LWT - Food Science and Technology 75 (2017) 386–392

Contents lists available at ScienceDirect

LWT - Food Science and Technology

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

Influence of milling intensity and storage temperature on the quality of Catahoula rice (*Oryza sativa* L.)

Usman Ahmad [a], Luis Alfaro [b], Millicent Yeboah-Awudzi [c], Emmanuel Kyereh [c], Bennett Dzandu [c], Franklin Bonilla [c], Alexander Chouljenko [c], Subramaniam Sathivel [b, c, *]

[a] *Department of Mechanical and Biosystem Engineering, Faculty of Agricultural Engineering and Technology, Bogor Agricultural University (IPB), Bogor, Indonesia*

[b] *Department of Biological and Agricultural Engineering, Louisiana State University Agricultural Center, Baton Rouge, LA, USA*

[c] *School of Nutrition and Food Sciences, Louisiana State University Agricultural Center, Baton Rouge, LA, USA*

ARTICLE INFO

Article history:
Received 1 June 2016
Received in revised form
26 August 2016
Accepted 9 September 2016
Available online 10 September 2016

Keywords:
Rice
Quality parameters
Storage temperature
Cooking
Milling

ABSTRACT

Rice is typically stored in the form of whole kernel (rough rice with husk) to minimize quality changes, although storage of milled rice is more convenient and economically feasible. Expenses associated with low temperature storage of rough rice have prompted the need for alternative processing and storage methods, especially in developing countries. Thus, the effects of temperature (30–60 °C) on quality characteristics of milled Catahoula rice during 31 d of storage were investigated. Additionally, the physicochemical properties and cooking quality of rice milled at different intensities (light, medium, and heavy milling) were analyzed. Storage temperature and milling intensity were found to affect the quality of stored and cooked rice, respectively. Higher levels of rice milling intensity correlated with greater water absorption, easier compression, and faster gelatinization of the cooked kernels. During the storage time, protein contents were consistent, while lipid contents slightly decreased. The milled rice experienced an increase in lightness and decrease in moisture content with increasing storage temperatures. This study revealed that by adjusting rice milling parameters and storage temperature the quality of Catahoula rice can be controlled.

1. Introduction

Rice has become a primary staple food for people in many countries in Asia and it serves as a valuable source of grains in the United States and various European countries. Rice distribution and storage are required to ensure its timely delivery to consumers year round. For rough rice, it has been reported that during storage a range of changes in the physicochemical, pasting, and nutritional properties of rice occur, which affects the rice quality (Chrastil, 1990, 1992; Swamy, Sowbhagya, & Bhattacharya, 1978; Villareal, Resurreccion, Suzuki, & Juliano, 1976; Zhou, Robards, Helliwell, & Blanchard, 2002). To minimize these changes, low temperature and controlled atmosphere storage are usually concluded as the recommended methods. However, low temperature storage is considered expensive due to high initial cost of cooling systems and high energy consumption during its operation, while controlled atmosphere storage needs special packaging and storing facilities, which are costly as well. Furthermore, the expenses of facility maintenance are also high, thus the suggested methods cannot be suitably applied in developing countries (Nguyen & Goto, 2009).

Rice storage is typically conducted in the form of whole kernel (rough rice with husk) to minimize quality change (Adhikarinayake, Palipane, & Muller, 2006). On the other hand, it is more convenient and economically feasible to distribute and store milled rice than rough rice, especially in grocery stores and supermarkets in cities. Additionally, milled rice is typically preferred over brown rice and under-milled rice for its superior eating quality (Piggott, Morrison, & Clyne, 1991; Rao, Narayana, & Desikachar, 1967; Roberts, 1979). Because the degree of milling influences cooking and eating qualities it is a critical factor that must be controlled during rice processing (Mohapatra & Bal, 2006). Therefore, the elements influencing quality change in milled rice during storage are important to observe. Through this knowledge, better processing

* Corresponding author. School of Nutrition and Food Sciences, 220 H.D. Wilson Laboratories, Louisiana State University Agricultural Center, Baton Rouge, LA 70803, USA.

E-mail address: ssathivel@agcenter.lsu.edu (S. Sathivel).

http://dx.doi.org/10.1016/j.lwt.2016.09.014

and storage conditions may be facilitated to prolong shelf life of the milled rice.

Milled rice is composed of starch, protein, lipid, and a small quantity of vitamins and minerals. Starch is the major constituent of milled rice at about 90 g/100 g dry matter, while total protein and lipid contents are 6.5 and 1.5–1.7 g/100 g dry matter, respectively (Juliano, 1993). Because protein and lipid are usually parts of the bran layer in the grain, their abundance is likely affected by the milling method. However, in common practices not all parts of this layer are removed by milling, otherwise the yield would drastically decrease. Meanwhile, Zhou et al. (2002) further explain that protein and lipid deteriorate more rapidly than starch, thus the existence of these substances contribute greatly to taste and color changes in milled rice during storage. While there has been prior investigation of the effects of milling and storage conditions on stored and cooked rice quality, there is still a need for more comprehensive research when conditions are varied, especially using Louisiana Catahoula rice, a seldom studied variety. The unique combination of degree of milling, storage temperature and time, and cooking assessment combinations have not been studied for rice. These factors facilitate the understanding of changes in rice protein, lipid, and moisture content, color, water absorption, and textural properties, which all play a critical role in consumer acceptance. In addition, the effect of degree of milling on surface morphological characteristics of rice using scanning electron micrographs has not been done or was lacking in previous studies. The objective of this research was to observe the effect of milling conditions and storage temperature on the quality of Catahoula rice.

2. Materials and methods

2.1. Sample preparation

The rough rice used was Catahoula rice (*Oryza sativa* L.), obtained from Louisiana State University Agricultural Center (LSU AgCenter) Rice Research Station, Rayne, Louisiana. Catahoula rice is a conventional long-grain rice that is a high-yielding, blast-resistant, semidwarf cultivar which has good milling quality, lodging resistance, and grain quality parameters (Blanche et al., 2009). Rough rice was dried to 11–13 g/100 g moisture, cleaned, packaged, and stored at room temperature by the Rice Station for 1 month until it was brought to the School of Nutrition and Food Sciences, LSU. The rough rice was hulled and milled using a pilot scale rice milling unit (Satake Corporation, Japan). Three degrees of milling were applied to obtain milled rice with light (4.37%), medium (7.34%), and heavy (10.19%) degrees of milling. The degree of milling is the percentage of rice layer removed by milling and it was obtained from the weight difference between unmilled and milled rice. Higher degree of milling values correspond with greater bran removal (Wadsworth, 1994). Degree of milling was set to minimum, medium, and maximum weight of load for opening the lever of the vertical polisher for light, medium, and heavy milling, respectively.

The milled rice obtained from medium milling was selected for a storage experiment. The samples were stored at three different temperatures: 30, 45, and 60 °C, for a period of 31 d. During the storage period, quality parameters of milled rice such as color and moisture, protein, and lipid content were measured. For determining cooking quality, analyses of water absorption, texture, and rate of gelatinization of cooked brown and milled rice were conducted. In addition, full length brown rice was separated into head rice and broken rice. The head rice yield was based on 75% or more of the total length of the whole brown rice (Yadav & Jindal, 2001). The head rice yield was determined by dividing head rice weight by initial rough rice weight (Daniels, Marks, Siebenmorgen, McNew, & Meullenet, 1998). Milling yield was based on rough rice and was calculated by dividing brown or milled rice weight by initial rough rice weight.

2.2. Moisture content

Measurement of rice moisture content was conducted using the conventional oven method. Each sample (3–5 g) was placed on an aluminum tray that was weighed before use. The sample was dried at 105 °C for at least 24 h. The dried sample was then weighed again and sample moisture content was determined gravimetrically.

2.3. Color and surface morphology

Rice color was measured using a LabScan XE HunterLab color meter (Hunter Associates Laboratory Inc., Reston, VA). The sample (5–6 g) was placed on a plastic tray and scanned by the color meter which directly displays the values of L^*, a^* and b^* in the Hunter Lab color model. The L^* values assess the degree of lightness to darkness, a^* values correlate with the degree of redness to greenness, and b^* values measure the extent of yellowness to blueness. Scanning electron micrographs of rice were obtained according to the method described by Chotiko and Sathivel (2014).

2.4. Protein and lipid content

Protein analysis of rice was conducted based on the dry combustion method using a Leco TruSpec nitrogen analyzer (Leco Corporation, St. Joseph, MI). A 0.15 g sample was used for analysis and the resulting nitrogen content was multiplied by a correction factor of 5.7 to get g/100 g protein. Lipid content of rice was analyzed using the Soxhlet method (AOCS Official Method Ai 3.75., 1997). Each sample (60 g) was dried at 105 °C for 24 h, and then ground for 20 s to get homogeneous particle size. The ground sample (2 g) was weighed into Whatman filter paper No. 1, folded according to the method, and placed into the Soxhlet system. The sample was extracted for 4 h using petroleum ether as solvent. At the end of the extraction, the weight of the extraction tube was recorded and the difference in weight was used to determine the mass of oil in the sample.

2.5. Water absorption

About 5 g of rice was added to 50 mL of boiling water in a 150 mL beaker. After 5 min of cooking in a 95 °C water bath, the rice was removed from the mixture with a spoon and placed in a strainer for 3–5 s to drain excessive water. Then the sample was placed on a filter paper and kept at room temperature (20 °C) for 10 min, then weighed. This method was repeated for cooking times of 5, 10, 15, 20, and 25 min. Water absorption (%) was determined from the weight difference between uncooked and cooked samples.

2.6. Gelatinization

This method comprises adding 10 kernels of rice to 50 mL of boiling water in a 150 ml glass beaker. After 5 min of cooking in a 95 °C water bath, the kernels were removed from the mixture with a spoon, drained in a strainer, and placed on a filter paper. The sample was kept in room temperature for 10 min and then placed between glass plates (30 × 10 cm) and pressed by hand. Well-cooked kernels are easy to deform into a flat form so their size would become bigger, while the ones that are uncooked would remain the same or slightly larger in size. Analysis was done by visual inspection. The procedure was repeated for cooking times of 5, 10, 15, 20, and 25 min (Billiris, Siebenmorgen, Meullenet, & Mauromoustakos, 2012).