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Effect of infrared and microwave radiations on properties of Indian Horse Chestnut starch

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ABSTRACT

Starch extracted from Indian Horse Chestnut (IHCN) was subjected to infrared and microwave radiations for different time intervals (15 s, 30 s, & 45 s) at constant dose. The structural change of MW and IR radiated IHCN starches were determined by Fourier transform-infra red spectroscopy. The increased peak intensity at 3240 cm^{-1} of treated starch represents more exposure of hydroxyl groups due to radiation. Granule morphology of native starch showed round and elliptical granules with smooth surfaces. However radiation treatment resulted in the development of surface cracks. Effect of radiation on physicochemical properties of starch revealed increase in water absorption capacity and light transmittance and decrease in apparent amylose content, pH, and syneresis. The peak, trough, final, and setback viscosities were significantly reduced with increase in treatment time. Radiated starches displayed significantly lower values of T_o, T_p, and ΔH_{gel} than native starch. Further antioxidant activities were evaluated by DPPH and FRAP assays. Results showed significant improvement in antioxidant activity of starch by both MW and IR treatments.

1. Introduction

Indian Horse chestnut (IHCN) (*Aesculus indica Hook)* is distributed widely in the Himalayas region ranging Kashmir to west Nepal (900–3600 m). IHCN seeds are used as food, feed, and fodder and for production of alcohol. The edible portion of fruit contain 50.5% moisture, 5.85% sugars, 0.39% protein,1.93% ash [1] and about 38.3% starch on dry weight basis. Seeds possess therapeutic importance, e.g., in the treatment of fevers, for use in curing piles, wound healing, anti-inflammatory, antiviral, rheumatism, skin diseases and cardiovascular diseases [2,3]. The seed also contains number of flavonoids such as derivatives of Quercetin and Kaempferol, and is said to have powerful antioxidant properties than vitamin E [4]. Natural polysaccharide starches are renewable resource, inexpensive and widely available [5], but its low functionality (Shear resistance, thermal resistance, thermal decomposition and high tendency toward retrogradation) limits its industrial application [6].

In order to overcome the flaws and to produce various novel derivatives with improvised physicochemical properties along with useful structural attributes, irradiation treatments to biological macromolecules like starch are employed and studied to have beneficial effects. These techniques are simple, requires minimal sample preparation, do not induce significant increase in temperature and have no dependence on any type of catalysts besides its eco-friendly nature [7,8]. Among different radiation treatments used for modifying starch, microwaves (energy source) have gained tremendous interest as the generation power (heat) is high within short period of time consequently causing radical improvement in reaction rate and product yield [9,10]. Microwave fragments large molecules by cleaving the glycosidic linkages and there is possible generation of free radicals which are capable of hydrolyzing chemical bonds thereby producing smaller fragments of starch [11]. Infrared irradiation (IR) on the other hand is also an efficient food processing technology that employs short time and high temperature to treat cereals or legumes before their final applications in human food or animal feed. As a nondestructive and convenient tool, infrared has been widely shown to be a promising technique for food safety inspection and control due to its huge advantages of rapidity, ease of use, and minimal sample preparation. Although some literature is available on microwave and infrared radiations of starch but no reports were found on the effect of radiations on the structure and antioxidant activity of IHCN starch. Thus the present study was designed to evaluate the time dependent effects

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of microwave (MW) and infrared (IR) radiations on functional, structural and antioxidant properties of starch characteristics.

2. Materials and methods

2.1. Materials

The seeds of Indian Horse Chestnut (IHCN) were harvested from the trees of botanical garden, Department of Botany, University of Kashmir, Hazratbal, Srinagar, India 190006 during the month of November, 2014. Seeds were dehulled and stored at refrigeration temperature until further use. All the reagents used in the study were of analytical grade.

2.2. Starch isolation

Alkali steeping method was used for isolation of starch [1]. Seeds were manually deshelled and the cotyledons were chopped into small pieces. The pieces were pulverized along with water for 5 min in a domestic mixer blender. The slurry obtained was then diluted to ten times (volume/volume) with distilled water, and the pH was adjusted to 9 using 0.5 M NaOH. The slurry was continuously mixed using magnetic stirrer for 1 h and then filtered through a 75 mm-mesh sieve to separate the fiber. The filtered slurry was then centrifuged at 3000 × *g* for 30 min at 10 °C (5810R, Eppendroff, Hamburg, Germany). The aqueous phase obtained on centrifugation was discarded, whereas the sediment obtained was scraped off from the surface and the lower white portion was washed three times with double distilled water and recovered as starch. The starch was dried at 40 °C in a hot air oven.

2.3. Starch Irradiation

The IHCN (30 g) were tempered to 22 ± 3% moisture content before treatment. Samples were subjected to infrared and microwave radiations for different time periods (15, 30, and 45 s). The sample was ground and packed in low-density polyethylene air locked pouches and stored at −18 °C.

2.4. Physicochemical properties

2.4.1. Composition

The moisture was estimated using a moisture analyzer (Model 61 MA 100, Sartorius, Goettingen, Germany). Protein, ash, and lipid contents of the starches were determined according to the AACC methods [12].

2.4.2. Color

Color of the starch was determined by Color Flex Spectro colorimeter (Hunter Lab Colorimeter D-25, Hunter Associates Laboratory, Ruston, USA).

2.4.3. Apparent amylose content

Apparent amylose contents of the starch samples were determined by the method of Williams et al. [13]. Starch sample (20 mg) was mixed with, 10 mL of 0.5 M KOH. The dispersed was thoroughly mixed and transferred to a 100 mL volumetric flask and the volume was made up to the mark with distilled water. An aliquot of the test starch solution (10 mL) was pipetted into a 50 mL volumetric flask and 5 mL of 0.1 M aqueous HCl was added followed by 0.5 mL of iodine reagent. The volume was diluted to 50 mL and allowed to stand for 5 min. The absorbance was measured at 625 nm (UV Spectrophotometer, U-2900, Hitachi, Tokyo, Japan). The content of amylose was determined from a standard curve.

2.4.4. Determination of pH

The pH of starch slurry (10% w/v) was determined using a digital pH meter calibrated at 25 °C as described by Gani et al. [14].

2.4.5. Determination of water absorption capacity

Water absorption capacity of the starches was determined as described by Gani et al. [15] with certain modifications. 1 g of sample was weighed into a 25 mL graduated pre-weighed centrifuge tubes and 10 mL of water was added then. The suspensions were allowed to stand at room temperature (30 ± 2 °C) for 1 h with intermittent shaking. The suspension was centrifuged at 1500 × *g* for 30 min. The supernatant was decanted and then the sample was reweighed. The change in weight was expressed as percent water absorption based on the original sample weight.

2.4.6. Swelling power and solubility determination

Swelling power and solubility of IHCN starch were determined by heating starch water slurry (0.35 g starch in 12.5 mL of distilled water) in a water bath at 60 °C for 30 min, with constant stirring. The slurries were centrifuged at 168 × *g* for 15 min, the supernatant was decanted into a pre-weighed evaporating dish and dried at 100 °C for 20 min. The difference in weight of the evaporating dish was used to calculate starch solubility. Swelling power was obtained by weighing the residue after centrifugation and dividing by original weight of starch on dry weight basis [16].

2.4.7. Light transmittance %

Light transmittance of starch gels was determined according to the method of Ashwar et al. [5]. An aqueous starch suspension (1% db) was prepared by heating at 90 °C in a water bath for 30 min with constant stirring at 75 rpm. The suspension was cooled for 1 h at 30 °C. The samples were stored for 5 days at 4 °C in a refrigerator, and transmittance was determined every 24 h at 640 nm.

2.4.8. Syneresis

Syneresis was determined by the method of Akhter et al. [17]. Starch suspensions (6%, w/w db) were heated at 90 °C for 30 min in a water bath with constant stirring at 75 rpm. The starch sample was stored for 0, 24, 48, 72, 96, and 120 h at 4 °C in separate tubes for each day. Syneresis was measured as % amount of water released after centrifugation at 3000 × *g* for 10 min.

2.4.9. Freeze thaw stability

Aqueous starch slurry (6%, w/v db) was heated in a water bath at a temperature of 90 °C, for 30 min. The gels were subject to cold storage at 4 °C for 6 and then frozen at ±16 °C. Five cycles of freeze thaw were performed. To measure freeze thaw stability, the gels frozen at ±16 °C for 24 h, were thawed at 25 °C for 6 h and then refrozen at ±16 °C. The tubes were centrifuged at 1000 × *g* for 20 min at 10 °C and the released water was measured as freeze thaw stability [18].

2.5. Pasting properties

The pasting properties of the starches were measured using a Rapid Visco Analyzer (Tech Master, Pertain Instruments Warriewood, Australia). An aqueous dispersion of starch 14% moisture basis (10.7%, w/w; 28 g total weight) was equilibrated at 50 °C for 1 min, heated at the rate of 12.2 °C/min to 95 °C, held for 2.5 min, cooled to 50 °C at the rate of 11.8 °C/min and again held at 50 °C for 2 min. A constant paddle rotational speed (160 rpm) was used throughout the entire analysis, except for rapid stirring at 960 rpm for the first 10 s to disperse the sample.