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FULL LENGTH ARTICLE

Effect of toasting on physical, functional and antioxidant properties of flour from oat (*Avena sativa* L.) cultivars

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Abstract Oat cultivars were toasted and studied for their physical properties (1000 kernel weight, bulk density, and *l*/*b* ratio). Both the control and toasted samples were milled into flour and studied for their functional (water absorption capacity, WAC; oil absorption capacity, OAC), color (L^*, a^*, b^* values), and antioxidant (total phenolic content, TPC; antioxidant activity, AOA; metal chelating activity, MCA; and total flavonoids content, TFC) properties. Toasting resulted in significant ($p < 0.05$) decrease in physical parameters, hunter L^* value, and TFC. However, it resulted in increase in WAC, OAC, hunter a^* and b^* values, TPC, AOA and metal chelating values. Toasting increased TPC, AOA, and MCA by 11.5–27.1%, 29.1–53.6%, 33.9–74.4%, respectively and decreased TFC by 23–40.1%. Pearson correlation coefficients (r) were also calculated to study the relationships among various properties studied. AOA exhibited a positive correlation ($r = 0.931$, $p < 0.05$) with TPC which upon toasting showed a decrease ($r = 0.851$, $p < 0.05$). TPC, AOA, MCA, and TFC of control oat cultivars varied from 1744 to 2687 μg GAE/g, 11.9% to 15.3%, 28.4% to 46.2%, and 433 to 612 μg CE/g, respectively.

1. Introduction

Oat (*Avena sativa* L.) ranks sixth in world production and almost 96,08,318 hectares of land are under oat cultivation with total production of 21.06 Million tonnes (FAO, 2012). Carbohydrate, predominantly starch (~60 g/100 g), and soluble fiber (β-glucan), which ranges from 1.8 to 7.5 g/100 g are the major components in oat groats (Bhatty, 1992). Oats being a good source of soluble dietary fiber β-glucan and unsaturated fatty acids, also contain bioactive phytochemicals such as vitamins, phenolic acids, and avenanthramides (Welch,

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2011). β-glucan is found effective in reducing serum cholesterol concentration and postprandial blood glucose level (Tiwari and Cummins, 2009) and has good water binding and emulsion stabilizing properties, thus it has been used in different food products to improve the textural and rheological properties (Lazaridou and Biliaderis, 2007).

Thermal processing is the most extensively used method applied to cereals for improving their texture, palatability and nutritive value by gelatinization of starch, denaturation of proteins, increased nutrient availability, inactivation of heat labile toxic compounds and other enzyme inhibitors (Bakr and Gowish, 1991). Toasting is a rapid processing method that uses dry heat for short periods of time. In India, toasted and roasted cereals are consumed in the form of "sattu" which is a good source of natural fiber and carbohydrate. The toasted grain exhibits improved texture, enhanced crispiness and volume due to puffing and improves the digestibility, color, flavor, shelf life and reduces the antinutrient factors of cereals. Ovando-Martinez et al. (2013) found that oat grains kilned at 88–115 °C for 90–120 min gave more intense flavor to the oat product and denatures approximately 60–80% of lipase in the grain. As toasted grains have numerous health benefits and they improve product quality, the present investigation thus aimed to study the effect of toasting on functional, color, and antioxidant properties of flours from different oat cultivars grown in India.

2. Materials and methods

2.1. Procurement of oat samples

Five commonly grown hulled oat cultivars (cv.) namely OS-6, OS-7, OS-346, HF0-114 and Kent were collected from Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India. The grains from these cultivars were cleaned and stored in a refrigerator till further evaluation.

2.2. Reagents

Standard gallic acid, 2,2-diphenyl-1-picrylhydrazyl (DPPH), ferrozine, Folin–Ciocalteu's, ABTS and catechin were purchased from Sigma–Aldrich (Steinheim, Germany). All chemicals were of analytical grade.

2.3. Toasting, dehusking and milling of oats

Toasting of oat cultivars was done by following the method of Fares and Menga (2012). Oat cultivars (200 g each) were conditioned to moisture content of 10% to maintain uniformity during toasting process and then toasted at 115 ± 2 °C for 3 h in an oven. Both the control and toasted grains were placed in the polishing chamber and the polisher was run till the husk was completely removed from the grain. Oat flour was prepared by grinding dehusked oat in a super mill and flour thus obtained was sieved through 250 mm sieve.

2.4. Physical properties of oat cultivars

Physical properties of oat cultivars were measured by following the method of Sandhu et al. (2007). Oat grains were randomly selected and 1000 kernels of grains were counted. The counted grains were then weighed and expressed in grams. All the measurements were triplicated. For measuring the bulk density, grains were gently filled in a 100 ml graduated cylinder, previously tared. The bottom of the cylinder was gently tapped on a laboratory bench, several times, until there was no further diminution of the sample level after filling to the 100 ml mark. Bulk density was calculated as weight of sample per unit volume of sample (g/100 ml). All the measurements were triplicated. l/b ratio was calculated using vernier caliper. The puffing index was calculated by dividing the bulk density of control with bulk density of toasted samples.

2.5. Proximate analysis

Oat flour from different cultivars was tested for moisture, ash, fat, fiber and protein contents, by employing the standard methods of analysis (AOAC, 1990). The carbohydrate content was calculated by difference. All the results were recorded on a dry weight basis (dwb).

2.6. Water and oil absorption capacity

Water absorption capacity of flours was measured by the centrifugation method described by Sosulski (1962). For determination of fat absorption capacity the method of Lin et al. (1974) was followed.

2.7. Foaming capacity and foaming stability

The foaming capacity and stability were determined by following the homogenization method described by Lin et al. (1974).

2.8. Emulsion activity and stability

Emulsifying properties were determined by following the homogenization method described by Naczk et al. (1985).

2.9. Color characteristics of oat flour

Color measurement of flour was carried out using a Hunter Colorimeter fitted with optical sensor (Hunter Associates Laboratory Inc. Restan VA., USA) on the basis of L^*, a^*, b^* color system.

2.10. Total phenolic content (TPC)

The total phenolic content was determined by following the Folin–Ciocalteu spectrophotometric method described by Gao et al. (2002). Oat flour samples (200 mg) were extracted with 4 ml acidified methanol (HCl/methanol/water, 1:80:10, v/v/v) at room temperature (25 °C) for 2 h using wrist action shaker (Narang Scientific, Delhi, India). The mixture was centrifuged at 3000 rpm for 10 min on a centrifuge. The supernatant was used for determination of total phenolic content. Aliquot of extract (200 µl) was added to 1.5 ml freshly diluted (20-fold) Folin–Ciocalteu reagent. The mixture was allowed to equilibrate for 5 min and then mixed with 1.5 ml of sodium carbonate solution (60 g/l). After incubation at room temperature (25 °C) for 90 min, the absorbance of the mixture was

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