LWT - Food Science and Technology 61 (2015) 152–157

Contents lists available at ScienceDirect

LWT - Food Science and Technology

journal homepage: www.elsevier.com/locate/lwt

Some properties of rice grains, flour and starches: A comparison of organic and conventional modes of farming

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ARTICLE INFO

Article history:
Received 24 January 2014
Received in revised form
17 July 2014
Accepted 3 November 2014
Available online 11 November 2014

Keywords:
Rice
Starch
Organic
Conventional
Pasting

Chemical compounds studied in the article:
Amylose (PubChem CID: 53477771)
Amylopectin (PubChem CID: 439207)
Starch (PubChem CID: 24836924)
Urea (PubChem CID: 20994)
Muriate of potash (PubChem CID: 4873)
Diammonium phosphate (PubChem CID: 24540
Potassium hydroxide (PubChem CID: 14797)
Iodine reagent (PubChem CID: 24542)
Ethanol (PubChem CID: 702)
Hydrochloric acid (PubChem CID: 313)

ABSTRACT

The research focused on comparison of properties of rice grown by organic mode (OM) and conventional mode (CM) of farming. Paddy obtained from both the modes of farming was milled and studied for physicochemical, cooking and textural properties. Both the rice was then powdered to flour and their properties were compared. Starch was then isolated from both types of rice and analyzed for their amylose, swelling power, X-ray diffraction, pasting and morphological properties. Milled rice from OM farming exhibited significantly ($P < 0.05$) higher thousand kernel weight and length/breadth ratio but lower bulk density and protein content in comparison to rice from CM farming. Cooked rice grains from OM farming showed significantly ($P < 0.05$) higher elongation and width expansion ratio and lower gruel solid loss and grain hardness. Starch isolated from milled rice of CM farming showed significantly ($P < 0.05$) lower amylose content, pasting properties but higher swelling power and solubility in comparison to its counterpart OM starch. Both the starches showed typical A-type X-ray diffraction pattern. Scanning electron micrographs of starches from both modes of farming revealed the presence of smooth surfaced granules with polyhedral shape and a very few round shaped granules.

1. Introduction

Rice (*Oryza sativa* L.) is the most important cereal crop and is a staple food for more than half the world population. India ranks second in production of rice in the world with total production of 1579×10^5 tonnes (FAO, 2011). Most industrial countries achieved sustained food surpluses by second half of the 20th century, and eliminated the threat of starvation but the conditions were opposite in developing countries of Asia and Africa. The Green Revolution was introduced in India in 1960's and made the country overcome its food crises. One of the important aspects of Green Revolution was the use of conventional fertilizers to increase the crop production. Fertilizer has become an essential agro-chemical input for modern rice farming and plays a key role in increasing the productivity of rice land (Gunaratne et al., 2011). Although, Green Revolution resulted in many benefits but it has been criticized for causing environmental damage. Excessive and inappropriate use of fertilizers and pesticides has polluted waterways, salt build up in soils, poisoned agricultural workers, and killed beneficial insects and wildlife (International Food Policy Research Institute, 2013). There are indications that the high doses of fertilizers and seed technologies introduced over the past few decades may be reaching a point of diminishing returns (Cassman et al., 1995). Conry (1995) reported that increased rate of fertilizer nitrogen may increase the yield but reduces the quality of the grain.

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http://dx.doi.org/10.1016/j.lwt.2014.11.007
0023-6438/

Organic farming on the other hand, is a system which avoids or largely excludes the use of synthetic inputs such as chemical fertilizers, pesticides, hormones, feed additives etc and to maximum extent rely upon crop rotation, crop residues, animal manures, off farm organic wastes, mineral grade rock additives and biological system of nutrient mobilization and plant protection (Banerjee, 2010). The organic farming today is not traditional agriculture. The principles governing organic farming are more scientific than even the principles followed in modern agriculture (Banerjee, 2010). It should not be overlooked that, with recently increasing food prices, organic farming could meet some economic limits (Mahapatra, Ramasubramanian, & Chowdhury, 2009). Since rice is produced by both organic mode (OM) and conventional mode (CM) of farming, scientific research is required to compare the properties of crop produced by both the modes. Although research has been carried out to investigate the effect of nitrogen fertilizer application on quality of rice grain (Champagne, Bett-Garber, Thomson, & Fitzgerald, 2009; Gunaratne et al., 2011; Hao, Wei, Yang, Feng, & Wu, 2007; Leesawatwong, Jamjod, Kuo, Dell, & Rerkasem, 2005; Perez, Juliano, Liboon, Alcantara, & Cassman, 1996; Xiong, Wang, Gu, Chen, & Zhou, 2008) there is dearth of information on comparison of properties of rice grain grown by organic and conventional modes of farming. The present research was thus undertaken to evaluate and compare the physicochemical, color characteristics, cooking and textural properties of milled rice grown by OM and CM of farming. Starch was also isolated from milled rice produced by OM & CM and compared for their selected functional, pasting and structural characteristics.

2. Materials and methods

2.1. Materials

Basmati rice (variety PUSA BASMATI-1) grown by two different modes of farming was procured from Govind Ballabh Pant University of Agriculture & Technology, Pantnagar (Uttarakhand), India. Geological coordinates of Pantnagar are longitude 79 30 E, latitude 29 N and altitude 243.84 m (above mean sea level). The climate of the area is humid sub-tropical with hot summer and cool winter season with mean annual rainfall of 1500 mm. The crop was grown by organic mode (OM) and conventional mode (CM) of farming during the kharif season of 2009–2010. The experiment was laid out in split plot design replicated thrice. Soil of the experimental plot was silty clay loam with pH 7.3, organic matter 2.132 g/100g, available nitrogen 227 kg/ha, available phosphorus 20.5 kg/ha and available potassium 145 kg/ha. Twenty day old seedlings of rice were transplanted at a spacing of 20 cm × 15 cm. Under OM farming, 100% nutrients were provided through farm yard manure (FYM) @ 20 ton/ha. FYM contained 5–6 kg/ton N, 1.2–2 kg/ton P and 5–6 kg/ton K. Under CM of cultivation, 100 g/100g nutrients were delivered through inorganic fertilizer (i.e. Urea as a source of N, diammonium phosphate as a source of P and muriate of potash as a source of K). The amount of N, P and K in inorganic farming was 120, 60 and 40 kg/ha. Nitrogen as urea was applied in 3 splits (50 g/100g at planting, 25 g/100g at tillering and 25 g/100g at panicle initiation) to rice. Phosphorus @ 60 kg/ha and potassium @ 40 kg/ha were applied as basal dose. Crop was harvested at maturity and grains were stored at 14 g/100g moisture content.

2.2. Dehusking and milling

The paddy samples were dehusked in a McGill sheller (Rapsco, Brookshire, TX, USA). The brown rice samples so obtained were then polished to obtain a 10 g/100g degree of milling in a McGill mill no. 2 (Rapsco, Brookshire, TX, USA). Milled whole rice grains were separated from broken rice grains for the evaluation of physicochemical, cooking and textural properties.

2.3. Milled rice characteristics

2.3.1. Physicochemical and color properties

Rice grains obtained by both the modes of farming were tested for their moisture, ash, fat and protein content by employing the standard methods of analysis (AOAC, 1990). One thousand head rice grains of milled rice from both OM and CM farming were counted randomly in triplicate and weighed separately. Mean of three replications was reported as thousand kernel weight (TKW). Bulk density was calculated as the ratio of milled rice grains to their volume and reported as g/ml. Length-breadth (l/b) ratio was determined as the ratio of length to breadth using digital vernier calipers. A mean of 10 replications was reported. Color parameters (L^*, a^*, b^*) of milled rice kernels and flours from OM and CM were carried out using an ultra scan VIS Hunter Lab (Hunter Associates Laboratory Inc, Reston, VA, USA). A glass cuvette containing rice kernels was placed above the light source, covered with a white plate and L^*, a^*, b^* values recorded. The L^* value indicates the lightness, 0–100 representing dark to light. The a^* value gives the degree of red-green color, with a higher positive value a^* value indicating more red. The b^* value indicating the degree of the yellow–blue color, with a higher positive b^* indicating more yellow.

2.3.2. Cooking properties

Head rice samples were taken in test tubes and cooked in distilled water (1:10) in a boiling water bath. Cooking time (CT) was determined by removing a few grains after 5 min and thereafter 1 min interval during cooking by pressing them between two glass plates until no white core was left. The contents were drained on a Buchner funnel and the total volume of gruel was measured. The gruel was collected in tared petri dishes and evaporated at 110 °C in a hot air oven to a constant weight. The weight of dried material was reported as gruel solid loss (g/100g). For the measurement of water uptake the superficial water on the cooked rice was sucked by pressing the cooked samples between filter paper sheets. The cooked samples were then weighed accurately and the water uptake was calculated as the ratio of weight of cooked grains to the weight of uncooked grains. Cumulative length of 10 cooked rice kernels was divided by length of 10 uncooked raw kernels and the result was reported as elongation ratio. Width expansion ratio was determined by dividing the cumulative breadth of 10 cooked kernels by the breadth of 10 uncooked kernels. Cooked length-breadth ratio was determined as ratio of length and breadth of cooked kernels.

2.3.3. Textural properties

Textural profile analysis (TPA) of cooked rice kernels from OM and CM of farming was performed using a TA-XT plus Texture Analyzer (Stable Micro Systems, Surrey, England). A single cooked grain was placed at the center of platform and subjected to a two-cycle compression force versus time program to compress the samples up to 90 g/100g compression using 5 kg load cell with pre-test and post-test speeds of 1 mm/min and test speed of 0.5 mm/min with an aluminum cylindrical probe of 40 mm diameter (P/40) for compression. Parameters recorded from the test curves were hardness, cohesiveness, springiness, gumminess and chewiness. All textural analyses were replicated five times per sample.