage of tissues (e.g., grinding, chewing). In PL, β-phellandrene, α-terpinolene, 1.3.8-p-menthatriene, myristicin, and elemicin were found [61]. Interestingly, Bouasla et al. [43] replaced semolina with powdered PL in pasta production and found that there was no significant impact on the overall acceptability of pasta when PL were incorporated into semolina up to 10%. However, the lowest scores for sensory attributes were obtained for pasta with 2.5% PL. A similar relationship was reported in other authors when PL were added to common wheat noodles [19].

Table 4. The results of sensory evaluation of control bread and bread enriched with dried parsley.

Sample	Appearance	Taste	Odor	Color	Texture	Overall
CB *	6.5 ± 0.26 ^{e} **	6.5 ± 0.31 ^{d}	6.0 ± 0.21 ^{f}	6.5 ± 0.21^{d}	5.6 ± 0.17 ^{a}	6.5 ± 0.29 ^{e}
PB1	5.7 ± 0.28 ^{d}	6.1 ± 0.46 ^{d}	5.6 ± 0.33 ^{e}	5.8 ± 0.33 ^{c}	5.8 ± 0.21 ^{a}	6.1 ± 0.23 ^{e}
PB2	5.4 ± 0.59 ^{c}	5.5 ± 0.32 ^{c}	5.0 ± 0.29 ^{d}	5.8 ± 0.29 ^{b}	5.8 ± 0.15 ^{a}	5.5 ± 0.22 ^{d}
PB3	5.0 ± 0.33 ^{bc}	4.5 ± 0.26 ^{b}	4.0 ± 0.31 ^{c}	4.5 ± 0.31 ^{a}	5.6 ± 0.14 ^{a}	4.5 ± 0.19 ^{c}
PB4	4.6 ± 0.50 ^{ab}	3.2 ± 0.31 ^{a}	3.6 ± 0.22 ^{b}	4.1 ± 0.22 ^{a}	5.5 ± 0.22 ^{a}	3.6 ± 0.35 ^{b}
PB5	4.5 ± 0.47 ^{a}	3.0 ± 0.27 ^{a}	2.7 ± 0.18 ^{a}	3.8 ± 0.18 ^{a}	5.6 ± 0.17 ^{a}	2.9 ± 0.37 ^{a}

CB *—control bread, PB1, PB2, PB2, PB3, PB4 and PB4—bread with 1, 2, 3, 4 and 5% of parsley powder, respectively). ** Values followed by the same letter (a–e) are not significantly different ($p < 0.05$), $n = 3$.

4. Conclusions

The incorporation of PL into wheat flour led to a decrease in bread volume and an increase in the moisture content. However, these changes had little influence on crumb texture. Both control and enriched bread showed similar values of crumb hardness. The color of the crumb was significantly influenced by PL: the addition of PL decreased the lightness and increased the redness of the crumb. The partial replacement of wheat flour with PL (up to 3%) resulted in bread with enhanced antioxidant activity and adequate sensory acceptability. The proposed PL-enriched bread can be recommended for people who are looking for healthy food with an enhanced nutritional value.

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