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Effect of autoclaving and cooking on phenolic compounds in buckwheat-enriched whole wheat tagliatelle

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ABSTRACT

The effect of buckwheat achene autoclaving on the phenolic content of the flour obtained by grinding was investigated. The potential of obtained flour to improve the phenolic profile of common whole wheat tagliatelle, and cooking quality, expressed by the amount of phenolics loss during pasta cooking, were also studied. Autoclaving reduced free, but increased bound phenolic forms in flour and tagliatelle samples. Moreover, it reduced rutin conversion into quercetin in great extent during production of tagliatelle with autoclaved buckwheat flour while during cooking of these samples conversion did not occur. The loss of phenolic compounds from buckwheat-enriched whole wheat tagliatelle during cooking (48.1–61.1%) was in the range of the control sample (57.6%) indicating that pasta containing buckwheat flour may maintain cooking quality.

1. Introduction

Durum wheat semolina has been traditionally used for pasta production. Today, accompanying new trends in eating habits and consumer demands for healthier foods, pasta manufacturers together with researchers, have been looking for non-traditional ingredients that contribute to the improvement of the nutritional and functional properties of products (De Marco et al., 2014; Wood, 2009; Wójtowicz and Mościcki, 2014).

Both, whole grain wheat and buckwheat flour can be considered as good candidates for pasta enrichment because they provide numerous health benefits when consumed. Whole wheat products contain more dietary fibre, vitamins, minerals, and antioxidants than the refined ones since these components are highly concentrated in the bran and germ (Yu and Nanguet, 2013). Among pseudocereals, buckwheat is one of the best sources of essential amino acids, such as lysine and threonin, flavonoids, phenolic acids, tannins, phytosterols and tocopherols (Kreft et al., 2006). Buckwheat contains rutin and quercetin, which are not found in other cereals. Apart from these constituents, buckwheat also contains catechin, condensed tannin with relatively high antioxidant capacity accompanied with cardioprotective, diuretic and hypotensive actions (Yetuk et al., 2014).

Beside pasta fortification, long term goal for the food industry is to produce food which will preserve naturally presented antioxidants, both for food stabilization and nutritional purposes. In this sense, a lot of attention has been devoted to the impact of food processing on the availability of beneficial components since it is of great importance that desired health promoting components are accessible at the time of consumption. Processing of food may affect the content of phenolic compounds and their health benefits positively or negatively (Duodu, 2011). Many studies reported about both, harmful and beneficial effects of different thermal processing such as baking, roasting, pressure steam-heating, microwave heating, boiling, and extrusion cooking on food phenolics content (Fares et al., 2010; Ragaee et al., 2012; Zielinski et al., 2001).

There are several reports about the effects of processing conditions on a few buckwheat functional components and antioxidant properties. Dietrich-Szostak and Oleszek (1999) observed drastic reduction of the total flavonoid in buckwheat grains and smaller but significant reduction in hulls during dehulling process under the different temperature and heating time regimes. According to Zieliński et al. (2006) phenolic acids content in buckwheat flour was affected by extrusion cooking at different temperatures. In contrast to them, Sensoy et al. (2006) did not found significant changes in total phenolics content after roasting

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(200 °C, 10 min) and extrusion (170 °C) of whole grain buckwheat flour. Vogrinčič et al. (2010) studied the impact of bread making on rutin, quercetin and polyphenol content and antioxidant activity of bread with tartary buckwheat flour.

Most of the published papers studied effects of thermal processing only on phenolic content of buckwheat grains, hulls and whole or refined buckwheat flours. The others investigated effects of processing by comparing phenolics content in products and raw materials (Dietrych- Szostak et al., 1999; Kreft et al., 2006; Lin et al., 2009; Sedej et al., 2011). However, there are a limited number of studies which can give an insight into the phenolic content of products prepared with previously thermally treated buckwheat flour. In a survey conducted by Yoo et al. (2012), hydrothermally treated (steamed and autoclaved) tartary buckwheat flour was used for noodle preparation in order to follow the rutin loss in the dough and to determine the influence of flour treatment on rheological properties of noodle doughs. Obtained results showed that hydrothermal treatments resulted in minimal rutin loss, changes in chemical composition and a distinct influence on dough rheological properties.

The usage of hydrothermal processes such as autoclaving can be various. It can be used to prevent rancidity during storage of the final product, to facilitate flaking of the groats or to kill bacteria (Bryngelsson et al., 2002). In the present study we employed autoclaving in order to prevent the rutin loss in final product. The objective of the study was to investigate the effect of autoclaving on rutin and other phenolic compounds content in both, raw material (flour) and in final product, tagliatelle made from this flour. The content of phenolic compounds in whole grain wheat, non-treated and autoclaved buckwheat flour, uncooked and cooked tagliatelle, including the cooking water were determined and discussed.

2. Material and methods

2.1. Raw materials

Common whole wheat flour (moisture 12.02%, protein ($N \times 5.7$) 13.60%, lipids 1.63%, ash 1.20%, reducing sugars 1.55%, and starch 72.00%) was purchased from the local market (Žitko, Bačka Topola, Serbia) and common buckwheat achenes were purchased from Hemija Commerce, Novi Sad, Serbia. Buckwheat achenes were autoclaved at 120 °C and 0.2 MPa for 10 min (Autoclav STERICLAV – S AES-75, Raypa trade, Barcelona, Spain). After autoclaving, buckwheat achenes were spread out on trays and left to rest overnight at 25 °C. The autoclaved whole buckwheat flour (TB) (moisture 13.10%, protein ($N \times 5.7$) 12.99%, lipids 3.43%, ash 2.38%, reducing sugars 1.89%, and starch 69.92%) and non-treated buckwheat (NB) flour (moisture 11.81%, protein 15.24%, lipids 3.24, ash 2.65%, reducing sugars 2.30%, and starch 71.60%) were obtained by grinding on a stone mill (mill stone diameter 1000 mm; Rajica Topalović i sin, Trstenik, Serbia) and sieved (100-mesh screen). Obtained buckwheat flour was a mixture of ground aleuron seed layer, germ, and a portion of hulls passed through the sieve.

Proximate composition of raw materials was analysed by using appropriate AOAC methods (AOAC, 1980).

2.2. Tagliatelle production

Seven different types of tagliatelle were produced on an industrial scale (capacity 80 kg/h) using single screw extruder Ital past Mac 60 Pasta Maker Extruder (Parma, Italy) by substituting whole wheat flour with different amounts (10, 20, and 30 g/100 g) of NB or TB flour in tagliatelle formulation. Whole wheat flour tagliatelle was produced as a control (Cntrl). Buckwheat-enriched whole wheat tagliatelle was labelled by the code 'nXB' where 'n' represents the level of substitution and 'XB' refers to type of buckwheat flour. This means that 'NB' was used for tagliatelle samples containing non-treated whole buckwheat flour and 'TB' was used for tagliatelle samples containing autoclaved whole buckwheat flour.

The flours were first mixed and hydrated with tap water in order to achieve proper dough consistency. The obtained dough was extruded at constant extrusion temperature of approximately 51 °C and the tagliatelle was dried in a dryer (Ital past D200, Parma, Italy) using a low temperature drying procedure for 13.5 h at approximately 50 °C until the final relative humidity was between 75 and 77%.

2.3. Extraction of phenolic compounds

The phenolic compounds were extracted from each flour type (whole wheat, NB and TB flour), uncooked and cooked tagliatelle, and from the cooking water. Tagliatelle was cooked according to AACC (AACC, 1995) until the optimum cooking time was reached, after which it was drained and dried at 45 °C for 1 day. Three portions (100 mL) of cooking water were taken, freeze dried and the obtained dry matter was measured. Uncooked and cooked tagliatelle samples were ground using 1095 Knifetec laboratory mill.

A portion of about 5 g of flour and ground tagliatelle samples was extracted with 12.5 mL of ethanol/water (4:1, v/v) in an ultrasonic bath at 40 °C for 15 min. Cooking water dry residues were extracted with 10 mL of ethanol/water (4:1, v/v) in the same way. The extraction procedure was done in triplicate. The mixture was than centrifuged for 10 min at 3000 rpm (1006.2 g). After centrifugation, the supernatant was analysed for free phenolic

Table 1
Total phenolic acids and total flavonoid content (free and bound forms) in whole wheat flour and whole buckwheat flour (non-treated and autoclaved).

Type of polyphenols		Whole wheat flour (mg/kg)	Whole buckwheat flour	
			Non-treated (mg/kg)	Autoclaved (mg/kg)
TPAC	Free	$9.42^{a} \pm 0.59$	$107.6^{c} \pm 4.12$	$69.15^{b} \pm 1.81$
	Bound	$75.54^{c} \pm 2.00$	$50.15^{a} \pm 2.04$	$56.54^{b} \pm 0.05$
TFC	Free	$62.29^{a} \pm 8.82$	$185.1^{b} \pm 5.16$	$198.6^{c} \pm 2.79$
	Bound	$11.69^{a} \pm 4.06$	$53.61^{b} \pm 3.11$	$64.32^{c} \pm 1.31$
Total PC		158.9	396.5	388.6

Values are means of three determinations ± standard deviation.
Values of the same row with the same superscript are not statistically different ($p < 0.05$).
TPAC – total phenolic acids content.
TFC – total flavonoids content.
PC – total phenolic compounds content.