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Effect of Orange Albedo on Nutritional, Functional and Cooking Properties of Semolina Pasta

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Abstract

In this study, the effect of debittered orange albedo on the nutritional, functional and cooking properties of pasta samples was investigated. Orange albedo was substituted into durum wheat semolina at 2.5%, 5% and 10% levels and the moisture, ash, protein, fat, carbohydrate, energy, total phenolic content, antioxidant activity, water uptake and cooking loss of the pasta samples were determined. Albedo substitution increased the fat content ($p>0.05$), ash content ($p<0.05$), carbohydrate content ($p>0.05$) and energy value ($p>0.05$) of pasta samples. Pasta sample without added albedo was found to have the lowest total phenolic content, antioxidant activity, water uptake and cooking loss, and as the albedo substitution rate increased, total phenolic content ($p>0.05$), antioxidant activity ($p<0.05$), water uptake ($p>0.05$) and cooking loss ($p<0.05$) of pasta samples increased. The use of albedo, one of the by-products of the food industry, in pasta production has both increased the functionality of the pasta and recovered a product separated as waste.

Key Words: *Albedo, Debittering process, Functional food, Orange, Pasta*

Introduction

In recent years, the demand for functional foods has increased due to constantly changing consumption habits and increasing population. Pasta is one of the most produced and consumed staple foods in the worldwide (Sissons, 2022). Neutral taste, ease of cooking, low cost and long shelf life are the reasons for its preference (Bustos et al., 2015; Obadi et al., 2021). In pasta production, firstly, durum wheat semolina and water are mixed and kneaded. Then, the obtained dough is shaped by extrusion and lamination. Lastly, the obtained product characterized by its own shape is dried (maximum moisture content 12.5%) and made ready for consumption (Costa et al., 2010). Although durum wheat semolina is rich in carbohydrates (Singh et al., 2023), it is poor in phenolic compounds, vitamins, minerals and dietary fibers (Nilusha et al., 2019). There are studies in the literature where various food industry by-products are included in the formulation in order to increase the functionality of pasta (Carpentieri et al., 2022). Tomato (Padalino et al., 2017), olive (Padalino et al., 2018), grape (Iuga and Mironeasa, 2021), carob (Rodríguez-Solana et al., 2021) and raspberry (De Santis et al., 2022) by-products are some of the materials used to enrich the pasta.

Fruit pulp and peels, which are one of the biggest by-products of the fruit juice industry, are rich in phenolic substances as well as containing high dietary fiber (Sindhu et al., 2019). Citrus fruits are one of the most widely produced and consumed fruits worldwide and contain many phytochemicals that are beneficial for human health (Rafiq et al., 2018). Among citrus fruits, orange is the most preferred type in terms of consumption and processing (Aşık, 2019). Citrus fruit peels consist of two layers called flavedo and albedo. Flavedo is the outer layer, which ranges in color from yellow to orange. Flavedo layer contains carotenoid pigments and lipid cells. Underneath the flavedo is the albedo, a white/cream colored, felt-like layer (Çoksever, 2009). Albedo layer contains loose tissues consisting of large intercellular spaces. It forms a structure consisting mostly of hesperidin and pectin. The majority of pectin, which is found in the citrus fruit peel at a rate of 30-35%, is found in the albedo layer at 73% (Schröder et al., 2004). Albedo layer is preferred because it is an important source of pectin. It has a higher dietary fiber potential and is of better quality than other dietary fiber sources because it contains bioactive compounds with antioxidant properties (Lliso et al., 2007).

The aim of this study is to improve the functional properties of pasta by adding orange peels, one of the by-products of the food industry, to the pasta formulation after subjecting them to various processes. First, the albedo obtained from the orange peel was subjected to the debittering process and then substituted into durum wheat flour at 2.5%, 5% and 10% levels. The nutritional (moisture, ash, protein, fat, carbohydrate, energy), functional (total phenolic content and antioxidant activity) and cooking (water uptake and cooking loss) analyses of the produced pasta were performed.

Materials and Methods

Materials

Durum wheat flour (*Triticum durum* L.) used in the study was supplied by a local producer in Gaziantep, Türkiye and oranges (*Citrus sinensis* L.) were supplied by a local market in Istanbul, Türkiye. All chemicals were used analytical grade.

Albedo production

The methods suggested by Sarıçoban and Unal (2022) and Chaudhary et al. (2024) were used with modifications in the production of albedo. First, the albedo layer was separated from the orange peels. Then, it was subjected to heat treatment at 100 °C for 10 minutes and kept in the same water for 18 hours. At the end of the period, the water was changed and kept in new water for 24 hours and filtered. The albedos, whose bitter taste was removed, were lyophilized (Bruker Co., Germany). The dried albedos were ground and sieved (<500 µm).

Pasta production

100 g durum wheat flour (2.5%, 5% and 10% albedo were substituted) was mixed with 50-70 mL distilled water at 40-45 °C and kneaded. The obtained dough was thinned in a pasta making machine and given the shape of tagliatelle. Pasta cut into 8-10 cm lengths were dried at 50 °C for 5 hours. Pasta without albedo was evaluated as the control (P0) and pasta with 2.5%, 5% and 10% albedo were named P2.5, P5 and P10, respectively.

Determination of nutritional properties

Moisture content of pasta samples was determined by AACC Method No: 44-15.02, ash content by AACC Method No: 08-01.01, protein content by AACC Method No: 46-11.02 and fat content by AACC Method No: 30-25.01 (AACC, 1990). The formula "CHO% = 100 – (Moisture% + Ash% + Protein% + Fat%)" was used to calculate carbohydrate content; the formula "Energy (kcal/100 g) = 4 x (CHO% + Protein%) + 9 x (Fat%)" was used to calculate energy value (Karaağaoğlu et al., 2008).

Determination of functional properties

For the extraction of phenolic compounds, 1 g sample was weighed and 5 mL 80% (v/v) methanol was added. After 15 min in an ultrasonic water bath (Protech, Turkey) and 10 min in an orbital shaker (Stuart SSL1, England), it was centrifuged (Hettich Rotofix 32A, Germany) at 1460 g for 10 min. The supernatant was collected, the sediment was subjected to the same procedures again and the supernatants were combined. The combined supernatants were passed through a 0.45 µm filter and the volume was completed to 10 mL with 80% (v/v) methanol (Czaja et al., 2020). For total phenolic content analysis, 0.1 mL extract was taken into analysis tubes. 2 N 0.2 mL Folin-Ciocalteu reagent and 2 mL distilled water were added. After mixing, it was waited at room temperature for 3 min. At the end of the period, 1 mL 20% (w/v) Na_2CO_3 solution was added. After mixing, it was waited at room temperature for 1 hour. At the end of the period, absorbance was read at 765 nm via the spectrophotometer (PG Instruments Ltd. T60, England). The standard for creating the calibration curve was gallic acid (Wojdyło et al., 2007). For the CUPRAC method (antioxidant activity), 1 mL 1.0×10^{-2} M $CuCl_2$ solution, 1 mL 1 M ammonium acetate buffer solution, 1 mL 7.5×10^{-3} M Neocuproin solution were taken into the analysis tubes. Then, x mL extract and (1.1-x) mL distilled water were added to make the final volume 4.1 mL. After mixing and waiting in the dark for 1 hour, absorbance was read at 450 nm via the spectrophotometer (PG Instruments Ltd. T60, England). The standard for creating the calibration curve was trolox (Apak et al., 2008).

Determination of cooking properties

In order to determine the optimum cooking time, which is the minimum necessary time required for the starch to completely gelatinize, the pasta was pressed between two glass plates every 30 seconds and the process was repeated until the white part in the middle of the pasta disappeared and the elapsed time was recorded as minutes (Oh et al., 1985). In order to determine water uptake, 20 g pasta was cooked in 250 mL distilled water for the optimum cooking time. The weights of the cooked pasta were determined after draining. The ratio between dry and cooked pasta weights was calculated as water uptake (%) (Özkaya, 2005). In order to determine the cooking loss, the cooking water was evaporated until a fixed weight of 135 °C was reached. The residue was detected. Cooking loss (%) was calculated based on the percentage of the dry pasta weight (Özkaya, 2005).

Statistical analysis

Experimental data were subjected to Variance Analysis using Minitab Version 16.0 (Minitab Inc., PA, USA) program in the form of tables prepared in accordance with the experimental design. Tukey Multiple Comparison Test was used to check whether the differences between the group means were significant. Duplicate measurements were made in all analyses.

Results and Discussion

Nutritional properties

The nutritional analysis results of the pasta samples are presented in Table 1. According to the nutritional analysis results, the moisture content of the pasta samples varied between 13.82-16.43%, ash content between 1.00-1.23%, protein content between 14.15-14.68%, fat content between 0.31-1.19%, carbohydrate content between 67.95-69.73% and energy value between 331.84-345.74 kcal/100 g. Although no statistically significant difference was found between the moisture, protein, fat and carbohydrate contents and energy values of the pasta samples ($p>0.05$), pasta sample without added albedo (P0) was found to have the lowest fat and carbohydrate content and energy value. In addition, as the albedo concentration increased, the fat contents and energy values of the pasta samples increased. P0 pasta was found to have the lowest ash content ($p<0.05$) and ash content increased as albedo concentration increased ($p>0.05$).

Table 1. Nutritional properties of pasta samples.

Sample	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Carbohydrate (%)	Energy (kcal/100 g)
P0	16.43 ± 0.06^{a}	1.00 ± 0.07^{b}	14.32 ± 0.26^{a}	0.31 ± 0.05^{a}	67.95 ± 0.23^{a}	331.84 ± 0.31^{a}
P2.5	13.95 ± 2.15^{a}	1.05 ± 0.08^{ab}	14.55 ± 0.12^{a}	0.73 ± 0.22^{a}	69.73 ± 2.14^{a}	343.65 ± 10.03^{a}
P5	14.28 ± 1.61^{a}	1.13 ± 0.01^{ab}	14.68 ± 0.46^{a}	1.09 ± 0.36^{a}	68.82 ± 1.73^{a}	343.83 ± 8.27^{a}
P10	13.82 ± 2.21^{a}	1.23 ± 0.02^{a}	14.15 ± 0.22^{a}	1.19 ± 0.20^{a}	69.61 ± 2.21^{a}	345.74 ± 9.79^{a}

Values were given as means ± standard deviation. In the same column, different superscripts show significant differences between samples ($p<0.05$). Nutritional properties except moisture are based on dry matter. P0, P2.5, P5, P10 represent pasta samples with 0, 2.5, 5, 10% albedo substitution, respectively.

Dietary fiber was produced from by-products obtained from the orange juice industry and the produced dietary fiber was substituted in the pasta formulation at a level of 25-75%. The ash content of the produced pasta varied between 0.68-0.81%, protein content between 10.92-11.67%, fat content between 0.14-0.24% and carbohydrate content between 80.51-83.56% (Crizel et al., 2015). In the studies carried out, it was determined that as the albedo concentration in breads (Demir and Olcay, 2020) and biscuits (Demirel, 2017) increased, the ash content increased while the protein content decreased.

Functional properties

The functional analysis results of the pasta samples are shown in Figure 1. According to the functional analysis results, the total phenolic content (TPC) value of the pasta samples varied between 21.65-26.30 mg GAE/100 g dm and the antioxidant activity (CUPRAC) value of the pasta samples varied between 81.50-147.75 mg TE/100 g dm. Pasta sample without added albedo (P0) was found to have the lowest TPC ($p>0.05$) value and CUPRAC ($p<0.05$) value. Although the TPC value and CUPRAC value of the pasta samples increased as the albedo concentration increased, no statistically significant difference was found between the pasta samples ($p>0.05$).

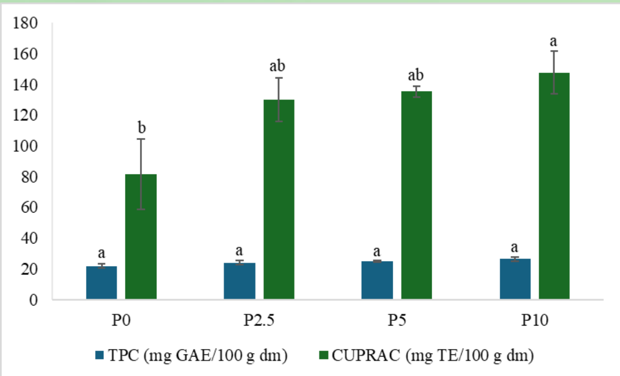

Figure 1. Functional properties of pasta samples. a-b represent the significant differences between samples ($p<0.05$). P0, P2.5, P5, P10 represent pasta samples with 0, 2.5, 5, 10% albedo substitution, respectively.

Orange by-products were substituted into pasta and total polyphenol (1.19-1.68 mg GAE/g) increased as the substitution rate increased (Crizel et al., 2015). Grapefruit albedo was substituted into pasta and DPPH (17.60-38.76%), FRAP (8.57-18.38 µmol AAE/g) and TPC (69.09-167.89 mg GAE/100 g) increased as the substitution rate increased (Chaudhary et al., 2024).

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Cooking properties

The cooking analysis results of the pasta samples are presented in Table 2. According to the cooking analysis results, the water uptake value of the pasta samples varied between 55.20-64.19% and the cooking loss value of the pasta samples varied between 1.82-2.18%. Pasta sample without added albedo (P0) was found to have the lowest water uptake ($p>0.05$) value and cooking loss ($p<0.05$) value. Although the water uptake value and cooking loss value of the pasta samples increased as the albedo concentration increased, no statistically significant difference was found between the pasta samples ($p>0.05$).

Table 2. Cooking properties of pasta samples.

Sample	Water Uptake (%)	Cooking Loss (%)
P0	55.20 ± 1.47^{a}	1.82 ± 0.07^{b}
P2.5	62.15 ± 4.26^{a}	1.93 ± 0.06^{ab}
P5	64.12 ± 1.82^{a}	1.99 ± 0.12^{ab}
P10	64.19 ± 2.60^{a}	2.18 ± 0.02^{a}

Values were given as means ± standard deviation. In the same column, different superscripts show significant differences between samples ($p<0.05$). P0, P2.5, P5, P10 represent pasta samples with 0, 2.5, 5, 10% albedo substitution, respectively.

Orange by-products were substituted for pasta and as the substitution rate increased, water uptake increased from 85.53% to 88.19% and cooking loss increased from 5.57% to 7.98% (Crizel et al., 2015). Grapefruit albedo was substituted for pasta and as the substitution rate increased, swelling index increased from 5.34% to 6.49% and cooking loss increased from 3.47% to 5.02% (Chaudhary et al., 2024).

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