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Functional and physico-chemical properties of flours and starches of African rice cultivars

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ABSTRACT

Functional, physico-chemical properties and FTIR analysis of flours and starches of two African rice cultivars (Transgressive Segregants TGS 3 and TGS 25) were investigated. The TGS 3 showed higher 1000 kernel grain weight (29.55 g), dockage (1.00 g), immature grain (1.97 g), thickness (2.10 mm), chalkiness (11.17%) and damaged grain (0.70%). However, the TGS 25 showed higher head rice yield (51.11%), milling degree (9.60%), length (6.88 mm) and elongation ratio (3.64). Also, the TGS 25 showed higher alkaline spread value (6.67), amylose content (30.81%), uncooked (7.15 mm) and cooked (10.17 mm) rice length. The WAC (2.77 g/mL) and OAC (1.08 g/mL) of TGS 25 flours were higher than TGS 3. The *L* value of TGS 25 flour (92.13) and starch (97.88) were higher than those of TGS 3. The TGS 3 flour and starch showed higher peak, breakdown and peak times of 4308 and 3531 cP, 2200 and 1947 cP, 5.43 and 4.60 min, respectively. The TGS 25 (85.67 °C) starch showed significantly higher boiling point than the TGS 3 (81.33 °C). Pasting temperatures of TGS 3 and TGS 25 starches were 78.65 and 78.75 °C, respectively. Cyclodextrin (A and B) and *L* (−) glucose were detected in the starch and flour of TGS 25 but were present in TGS 3 starch but absent in its flour.

1. Introduction

Rice (*Oryza sativa* L.) is the most important cereal crop in the developing world, and the most staple food of over half the world's population (Zhai, Lu, Zhang, Sun, & Lorenz, 2001). Rice is grown on approximately 155 million hectares and accounts for one-fifth of the global calorie supply (Mohanty, Singh, Balasubramanian, & Jha, 1999). It is estimated that 2.3 billion farmers and their households depend on rice as their main source of livelihood (Mohanty et al., 1999). Because of its long history of cultivation and selection under diverse environments, remarkable diversity exists in rice. About 20 species of the genus *Oryza* are recognized, however, *Oryza glaberrima* is a cultivated species that is found only in Africa (AfricaRice, 2010). Although *O. sativa* is known for its high yield and productivity, *O. glaberrima* is increasingly been adopted by many African farmers because of its adaptability, ceremonial and cultural importance.

Improving *O. glaberrima* could be an easy way of getting into farmers' hands cultivars with high yield potential and the essential traits needed to combat the Africa's multiple abiotic and biotic stresses. While it is important to develop new cultivars with better yield and strength against the anticipated stresses, more attention is required during harvest and postharvest. Information is required on the physical, functional, and physicochemical properties of these new lines for the design of new equipment and products which would facilitate handling, distribution, processing and utilization. Physical properties are required for the design and evaluation of equipment and systems for their handling, processing and storage (Asoegwu, 1995), while functional properties govern the behaviour of nutrients in foods during processing, storage and preparation as they affect food quality and acceptability. Physicochemical properties are those properties that affect the physical and chemical attributes of food during processing.

Despite the depth of work that had been reported on the agronomical development of different cultivars of rice in Africa through hybridization and genetic modifications, little attention had been paid to parameters that are important for their utilization and consumer preference (Virmani, 2003). There is therefore the need to investigate the properties which could indicate market value, utilization and consumer preferences of the newly developed rice cultivars. The information derived from this study would furnish rice breeders and end users with relevant information

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which could help in further development and improvement of agronomic traits as well as utilization, as well as recommend the cultivars that may be suitable for specific purposes and provide data for use in planning for production and trade. Recently, two transgressive interspecific (*O. glaberrima* Steud x *O. sativa L.*) recombinant Inbred lines: TGS 3 and TGS25 were developed by researchers at Africa Rice Centre (AfricaRice, 2010, 24 pp.). Understanding of the various characteristics and physicochemical properties of the interspecific *O. glaberrima* x *O. sativa* lines called *TGS 3* and *TGS 25* developed by AfricaRice rice breeders, currently being evaluated on farm and extensively used as bridge lines in upland rice breeding activities, is needed. Consequently the objective of this research was to evaluate the functional and physicochemical attributes of flours and starches of two cultivars of African rice.

2. Materials and methods

Paddy rice of TGS 3 and TGS 25 cultivars were provided by the upland rice breeder from the Africa Rice Center Sub-station based at the International Institute of Tropical Agriculture, Ibadan. Nigeria. The TGS 3 and TGS 25 were BC_1 progenies of two different crosses involving respectively *O. glaberrima* landraces CG 14 and RAM90 to the *O. sativa* var. Japonica cultivars Moroberekan as the recurrent common parent (AfricaRice, 2010, 24 pp.). Physical properties of the paddy rice were determined before and after milling. Portions of the milled rice were converted to flour, and starch was extracted. All these base rice material were further characterized under different parameters.

2.1. Extraction of starch from rice cultivars

Rice starch was extracted from milled grains by the method described by Lawal et al. (2011). Rice (100 g) was steeped in 0.2% NaOH solution at 25 °C for 24 h to soften the endosperm. The steeped liquor was drained off and the endosperm washed and blended using the warring blender (Model HGBTWT, Warring Blender commercial, Torringhton, USA). The slurry obtained was dispersed in 0.2% NaOH, stirred for 20 min and allowed to settle for 6 h. The supernatant was drained repeated until the supernatant gave a negative protein (Biuret) test. The slurry was suspended in the distilled water, pH adjusted to 7.0 with 0.5 M HCl and sieved through a Nylon screen (53 μm). Afterwards, it was allowed to settle for another 6hr, and the clear supernatant was discarded. The starch obtained as sediment was dried in a convention oven at 40 °C for 72 h. Samples were sealed in the polyethylene and kept for analysis.

2.2. Determination of moisture and protein contents, and pH

Moisture content was determined by gravimetric method in a cross flow Gallenkamp Size two BS model OV-160 hot air oven (Gallenkamp, England, UK) at 102 °C until constant weight (AOAC, 1990, pp. 770–771). Protein and fat contents were determined using a standard Kjeldahl distillation and solvent extraction methods, respectively (AOAC, 1990, pp. 770–771). pH of starch–water suspension (10%, w/v) was determined using a pH meter (Onwuka, 2005, pp. 133–161).

2.3. Measurement of physical dimensions of rice cultivars

Length, width and thickness of 200 randomly selected grain of each cultivar were measured using a vernier calliper (12″ Digital Calliper, Carrera Precision, China) with accuracy of ±0.01 mm. Subsequently, length:width ratio, effective diameter, sphericity and surface area were determined according to the equations highlighted by McCabe and Harriot (1986). Elongation ratio was determined by evaluating the ratio of mean length to mean width of the randomly weighed sample of the rice grain.

2.4. Determination of immature grain, dockage, 1000 grain weight, degree of milling, damage grain

The immature grain of 25 g rice sample was separated and weighted, and was determined as a percentage of total weight of sample. Dockage was determined by removing light and foreign matters, stones, weed and seeds from a 100 g sample. Dockage (%) was calculated as a percentage of total weighted sample. One thousand grain of paddy rice was counted and weighted using a weighing balance.

2.5. Determination of degree of milling, damaged grain, chalkiness and head rice yield

Milling degree (%) was calculated as the amount of bran removed from brown rice kernel during milling (FAO, 2004). Damaged grain was determined by identifying whole or broken grains that were defective either as a result of heat, moisture, pest or disease expressed as a percentage of the milled grains. Chalkiness (%) was determined as a percentage of milled rice (USDA, 2005). Head rice yield (%) was calculated as percent weight of milled unbroken head rice kernels compared to the weight of the rough rice or paddy kernels (Champagne et al., 1996; Champagne, Wood, Juliano, & Bechtel, 1996).

2.6. Determination of colour parameters of flour and starch of rice cultivars

Tristimulus *L a b* parameters of flour and starch were determined using colourimeter (Chroma meter CR-400, Konika Minolta, USA). The *L*, *a*, *b* colour phase was used after the colourimeter was standardised using the white porcelain standard ($L = 93.24$, $a = 00.96$, $b = -02.75$). The colourimeter was placed on the sample and multiple (10) measurements of several points were made. Deltachroma ($\Delta C = \sqrt{(\Delta a)^2 + (\Delta b)^2}$), colour intensity ($\Delta E = \sqrt{(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2}$) and hue angle ($H = \mathrm{Tan}^{-1}(b/a)$) were calculated (Hunt, 1991, pp. 75–76).

2.7. Determination of gelling and boiling point

Gelling and boiling points of flour and starch were determined using the method described by Narayana and Narasinga-Rao (1982).

2.8. Determination of water absorption capacity (WAC) of flour and starch

The WAC of both the flour and starch was determined by the method of Bryant et al. (2001) and Kadan et al. (2003). Each sample (2.5 g) was suspended in 30 mL of distilled water (30 °C) in a 50 mL pre-weighed centrifuge tube. The tubes were placed in a water bath at 30 °C and stirred intermittently for 30 min. The suspension was centrifuged for 10 min at 3000× g. The supernatant was decanted into a pre-weighed 50 mL beaker. The weight of the precipitate was measured, and WAC was calculated as weight gain divided by the weight of sample (Bryant et al., 2001; Kadan et al., 2003).