Effect of Moldavian dragonhead (Dracocephalum moldavica L.) leaves on the baking properties of wheat flour and quality of bread

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Abstract

The dried and powdered leaves of Moldavian dragonhead (Dracocephalum moldavica L.) (0, 1, 3, 4, and 5 g/100 g of wheat flour) were added to the wheat flour to make bread. Farinograph properties of dough were studied, and the properties of enriched bread were evaluated. According to the results, Moldavian dragonhead leaves increased water absorption by the flour but decreased the volume of bread and crumb lightness. The enriched breads were characterized by a higher value of crumb hardness than that of control bread. The total phenolics content linearly increased with the percentage increase in the addition of dragonhead leaves from 4.8 to 10.1 mg GAE/g dry mass. As a result, the antioxidant activity of bread increased. Sensory evaluation revealed that the wheat bread can be supplemented with Moldavian dragonhead leaves up to 3 g/100 g wheat flour addition of dragonhead leaves with good consumer acceptability.

Introduction

The Dracocephalum moldavica L., also called Moldavian dragonhead or Moldavian balm, is an annual herbaceous plant belonging to the Lamiaceae family. This plant is native to central Asia and has been naturalized in Europe (Martínez-Vázquez, Estrada-Reyes, Martínez-Laurrabaquio, López-Rubalcava, & Heinze, 2012). Moldavian dragonhead, known in Europe since the sixteenth century first as Melissa moldavica, originated from southern Siberia (Dmitruk, Weryszko-Chmielewska, & Sulborska, 2018). It is traditionally used to treat headache, gastric, hepatic, and cardiovascular disorders and is also used as a food additive (Dastmalchi, Damien Dorman, Laakso, & Hiltunen, 2007). Moldavian dragonhead is a good source of proteins, lipids, and fiber. Its oil is rich in unsaturated fatty acids (about 90%), principally the linolenic and linoleic acids (about 60% and 20%, respectively) (Domokos, Peredi, & Halasz-Zelnik, 1994). Moreover, the extracts and oil from Moldavian dragonhead are widely used in the food industry (Dmitruk & Weryszko-Chmielewska, 2010; Yousefzadeh et al., 2013). The leaves of Moldavian dragonhead are reported to contain various polyphenols, especially hydroxycinnamic acids and flavonoids, luteolin and their glycosides, quercetin, diosmetin, kaempferol, acacetin, agastachioside, and salvigenin (Aprotosoaie et al., 2016; Yang, Xing, He, & Wu, 2014). It has also been reported that the extract of Moldavian dragonhead has antibacterial and antioxidant properties along with cardio-protective effects (Jiang et al., 2014). A previous study has also reported the application of Moldavian dragonhead leaves (DL) as tea (Yang et al., 2014). Furthermore, in some countries, distilled aqueous extracts from DL have been used as a beverage (Dmitruk & Weryszko-Chmielewska, 2010). Recently, Wójtowicz et al. (2017) showed that dried Moldavian DL can be used as a functional additive for the...
processing of directly expanded corn crisps with the extrusion-cooking process.

Bread is a staple food in many countries, constituting a valuable source of energy and many important nutrients for the proper functioning of the body (Różyło, 2014). Till date, many studies have been published with regard to the improvement of nutraceutical properties of a bread via enrichment (Dziki, Różyło, Gawlik-Dziki, & Świeca, 2014; Gül & Şen, 2017; Xiao et al., 2016). Breads with high concentrations of antioxidants are especially in great demand because of their beneficial role in the maintenance and enhancement of health and protection against many diseases (Sivam, Sun-Waterhouse, Waterhouse, Quek, & Perera, 2011). However, to the best of our knowledge, there are no studies concerning the enrichment of bread with Moldavian DL.

Therefore, in this study, dried and powdered Moldavian DL were added to wheat bread with an aim to enrich wheat flour in bread production. The effect on bread quality was also assessed by evaluating the texture, color, sensory, and antioxidant properties.

We tested the possibilities of using dried and powdered Moldavian DL in the production of the wheat bread. Especially, the impact of DL on baking properties of wheat flour and bread quality was studied.

Materials and methods

Materials

Ferrozine (3-(2-pyridyl)-5,6-bis-(4-phenyl-sulfonic acid)-1,2,4-triazine); ABTS (2,2′-azino-bis-(3-ethylbenzothiazoline-6-sulfonic acid)); and sodium salicylate were purchased from Sigma-Aldrich company (Poznan, Poland). All other chemicals were of analytical grade.

Wheat flour (type 650, the particles below 0.2 mm) obtained from the local mill was used as the base raw material. The leaves of Moldavian dragonhead plants (D. moldavica L., Lamiaceae) grown in Poland in 2016 were used in the experiment. The plant was grown on an area of 0.5 ha in Perespa (50°660N 23°630E), Poland. Tillage for the Moldavian dragonhead followed the best agricultural practices (Wójcik et al., 2017). The leaves of this plant were manually cleaned and dried at 35°C using laboratory dryer SLN 15 STD (Pol-Eko-Aparatura, Poland) for 12 h. The dried DL was powdered using knife mill GM 200 (Retsch, Dusseldorf, Germany). The particles below 0.3 mm were used to supplement bread.

Composition of flour

The basic chemical composition of flour and DL was analyzed. The ash, protein, fat and total dietary fiber were determined (Romankiewicz et al., 2017). Moreover, the content of total dietary fiber in DL was evaluated (Wójcik et al., 2017).

Farinograph test

The wheat flour and flours with the addition of DL were analyzed using the farinograph test (Miş, Grundas, Dziki, & Laskowski, 2012) with the help of Farinograph-E equipped with mixer for 50 g of flour (model 810114, Brabender, Duisburg, Germany). The following parameters were determined: flour water absorption, the development time of dough, the stability of dough, and the degree of dough softening.

Bread preparation

For the preparation of dough, wheat flour was replaced with DL at 1, 2, 3, 4 and 5 g/100 g (DL1, DL2, DL3, DL4, and DL5, respectively). The control sample of bread (CS) was prepared without the addition of DL. Salt (2 g/100 g) (Solina SA, Poland) and instant dry yeast (1 g/100 g) (Lesaffre, France) were also used in the making of bread. The bread dough was prepared using a direct method. All ingredients were mixed in a laboratory mixer for 6 min (type GM-2, Sadvkie Instruments, Poland) and fermented at 30°C and 75% relative humidity (RH) for 60 min in a climatic chamber (Memmert ICH 256, Düsseldorf, Germany). After fermentation, each sample of dough was divided into 250 g pieces and was put in loaf tins (size about 10 × 10 × 10 cm) for 60 min (30°C and 75% RH). Then, the breads were baked at 230°C for 25 min in an oven (Sveba Dahlen, Sweden). Live steam was injected for 30 s after the loaves were placed in the oven. After baking, the loaves were removed from the tins and weighed. The breads were cooled for 1 h, packed in polyethylene bags, and were stored at 21°C for 5 h before testing.

The bread yield was recorded (Romankiewicz et al., 2017). The baking test was performed in three repetitions for each flour sample.

Volume, pH, and color evaluation

The bread volume was determined using a 3D scanner (NextEngine, Glasgow, USA) and expressed in cm³/100 g of bread (Anders, Kaliniewicz, & Markowski, 2012).

The pH of the bread crumb was measured using a pH meter (TESTO 206-pH2, Pruszków, Poland). Fresh and ground crumb (15 g) and distilled water (100 mL) were placed in a dry flask and stirred for 30 min. After 10 min, the pH value was recorded.

The crumb color parameters – lightness (L*), redness (+) or greenness (−) (a*), and yellowness (+) or blueness (−) (b*) – were determined using the Chromameter Minolta (CR-200, Japan). The color difference (ΔE) between the control sample (CS) and the breads with DL was also calculated (Izli, Yildiz, Ünal, Işik, & Uylaşer, 2014).

Bread crumb texture analysis

The measurement was performed after 5 h storage of cooled bread at 21°C; we used the texture analyzer type TA.XT2i (Stable Microsystems, Surrey, UK) for the measurement. The assay relied on a dual compression of the crumb cylindrical samples with a diameter of 22 mm from the center of slices (thickness of slices – 25 mm). A Cylindrical mandrel with a 25 mm diameter was used to measure the textural parameters.

The speed test was set at 1 mm/s. We applied 40% penetration of the sample with a 45-s break between the first and second pressure. Based on the graphs, the following parameters of bread crumb texture were determined: hardness, springiness, cohesiveness, gumminess, and chewiness (Armero & Collar, 1997).
**Total Phenolic Content (TPC) and Antioxidant Activity (AA)**

For the preparation of the extract, 0.5 g of ground samples (DL or dried and ground bread particles <0.3 mm) was extracted with a mixture of 5 mL of methanol: water (1:1, v/v, pH = 1). Samples were shaken for 30 min and centrifuged at 13000 g for 10 min. The supernatants were collected and used in the analysis of TPC by Folin-Ciocalteiu’s method (Singleton & Rossi, 1965) and calculated as gallic acid equivalent (GAE) in mg/g DM (Różyło, Hamed Hassoon, Gawlik-Dziki, Siastala, & Dziki, 2017). The ability of the extract to neutralize free radicals (ABTS) was analyzed (Re et al., 1999). Chelating power (CHEL) was determined by the method described by (Guo, Lee, Chiang, Lin, & Chang, 2001). Hydroxyl radicals were generated by Fenton reaction using FeSO₄ and H₂O₂ (Su, Wang, & Liu, 2009).

Antioxidant activities were described as the concentration of the extract showing 50% of the activity (EC₅₀).

**Sensory evaluation**

A team of 65 panelists in the age group of 25–56 years (36 male add 29 female) conducted a sensory evaluation of bread in a stable temperature and light. Breads were cut into slices (2 cm thick). Samples of bread were scored using at 7-point hedonic scale, where 1 stands for very much dislike and 7 stands for like extremely. The values from 1 to 3 were considered as a rejection, value 4 indicated indifference, and values from 5 to 7 demonstrated acceptance of the product according to the appearance, smell, taste, color, texture, and overall desirability (Zandonadi, Botelho, & Araújo, 2009).

**Statistical analysis**

All tests were performed in three replicates. The results were statistically analyzed in the Statistica 10. One-way analysis of variance (ANOVA) was performed with the significance level. The differences between means were determined by Tukey’s test. Moreover, Pearson correlation coefficients were determined. All statistical tests were performed at the significance level of α = 0.05.

**Results and discussion**

**Wheat and DL chemical composition**

Wheat flour was characterized by the following parameters: moisture content, 13.7 g/100 g; protein content, 12.1 g/100 g; ash content, 0.63; and falling number, 289 s. The average chemical composition of obtained powder was as follows: moisture content, 13.5 g/100 g; fiber content, 37.6 g/100 g; protein content, 24.6 g/100 g; fat content, 1.26 g/100 g; and ash content, 12.41 g/100 g.

**Dough properties**

The farinograph characteristics of wheat dough provided useful information on the modifying effect of DL on the behavior of the dough during its development and mixing. Table 1 presents the results of the farinograph test of wheat flour dough replaced with DL. DL caused an increase in the absorption of water by flour blends from 60.2% for CS to 64.1% for DL5. Dietary fibers possess a large number of hydroxyl groups, which interact with the hydrogen bonds of water and consequently, the flour can absorb a higher amount of water (Messia et al., 2016). In general, the addition of DL caused an increase in the time of development from 4.4 min (CS) to 7.8 min at 1% addition of DL. The highest stability of dough was also found when DL was added at a level 1 g/100 g. However, the higher levels of DL in the dough caused a decrease in the stability of dough. This might be explained by the fiber–gluten interactions, which can prevent the hydration capacity of proteins (Gómez, Ronda, Blanco, Caballero, & Apesteguía, 2003). Similar tendencies have been reported by other authors when different raw materials that are rich in fiber were supplemented with the wheat dough. Dachana, Rajiv, Indraní, and Prakash (2010) found that when dried and powdered moringa leaves were added to the wheat dough, the water absorption and development time increased, but the stability of the dough decreased. Similar results have been reported by (Sudha, Vetrimani, & Leelavathi, 2007). They added bran from different cereals into wheat flour. In our study, the addition of DL caused an increase in the degree of dough softening from 32 (CS) to 134 (DL5). Similar results have been reported by other authors after the addition of onion waste into the wheat dough (Prokopov et al., 2018). The degree of dough softening represents the susceptibility of the dough toward the destructive effect of mixing and is most strongly related to mixing energy. Martin-Esparzar et al. (Martin-Esparzar, Raigón, Raga, & Albors, 2018) showed that partial replacement of wheat flour by other plant materials rich in fiber causes the formation of a less cohesive and weaker structure of the dough due to the lower content of gluten. It means that the addition of DL into wheat flour, as a result of gluten weakening, makes the dough structure less stable during mixing. In addition, the interactions between dough components as well as the particle size play an important role in the development of dough structure and thus affects the rheological properties of the dough (Chillo et al., 2009). Miš et al. (2012) found that depending on the kind of the fiber used, the interactions might take place between the gluten matrix of the dough and the fiber, and these interactions are sometimes strong enough to counteract the weakening effect of the fiber-rich material on the dough structure.

| Sample | Water absorption (%) | Development time (min) | Stability of dough (min) | Degree of softening (FU) |
|--------|----------------------|------------------------|-------------------------|-------------------------|
| CS     | 60.2 ± 0.25          | 4.4 ± 0.17             | 5.5 ± 0.18              | 32.2 ± 2.8              |
| DL1    | 61.3 ± 0.31          | 6.3 ± 0.25             | 7.8 ± 0.21              | 73.4 ± 3.6              |
| DL2    | 61.9 ± 0.19          | 5.7 ± 0.21             | 5.2 ± 0.24              | 87.3 ± 3.9              |
| DL3    | 62.7 ± 0.28          | 5.5 ± 0.13             | 4.7 ± 0.13              | 105.5 ± 5.3             |
| DL4    | 63.2 ± 0.34          | 5.2 ± 0.32             | 4.5 ± 0.18              | 129.5 ± 6.2             |
| DL5    | 64.1 ± 0.36          | 5.1 ± 0.15             | 4.4 ± 0.14              | 134.7 ± 7.0             |

### Table 1. Farinograph indices for wheat flour and wheat flour blends with DL. | Table 1. Indices de farinografía para la harina de trigo y las mezclas de harina de trigo con DL. |
Table 2. Basic characteristics of control bread and bread enriched with DL.

| Bread sample | Bread yield [%] | Bread volume [cm³/100 g] | Ash content [g/100g] | Moisture content [g/100g] | pH     |
|--------------|----------------|--------------------------|----------------------|---------------------------|--------|
| CS           | 139.5 ± 0.25   | 343.8 ± 5.52             | 0.85 ± 0.012         | 42.6 ± 0.12               | 3.2 ± 0.02 |
| DL1          | 141.5 ± 0.62   | 333.4 ± 5.36             | 0.89 ± 0.019         | 43.2 ± 0.08               | 3.3 ± 0.04 |
| DL2          | 143.5 ± 0.58   | 326.1 ± 4.23             | 1.02 ± 0.015         | 43.6 ± 0.17               | 3.4 ± 0.03 |
| DL3          | 143.7 ± 0.36   | 324.4 ± 3.82             | 1.08 ± 0.006         | 43.7 ± 0.07               | 3.6 ± 0.08 |
| DL4          | 144.1 ± 0.18   | 323.6 ± 4.65             | 1.16 ± 0.034         | 43.9 ± 0.06               | 3.8 ± 0.06 |
| DL5          | 144.3 ± 0.53   | 322.4 ± 5.03             | 1.36 ± 0.036         | 44.0 ± 0.08               | 4.0 ± 0.08 |

DL – dragonhead leaves, CS – control sample of bread, DL1, DL2, DL3, DL4, DL5, bread with 1, 2, 3, 4 and 5 g/100 g of powdered leaves, respectively. 
Mean ± SD, n = 3. Values followed by the same letter in the same columns are not significantly different (p < 0.05).

Figure 1. Color coordinates (L*, a*, b*) of bread crumb and total color difference of bread samples; DL – dragonhead leaves, CS – control sample of bread, DL1, DL2, DL3, DL4, and DL5, bread with 1, 2, 3, 4, and 5 g/100 g of powdered leaves; Mean ± SD, n = 3, the values followed by the same letter are not significantly different (p < 0.05).
The texture characteristics of control bread and bread enriched with DL. ± 0.02 0.92 b 12.7 a – control sample of bread, DL1, DL2, DL3, DL4, DL5, bread with 1, 2, 3, 4 and 5 g/100 g of powdered green plant components rich in fiber into the dough of wheat bread decreases the lightness and increases the yellowness and greenness of the crumb (Zhu, Sakulnak, & Wang, 2016).

**Crumb texture**

Table 3 shows the textural characteristics of the bread. According to the results, the replacement of wheat flour by DL by up to 5 g/100 g flour had little effect on the determined indices of texture. Due to the addition of DL, the hardness and gumminess of the crumb increased. We found significant differences only between CS and breads with DL. The addition of DL had no significant effect on the resistance and springiness of the bread and caused a slight decrease in cohesiveness. Usually, the enrichment of wheat flour by other flours causes weakening of the gluten matrix and decreases the volume of the bread, and consequently, the hardness of the crumb increases (de Oliveira, da Silva Lucas, Cadaval, & Mellado, 2017). In our study, the addition of DL caused a decrease in the volume of bread; however, the moisture content of crumb slightly increased as a result of higher flour absorption of water by dough containing DL. Higher water content usually results in lower crumb hardness (de Oliveira, da Silva Lucas, Cadaval, & Mellado, 2017). The results of sensory evaluation of control bread and bread enriched with DL. ± 0.02 0.90 b 6.7 a – control sample of bread, DL1, DL2, DL3, DL4, DL5, bread with 1, 2, 3, 4 and 5 g/100 g of powdered leaves, respectively. 4.5 (DL1) to 14.4 (DL5). This parameter indicated significant differences in the color after the addition of DL compared to the CS. The increasing amount of DL in the bread dough significantly increased the total color difference of breads from 4.5 to 14.4. Similar trends in the changes of color coordinates were found when DL was added into corn snacks (Wójtowicz et al., 2017). Usually, the addition of green plant components rich in fiber into the dough of wheat bread decreases the lightness and increases the yellowness and greenness of the crumb (Zhu, Sakulnak, & Wang, 2016).

**Sensory evaluation**

Table 4 presents the results of sensory evaluation of the bread. The highest scores for bread quality attributes were obtained for CS and DL1 bread samples, and the differences between the overall score for these breads were not statistically and significantly different. More importantly, the enrichment of wheat flour by DL had low effect on the textural qualities of the bread, and all samples of bread containing DL were evaluated positively for this attribute. However, an increase in the addition of DL caused a decrease in the notes for other quality attributes, especially those related to the taste, odor, and color of the bread. These factors are the most important features for baked products because together with the taste, they have a significant influence on consumers’ acceptance of the product (Dhen, Ben Rejeb, Boukhris, Damergi, & Gargouri, 2018). Moreover, breads with the addition of DL were characterized by green color, slight citrus-like odor, and specific herbal taste, probably because of the presence of rosmarinic acid in DL (Wójtowicz et al., 2017). When the wheat flour was enriched with DL by more than 3 g/100 g, the bread was unacceptable due to the unpleasant odor, taste, and color. Thus, breads DL4 and DL5 exhibited unacceptable notes in the overall evaluation. Similar results were reported by Gawlik-Dziki et al. (2013) and Świeca, Sęczyk, Gawlik-Dziki, & Dziki (2014) when more than 3 g of quinoa leaves were

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**Table 3. The texture characteristics of control bread and bread enriched with DL.**

| Bread sample | Hardness (N) | Resilience | Springiness | Cohesiveness | Gumminess (N) |
|--------------|--------------|------------|-------------|--------------|---------------|
| CS           | 12.7 ± 1.3   | 0.24 ± 0.02| 0.90 ± 0.02 | 0.54 ± 0.03  | 6.7 ± 0.45    |
| DL1          | 15.9 ± 1.7   | 0.24 ± 0.03| 0.91 ± 0.03 | 0.57 ± 0.04  | 9.3 ± 0.52    |
| DL2          | 16.5 ± 1.8   | 0.23 ± 0.03| 0.89 ± 0.04 | 0.55 ± 0.02  | 8.5 ± 0.57    |
| DL3          | 15.4 ± 1.5   | 0.25 ± 0.04| 0.92 ± 0.02 | 0.58 ± 0.03  | 9.0 ± 0.28    |
| DL4          | 14.3 ± 1.7   | 0.26 ± 0.02| 0.90 ± 0.05 | 0.59 ± 0.02  | 8.7 ± 0.41    |

DL – dragonhead leaves, CS – control sample of bread, DL1, DL2, DL3, DL4, DL5, bread with 1, 2, 3, 4 and 5 g/100 g of powdered leaves, respectively.

Mean ± SD, n = 3. Values followed by the same letter in the same rows are not significantly different (p < 0.05).

**Table 4. The results of sensory evaluation of control bread and bread enriched with DL.**

| Bread sample | Appearance | Taste | Odor | Color | Texture | Overall |
|--------------|------------|-------|------|-------|---------|---------|
| CS           | 6.1 ± 0.16  | 6.5 ± 0.31 | 6.2 ± 0.21 | 6.5 ± 0.21 | 6.2 ± 0.17 | 6.5 ± 0.29 |
| DL1          | 5.7 ± 0.18  | 6.1 ± 0.46 | 5.6 ± 0.33 | 5.8 ± 0.33 | 6.1 ± 0.31 | 6.1 ± 0.23 |
| DL2          | 5.4 ± 0.59  | 5.5 ± 0.32 | 5.0 ± 0.29 | 5.2 ± 0.29 | 5.8 ± 0.15 | 5.5 ± 0.22 |
| DL3          | 5.0 ± 0.33  | 4.5 ± 0.26 | 4.0 ± 0.31 | 4.5 ± 0.31 | 5.6 ± 0.14 | 4.5 ± 0.19 |
| DL4          | 4.6 ± 0.50  | 3.2 ± 0.31 | 3.6 ± 0.22 | 3.6 ± 0.22 | 5.5 ± 0.22 | 3.5 ± 0.13 |
| DL5          | 4.5 ± 0.47  | 3.0 ± 0.27 | 2.9 ± 0.18 | 3.2 ± 0.18 | 5.5 ± 0.17 | 2.8 ± 0.16 |

DL – dragonhead leaves, CS – control sample of bread, DL1, DL2, DL3, DL4, DL5, bread with 1, 2, 3, 4 and 5 g/100 g of powdered leaves, respectively.

Mean ± SD, n = 65. Values followed by the same letter in the same rows are not significantly different (p < 0.05).

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Wójtowicz, L. (2017). The texture characteristics of control bread and bread enriched with DL. ± 0.02 0.90 b 6.7 a – control sample of bread, DL1, DL2, DL3, DL4, DL5, bread with 1, 2, 3, 4 and 5 g/100 g of powdered leaves, respectively. The results of sensory evaluation of control bread and bread enriched with DL. ± 0.02 0.90 b 6.7 a – control sample of bread, DL1, DL2, DL3, DL4, DL5, bread with 1, 2, 3, 4 and 5 g/100 g of powdered leaves, respectively.

Mean ± SD, n = 65. Values followed by the same letter in the same rows are not significantly different (p < 0.05).
used to enrich 100 g wheat flour in the preparation of wheat bread dough.

**TPC and AA**

TPC in DL was 82.6 (±1.36) mg gallic acid equivalents (GAE)/mg dry mass (DM). A similar result was reported by Povilaityté et al. (Povilaityté, Cuvelier, & Berset, 2001) in DL. The antioxidant activities, expressed as EC$_{50}$ value in the extracts obtained from DL were as follows: 1.6 (±0.18), 6.3 (±0.12), and 8.1 (±0.21) mg DM/mL for ABTS, CHEL, and OH, respectively. Figure 2 presents the results of TPC and AA in the extracts obtained from bread samples. Increase in the percentage of DL in the dough caused a linear increase in the value of TPC (from 4.8 mg GAE/g DM for CS to 10.1 mg GAE/g DM for DL5).

The addition of DL also caused a significant decrease in the value of EC$_{50}$. This means that AA increased with an increasing amount of DL. The increase in the AA was observed in each antioxidant assay. The highest AA was found for ABTS assay (decrease of EC$_{50}$ from 156.9 to 24.8 mg DM/mL) and the lowest for OH method (decrease of EC$_{50}$ from 39.9 to 22.5 mg DM/mL). The correlation coefficients between TPC and EC$_{50}$ were $-0.87$, $-0.91$, and $-0.96$ for ABTS, CHEL, and OH, respectively. Wójtowicz et al. (Wójtowicz et al., 2017) also found an increase in the AA of extruded snacks with an increasing amount of DL in the snack recipe. Usually, the TPC in breads obtained from refined wheat flours was about two times lower than that of the bread obtained from wholemeal flour (Yu, Nanguet, & Beta, 2013). It means that the addition of DL at 5 g/100 g provided similar results with respect to TPC as in the production of wholemeal bread. However, ferulic acid was found to be the primary phenolic acid in wheat flour, whereas rosmarinic acid was the primary phenolic acid in DL responsible for TPC and AA (Povilaityté et al., 2001). Rosmarinic acid is considered one of the most important polyphenols. Several studies have shown biological activities and protective efficacies of rosmarinic acid, including antioxidant, antibacterial, anticancer, and anti-inflammatory activities (Chun, Kundu, Chae, & Kundu, 2014; Rocío, Garrido, Espinosa, & Linares, 2015). Moreover, according to Aslanipour et al. (Aslanipour, Heidari, & Farnad, 2017), DL also contains ferulic, caffeic, vanillic, chlorogenic, 4-hydroxybenzoic, and chlorogenic acids as well as flavonoids such as quercetin and apigenin (Dastmalchi et al., 2007). These compounds are also responsible for AA of DL.

**Conclusion**

Enrichment of wheat flour with the powder of Moldavian DL caused an increase in the water absorption by the flour thereby weakening the tolerance of the dough. As a result, the yield of the bread increased, but the volume of the crumb decreased. More importantly, the addition of DL had little influence on the textural parameters of the bread. The lightness of crumb decreased due to the addition of DL, whereas the greenness and yellowness increased. Moreover, the addition of DL caused an increase in the TPC and AA of breads. This was observed for all the methods of AA assay (ABTS, CHEL, and OH). Thus, based on our results we recommend that the enrichment of bread with DL should not exceed 3 g/100 g of wheat flour in the production of functional bread with acceptable sensory qualities and enhanced antioxidant capacity.

**Disclosure statement**

No potential conflict of interest was reported by the authors.
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