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Cultivar difference in physicochemical properties of starches and flours from temperate rice of Indian Himalayas

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ABSTRACT

Starch and flour of seven temperate rice cultivars grown in Himalayan region were evaluated for composition, granule structure, crystallinity, Raman spectrometry, turbidity, swelling power, solubility, pasting properties and textural properties. The rice cultivars showed medium to high amylose content for starch (24.69–32.76%) and flour (17.78–24.86%). SKAU-382 showed the highest amount of amylose (32.76%). Rice starch showed polyhedral granule shapes and differences in their mean granule size (2.3–6.5 μm) were noted among the samples. The starch and flour samples showed type A-pattern with strong reflection at 15, 18, and 23. Pasting profile and textural analysis of rice starch and flour showed that all the cultivars differences, probably due to variation in amylose content. The present study can be used for identifying differences between rice genotypes for starch and flour quality and could provide guidance to possible industries for their end use.

1. Introduction

Rice (*Oryza sativa* L.) is the most important cereal crop and staple food of over approximately one-half of the world's population. In Asia, more than 2000 million people obtain their 60–70% calories from rice and its products (Lin, Singh, Chang, & Chang, 2011). Diversity in rice, largely affects their physical, chemical and cooking properties of a particular cultivar (Mir, Bosco, & Sunooj, 2013; Wani et al., 2012). Physico-chemical properties of rice flour and starch depend mostly on the variety, genetic background, climatic and soil conditions during the rice grain development (Falade, Semon, Fadairo, Oladunjoye, & Orou, 2014; Wu et al., 2013).

Starch is the major component of rice grain and an important energy source for human nutrition, mainly determines the acceptability of the rice cultivar in terms of physicochemical and cooking properties. Diversification of rice cultivars has an impact on different properties of rice starches as reported by several researchers (Lee & Osman, 1991; Wang et al., 2012). Although a great number of native starches with different functionalities are available in the market, increasing demand for specific starch properties requires new strategies or, alternatively, novel sources (Wani et al., 2012). The physico-chemical characteristics of starches are of great importance because of their extensive utilization in the food and non-food industries. The starch has important role in developing food products either as a raw material or as a food additive, such as thickener, texture enhancer or stabilizer (Aina, Falade, Akingbala, & Titus, 2012).

Many factors, including composition, granular size and structure, type of crystal polymorph, amylose/amylopectin ratio, gelatinization, lipid-complexed amylose, and presence of non-carbohydrate content of starch affect the quality of rice flour and its products (Lin et al., 2011; Yu, Ma, Menager, & Sun, 2012; Zhu, Liu, Wilson, Gu, & Shi, 2011). Several techniques have been used to study the properties of rice starches and flours by using different techniques, such as X-ray diffractometry (Yu et al., 2012; Zhu et al., 2011), scanning electronic microscopy (Zhu et al., 2011), Raman spectroscopy (Labanowska, Birczynska, Kurdziel, & Puch, 2013), rapid visco analysis (Puncha-arnon & Uttapap, 2013), and textural profile analysis (Puncha-Arnon & Uttapap, 2013; Yu et al., 2012).

The diverse industrial applications have spurred towards investigating the physico-chemical properties of rice flours and starches from different genotypes. Due to the special agro-climatic conditions in temperate regions of India, Kashmir is endowed with large cultivars of rice germplasm. Therefore, the objective of the present work is to compare the physico-chemical properties of starch and flour from seven different genotypes of temperate rice of Indian Himalayas.

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2. Materials and methods

2.1. Materials

Seven different rice cultivars were used in this study, namely Jehlum, K-332, Khosar, Pusa-3, SKAU-345, SKAU-382 and Shalimar Rice-1 grown in temperate regions of India, were collected from Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, India. The grains were dried and cleaned manually to remove foreign matter. The dried and cleaned paddy samples were dehusked on a Stake Testing Rice Husker (THU-34A, Stake, Japan) to obtain brown rice.

2.2. Flour preparation

Flour was prepared by grinding the rice grains using Mini Grain Mill (A11B, IKA Inc.) and sifting the material through 300 μm sieve and kept in a refrigerator at about 4 °C for further analysis.

2.3. Starch preparation

Starch was isolated according to the method of (Lawal et al., 2011) with some modifications. Rice was steeped with five times the weight of sodium hydroxide solution (0.3%) at 24 °C for 24 h to soften the endosperm. The steep liquor was drained off, then the rice was washed and ground with a blender (Crompton Greaves, CG-BX, Mumbai, India). The slurry was again dispersed in sodium hydroxide solution (0.3%) stirred manually for 20 min and allowed to settle for 6 h and the supernatant was drained off. The sediment was diluted to the original volume with distilled water and the supernatant was drained off after 6 h. The process was repeated until the supernatant was free from NaOH. The starch was suspended in distilled water, passed through 100–200 mesh nylon and repeatedly washed with water. The starch was collected by sedimentation process. Afterwards, the slurry centrifuged at 3000*g* for 10 min., the supernatant and any brown surface layer of the starch were removed while as, the lower white starch layer was washed with deionised water. The slurry was suspended in distilled water, the pH was adjusted to 7.0 with HCl (0.5 M) and passed through nylon screen (53 mm). Afterwards, it was allowed to settle for another 6 h and the clear supernatant was discarded. The starch obtained as sediment was dried in oven at 40 °C.

2.4. Chemical composition

The powdered samples of rice flour and starch were analyzed for protein, fat, and ash content according to AACC (2000) procedures. The amylose content was estimated by the method described by Williams, Kuzina, and Hlynka (1970).

2.5. Scanning electron microscopy

Morphology of the starch samples was analyzed by scanning electronic microscopy (Hitachi, S-3400N, Tokyo, Japan). The samples were mounted on aluminium stubs using double sided adhesive tape to which the samples were fixed and afterwards were coated with a thin layer of gold. An acceleration potential of 15 kV was used during micrography.

2.6. X-ray diffraction and crystallinity

X-ray diffraction analysis was performed using an X-ray diffractometer (Shimadzu XRD 7000) with Cu Kα value of 1.54060 radiation at a speed of 2°/min, diffraction angle of 2θ at 4° and 50° at 40 kV and 30 mA. The total area under the curve and the area under each prominent peak was determined using OriginPro software package and the percentage crystallinity was estimated by using the following formula:

% Crystallinity = (Area under peaks/Total area) × 100.

2.7. Raman spectroscopy

The Raman spectra were recorded with a Raman spectrometer (InVia, Renishaw, Gloucestershire, United Kingdom), working in confocal mode. Dry rice starch and flour samples were placed on an aluminium holder. The samples were excited with 785 nm laser line of HP NIR diode laser Renishaw (UK). The laser power was kept low enough to ensure that it did not damage the sample. Measurements were performed with microscope and spectra were taken from the same spot size of each sample in the range of 1800 to 400 cm^{-1}.

2.8. Swelling power and solubility

Swelling power (SP) and solubility (S) of the rice starch and flour samples were determined according to the methods (Adebooye & Singh, 2008; Li & Yeh, 2001) with slight modification. 500 mg of each flour and starch sample was cooked with 20 ml of water at temperatures of 80 °C for 30 min. Then samples were cooled to room temperature and centrifuged at 2500*g* for 15 min. The supernatant was decanted, and the residue was weighed for swelling power estimation. The supernatant was poured into a glass dish and kept in a boiling water bath for evaporation. Afterwards, the dish was dried at 105 °C and weighed. The solubility and swelling power were calculated as follows:

S = (weight of the dried supernatant/weight of the wet sediment) × 100.

SP = (weight of the wet sediment/weight of sample-weight of the dried supernatant).

2.9. Turbidity

The turbidity of starch and flour samples from different rice cultivars were measured by the method (Sodhi & Singh, 2003) with a slight modification. A 2% aqueous suspension of starch or flour from each rice cultivar was heated in a boiling water bath for 1 h with constant stirring. The suspension was cooled to room temperature, and then stored for 8 days at 4 °C in a refrigerator. Turbidity was determined every 24 h by measuring absorbance at 640 nm against a water blank with a UV–Vis Spectrophotometer (UV-1800, Shimadzu, Japan).

2.10. Pasting properties

Pasting characteristics of rice starch and flour samples was determined using the Rapid Visco Analyzer (Starch master 2, Newport Scientific Pty. Ltd, Warriewood, Australia). Each of 3 g of rice starch and flour sample was weighed in RVA canisters and 25 ml of water was added. The prepared slurry in the canisters was heated to 50 °C and stirred at 160 rpm for 10s to enable the complete dispersion. The slurry was held at 50 °C for 1 min and temperature was raised to 95 °C for 7.5 min. and then held at 95 °C for 5 min. The slurry was cooled at 50 °C for 7.5 min, and then held at 50 °C for 2 min. Pasting parameters including peak viscosity, holding viscosity, final viscosity, breakdown, setback and pasting temperature were recorded.

2.11. Gel textural properties

The textural properties of RVA gels were determined by texture profile analysis (HDP/BS blade of texture analyzer (TA-XT2i Stable