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Changes in antioxidant activity and phenolic acid composition of tarhana with steel-cut oats

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ABSTRACT

Steel-cut oats (SCO) was used to replace wheat flour in the tarhana formulation (control) at the levels of 10%, 20%, 30% and 40% (w/w). Control sample included no SCO. Substitution of wheat flour in tarhana formulation with SCO affected the mineral contents positively. SCO additions also increased phenolic acid contents of tarhana samples. The most abundant phenolic acids were ferulic and vanillic acids, followed by syringic acid in the samples with SCO. Tarhana samples with SCO also showed higher antioxidant activities than the control. Compared with the control, the total phenolic content increased when the level of SCO addition was increased. SCO addition did not have a deteriorative effect on sensory properties of tarhana samples and resulted in acceptable soup properties in terms of overall acceptability. SCO addition improved the nutritional and functional properties of tarhana by causing increases in antioxidant activity, phenolic content and phenolic acids.

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1. Introduction

Tarhana is a fermented food made from cereal flours, yoghurt, and different vegetables (Ozdemir, Gocmen, & Kumral, 2007). It is produced by mixing cereal flour, yogurt, baker's yeast (*Saccharomyces cerevisiae*), vegetables (tomatoes, onions, green peppers and red peppers), salt and spices (mint, thyme, dill, tarhana herb, *etc.*), followed by fermentation for 1–7 days (Ibanoglu, Ibanoglu, & Ainsworth, 1999). At the end of this period, the fermented dough is usually sun dried at a domestic level or oven dried at an industrial level and ground to fine particle dimensions (<1 mm) (Kose & Çagindi, 2002; Tarakci, Dogan, & Koca, 2004). The low moisture content (6–9%) and pH (3.8–4.4) make tarhana a poor medium for pathogens and spoilage organisms; tarhana is not hygroscopic and it can be stored for 2–3 years without any signs of deterioration (Ibanoglu et al., 1999). It is generally consumed as soup at lunch and dinner (Ozdemir et al., 2007).

Regional diversity of the amount and the type of ingredients, as well as the processing techniques in Turkey, affects chemical composition, nutritional content and sensory attributes of tarhana (Degirmencioglu, Gocmen, Dagdelen, & Dagdelen, 2005; Tarakci et al., 2004). Basically, 4 different types of tarhana have been defined by the Turkish Standardization Institute: (a) flour tarhana, (b) goce tarhana, (c) semolina tarhana, and (d) mixed tarhana. Using wheat flour, chopped wheat and semolina separately or as combinations in the recipe causes some differences (Daglioglu, 2000). Cereal and legume flours other than wheat flour (rye, maize, barley, soybean, and chickpea) can also be used in the production of tarhana (Ozdemir et al., 2007).

Some researchers fortified, supplemented or replaced wheat flour and/or yoghurt in tarhana by adding other cereals, legumes, wheat germ, or wheat bran to raise the biological value of tarhana and tarhana-like products (Ozdemir et al., 2007). The nutritional value of wheat germ protein is comparable to animal proteins and wheat germ is a very good source of free sugars and mineral content when compared with wheat flour. Wheat bran can also be used in food products due to its high fibre content and antioxidant properties. Wheat germ and wheat bran were successfully included into tarhana formulation in a study by Bilgicli et al. (2006). The wheat germ/bran addition increased pH values, the crude protein, minerals and total phenolic compounds of the samples. Ibanoglu, Ainsworth, Wilson, and Hayes (1995) produced tarhana using either whole meal wheat flour or white wheat flour and changed level of salt and yoghurt. An increase in the protein and vitamin content of tarhana was observed with the replacement of white wheat flour with whole meal flour. They reported that overall acceptability of tarhana sample with whole meal wheat flour was scored lower, but its score for mouthfeel was found to be the highest. No significant difference was found in the overall acceptability between standard tarhana and tarhana with increased yoghurt. Erkan, Celik, Bilgi, and Koksel (2006) used barley flour in tarhana production in order to produce a new food product with relatively high β-glucan content. β-glucan is known to have cholesterol lowering effect, regulate blood glucose level

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and have insulin response in diabetics and even reduce the risk of cancer. The level of β-glucan in tarhana samples was lower than that of barley flours due to the decrease in β-glucan content during fermentation. Utilisation of barley flour in tarhana production resulted in acceptable soup properties in terms of most of the sensory properties. Slightly lower values in colour and taste could be compensated by the health benefits of barley products.

The established health-beneficial properties of oats have led to an increase in the consumption of oats and oat-based food products in recent years (Ryan, Thondre, & Henry, 2011). *β*-Glucan and phenolic compounds have recently greatly increased interest in oats as a human food (Gray et al., 2000; Liu, Zubik, Collins, Marko, & Meydari, 2004; Malkki, Myllymaki, Teinila, & Koponen, 2004; McMullen, 2000; Peterson, Emmons, & Hinns, 2001). The most important of oats' bioactive compounds are phenolic compounds. Some oat phenolics have huge potential as nutraceuticals, while some are powerful antioxidants. Before the commercialisation of synthetic antioxidants, SCO was used as antioxidant to extend the shelf life of milk powder, butter, ice cream and some cereal products for many years. The antioxidant potential of oats have been recognised for many years (Webster, 2002). In addition to having nutritional and antioxidant properties, phenolic compounds influence multiple sensorial food properties, such as flavour, astringency, and colour. Phenolic compounds contribute to the aroma and taste of numerous food products of plant origin (Rodriguez et al., 2009).

The aim of this research is to determine the effects of steel-cut oats on the antioxidant capacity, phenolic acid composition, phenolic compounds and mineral contents of tarhana.

2. Materials and methods

2.1. Materials

To produce tarhana, wheat flour (*Triticum aestivum*) (Type 650), salt (NaCl), yoghurt, dried onion, tomato and paprika pastes were purchased from local markets in Bursa, Turkey. Stabilised oat meal (inactivated fat hydrolysing enzymes) was obtained from Eti Food Co., Ltd. (Bozuyuk, Bilecik, Turkey). Steel-cut oats (SCO) were obtained from Eti Food Co., Ltd. (Bozuyuk, Bilecik, Turkey). These were whole oat grain that had been cut into small pieces. The SCO were kept in refrigerator prior to analyses or until analysed.

2.2. Methods

2.2.1. Production of tarhana

To prepare tarhana samples, flour (100%), yogurt 50% (w/w, flour base), dried onion 2.5% (w/w, flour base), tomato paste 2.5% (w/w, flour base), paprika paste 7.5% (w/w, flour base) and salt (NaCl) 7.5% (w/w, flour base) were used. Steel-cut oats (SCO) were used to replace wheat flour at the levels of 10%, 20%, 30% and 40% (w/w). Control samples included no SCO. The ingredients were mixed in a mixer (Electrolux Ditomix 5, GA, USA) for 5 min and dough samples were fermented at 30 °C in a fermentation cabinet (Efe Co. Ltd., İzmir/Turkey) for 3 days. The fermented dough samples were dried at 50 ± 2 °C in an air-convection oven (Efe Co. Ltd., İzmir/Turkey) to 9–10% moisture content. After drying, tarhana samples were ground into a rough powder by a hammer mill equipped with a 1-mm opening screen. The resulting powders were stored in a glass jar (0.5 L) in the refrigerator until analysed.

2.2.2. Determination of minerals

All solutions were prepared with analytical reagent grade chemicals and ultra-pure water (18 MΩ cm resistivity) generated by purifying distilled water with the TKA Ultra Pacific and Genpura water purification system (Germany). Suprapur HNO_3 (67% v/v) was purchased from Merck (Darmstadt, Germany). Standard stock solutions containing 1000 mg L^{-1} of each element (K, Ca, P, Mg, Fe, Cu, Zn and Mn) were purchased from Merck (Darmstadt, Germany) and used to prepare calibration standards. Working standards were prepared daily in 0.3% (v/v) HNO_3 and used without further purification. 1000 mg L^{-1} standard stock solutions (Merck, Darmstadt, Germany) were prepared in 0.3% HNO_3 for internal standard solution. Argon (99.9995% pure, Linde, Turkey) was used as carrier gas.

Sample digestion was carried out using the Millestone MLS 1200 (Italy) microwave digestion system. The samples were homogenised and subsequently around 0.5 g of them were weighed directly on PTFE flasks after adding 6 mL of HNO_3 and subjected to a digestion program: 250 W (2 min), 0 W (2 min), 250 W (6 min), 400 W (5 min) and 600 W (5 min). After cooling at room temperature, sample solutions were quantitatively transferred into 50 mL polyethylene flasks. 100 μL of internal standard solution (1 mg L^{-1}) was added and then the digested samples were diluted to 25 mL before analysis by ICP-OES.

The mineral content of the tarhana samples (K, Ca, P, Mg, Fe, Cu, Zn and Mn) were measured using the microwave (Millestone MLS 1200, Italy) nitric acid digestion procedure according to the method described by Sahan, Basoglu, and Gucer (2007) followed by induction coupled plasma optical emission spectrometry (Perkin Elmer 2100 ICP-OES). The emission intensities were obtained for the most sensitive lines free of spectral interference. The analyses were performed at the following flow rates: (a) plasma gas of 15 L min^{-1}, (b) auxiliary gas of 1L min^{-1}, and (c) sample of 0.8 mL min^{-1}. The mineral eluates were monitored at different wavelengths: 317.9 nm-Ca, 214.9 nm-P, 285.2 nm-Mg, 766.5 nm-K, 206.2 nm-Zn, 238.2 nm-Fe, 327.4 nm-Cu and 257.6 nm-Mn. All chemical analyses were carried out in duplicate on each sample.

2.2.3. Extraction of free phenolic compounds

Free phenolic compounds were extracted according to Vitali, Vedrina Dragojevic, and Šebecic (2009) with some modifications. Samples (10.0 g dry weight-dw) were defatted two times with 20 mL of hexane at 30 °C by an ultrasonic homogeniser (Scientz-IID, Ningbo Scientz Biotechnology Co., Ltd., Zhejiang, China). The defatted samples (2.0 g dry weight-dw) were mixed with 20 mL of HCl conc/methanol/water (1:80:10, v/v) mixture and shaken with a laboratory rotary shaker (JB50-D; Shanghai Shengke Instruments, Shanghai, China) at 250 rpm for 2 h at 20 °C, and then the mixtures were centrifuged at 3500 rpm for 10 min at 4 °C in a centrifuge (Eppendorf 5417R, Germany). The supernatants (*free/extractable phenolic compounds*) obtained after centrifugation were stored at −20 °C until used.

2.2.4. Extraction of bound phenolic compounds

Bound phenolic compounds were extracted according to Vitali et al. (2009) with some modifications. After free phenolic extraction, the residues were combined with 20 mL of methanol/H_2SO_4 conc (10:1) mixtures and placed in water bath at 85 °C for 20 h and then cooled at room temperature. The mixtures were centrifuged at 3500 rpm for 10 min at 4 °C in a centrifuge (Eppendorf 5417R, Germany). The supernatants (*bound/hydrolysable phenolic compounds*) were stored at −20 °C until used.

2.2.5. Determination of phenolic content

Phenolic contents (*free, bound and total phenolics*) were determined based on the Folin–Ciocalteu colorimetric method as described by Xu et al. (2009) with some modifications. Briefly, an aliquot (0.5 mL) of appropriately diluted extracts, 2.5 mL of deionised water and 0.5 mL of 1.0 M Folin–Ciocalteu reagent, were mixed within 10 mL volumetric flasks and vortexed for 10 min at room temperature. After 30 min, 1.5 mL of 7.5% sodium carbonate

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