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Effect of sand roasting on beta glucan extractability, physicochemical and antioxidant properties of oats

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ABSTRACT

The antioxidant properties, damaged starch, beta glucan extractability and physicochemical properties of ten different oat cultivars were studied after sand roasting at 280 °C for 15 s. The groat content within the cultivars varied from 6.59 to 7.76 g/10 g oats. Roasting lowered the length/breadth ratio and bulk density and resulted in puffing of the groats. Color characteristics a^* indicating redness and b^* indicating yellowness and nonenzymatic browning index significantly ($p < 0.05$) increased upon roasting. The total phenolic (μg FAE/g) and flavonoid content (μg/g) decreased significantly by 11.4–50.2% and 22.7–49.9%, respectively. An increase in reducing power (μmol AAE/g) ranging from 1.1 to 37.6% and metal chelating activity ranging from 13.2 to 180.2% was observed in the roasted groats. The DPPH radical scavenging activity in the roasted groats increased by 4.6–73.0%. The peak viscosity of the roasted groat flour decreased by 9.1–51.1% while the final viscosity decreased by 15.4–57.5%. The damaged starch content in the groats increased after roasting and the increase ranged from 72 to 82%. Roasting significantly increased the extractable beta glucan content in the groats by 9.8–61.1%. It was concluded that roasting significantly affects the physicochemical and pasting behavior of groats and increases the availability of phytochemicals like beta glucan and the total antioxidant activity.

1. Introduction

Within cereals, oats (*Avena sativa*) rank sixth in world production and in India almost 1.0 lakh hectares of land is under oat cultivation as a fodder crop with an average yield of 42 tons/hectare (ICAR, 2006). It is mainly grown as a fodder crop for feeding farm animals. However today oats are receiving increased interest because of their excellent health related properties. They are a rich source of soluble fiber, balanced proteins, vitamins and minerals, which are essential for human health (Brindzova et al., 2008).

When used as a human food they are rolled or crushed into oatmeal and eaten as porridge or ground into oat flour and used in baked goods and baby foods. Oats have been labeled as a functional food as they contain β-glucan, minerals and antioxidants. β-glucan has been reported to be effective in reducing serum cholesterol concentration and postprandial blood glucose level (Tiwari & Cummins, 2009). β-glucan also 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 & Biliaderis, 2007). Phenolic compounds are important phytochemicals in oats and function as free radical scavengers and are involved in reducing the risk of atherosclerosis, prevent some forms of cancer and coronary heart disease (Emmons & Peterson, 1999).

Sand roasting is a traditional method of grain processing in India. A variety of whole grains like black gram, barley, rice, corn, groundnuts etc are roasted in hot sand at temperatures varying from 250 to 350 °C to produce ready to eat snack food (Sharma & Gujral, 2011; Sharma, Gujral, & Rosell, 2011). Flour made from roasted grain popularly referred to as *Sattu,* is widely consumed as a health food. Subjecting oats to a high temperature is an important step in its processing as heating produces a characteristic flavor by maillard browning and also terminates the activity of lipolytic enzymes (Klensporf & Jelen, 2008). The objectives of the present investigation were to study the physicochemical changes occurring in the oats upon roasting in hot sand. The extent of damaged starch produced, changes in pasting behavior, β-glucan extractability and antioxidant properties were also studied.

2. Materials and methods

2.1. Oats samples

Ten commonly grown hulled oat cultivars namely OL-1682, OL-1683, OL-1684, OL-125, OL-1528, IOM-6, Kent, OS-342, OL-9

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and OL-1678 were collected from Punjab Agricultural University, Ludhiana, Punjab, India. The grain was cleaned and stored in PET jars at 4 °C in a refrigerator for further evaluation.

2.2. Reagents

Standard ferulic acid, 2,2-diphenyl-1-picrylhydrazyl (DPPH), ferrozine and catechin were procured from Sigma–Aldrich (Steinheim, Germany). L-ascorbic acid, potassium ferricyanide, ferric chloride, ferrous chloride, trichloroacetic acid, sodium carbonate and Folin-Ciocalteu's reagent were procured from Loba Chemie, Mumbai, India. All chemicals were of analytical grade.

2.3. Roasting of oats

The sand roasting treatments were carefully optimized in such a way that it resulted in grain with maximum expansion and no burning. Different oat cultivars (200 g each) conditioned to a moisture content of 10% so as to eliminate the effect of differences in moisture content on roasting behavior were roasted at 280 ± 5 °C for 15 s in a traditional sand roaster as described by Sharma and Gujral (2011) and Sharma et al. (2011).

The dehulling of the control and roasted oats was carried out in a laboratory impact huller (Lab Impact 1, Creative India, Mohali, Punjab). The hulls and groats were separated manually and weighed. 10 g of oats were dehulled manually and the groat content was reported as weight of groats divided by the weight of oats. For converting groats into flour the groats were ground in a Super Mill 1500 (Newport Scientific, Australia) and passed through 60 (BSS) sieve. Any fraction retained on the sieve was reground till all of it passed through the sieve so as to obtain a flour of 100% extraction.

2.4. Physical properties of oat samples

The bulk density was evaluated by measuring the weight of known volume of control and roasted groats. Sample were poured into a graduated cylinder, gently tapped ten times and filled to 250 ml. Results were expressed as g/ml. Length/breadth ratio was reported by measuring length and breadth of ten kernels. The puffing index was calculated by dividing the bulk density of control groats with bulk density of roasted groats.

2.5. Hardness of groats

The hardness was determined on a Texture Analyzer (Model TA-HD$_i$ Stable Microsystems, Surrey, U.K). The force required to compress the groats by 1 mm was reported in Newtons. The cylindrical probe used had a diameter of 25 mm, a 50 kg load cell was used and the pre, post test and test speed was 1.5, 10 and 1 mm s^{-1}, respectively.

2.6. Color characteristics of flour

Color measurements were carried using a Hunter Colorimeter fitted with an optical sensor (Hunter Associates Laboratory Inc. Restan VA., USA) on the basis of CIE L^*, a^*, b^* color system. The color difference (ΔE) was calculated by applying the following equation:

$$\Delta E = [(\Delta L^*) + (\Delta a^*) + (\Delta b^*)]^{1/2}$$

2.7. Water absorption capacity and water solubility index

Water absorption capacity and solubility index of flour was measured by the centrifugation method of Anderson, Conway, Pfeifer, and Griffin (1969). The results were reported as g/100 g of oat flour.

2.8. Pasting properties

Pasting properties of flours were studied using a Rapid Visco Analyzer (Newport Scientific Pty Ltd., Australia) using the Standard profile 1 with flour (3 g on 14% moisture basis) and 25 ml water (Sharma & Gujral, 2010a). The peak viscosity, breakdown viscosity, final viscosity, setback viscosity, peak time and pasting temperature were reported.

2.9. Damaged starch content

Damaged starch was measured enzymatically using the 'Starch Damage Assay Kit' (Megazyme International Ireland Ltd., Wicklow, Ireland). The results were reported as g/100 g oat flour.

2.10. Extractable β-glucan

Extraction of β-glucan was carried out as reported by Temelli (1997). Whole oat flour (50 g on dry weight basis) was extracted in water, pH lowered to remove proteins and β-glucan precipitated by ethanol, air dried to a constant weight and reported as extractable β-glucan.

2.11. Total phenolic content (TPC)

The total phenolic content was determined according the Folin-Ciocalteu spectrophotometric method explained by Sharma and Gujral (2010b). Acidified methanol was used as a blank. The results were expressed as μg of ferulic acid equivalents per gram of flour.

2.12. Antioxidant activity (AOA)

Antioxidant activity was measured using a modified version of the method explained by Brand-Williams, Cuvelier, and Berset (1995). This involved the use of free radical 2,2-diphenyl-1-picrylhydrazyl (DPPH) solution. Absorbance (A) at 515 nm was read at 0 and 30 min using a methanol blank. Antioxidant activity was calculated as % discoloration.

$$\%\,\text{Antioxidant activity} = (1 - (\text{A of sample}_{t=30}/\text{A of control}_{t=0})) \times 100$$

2.13. Reducing power

Oat flour (0.5 g) was extracted with 70% methanol and the supernatant was mixed with phosphate buffer and potassium ferricyanide followed by involving trichloroacetic acid solution and ferric chloride and absorbance measured at 700 nm as described by Zhao et al. (2008) and Sharma and Gujral (2011). A standard curve was prepared using various concentration of ascorbic acid equivalents/g of flour.

2.14. Metal chelating (Fe^{+2}) activity

The metal chelating activity of oat extract was measured as reported by Dinis, Madeira, and Almeidam (1994) and Sharma and Gujral (2011). The chelating activity of the extract for Fe^{+2} was calculated as follows: