JAEFS

International Journal of Agriculture, Environment and Food Sciences

e-ISSN : 2618-5946 DOI: 10.31015/jaefs.18016 www.jaefs.com

Research Article Int J Agric Environ Food Sci 2(3):99-103 (2018)

Physicochemical properties and morphological observations of selected local rice varieties in northern Afghanistan

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Abstract

In this study, milled rice (*Oryza sativa* L.) samples of local varieties (Sarda Barah, Garma Barah, Surkha Zurahti and Shah Lawangi) were procured from Kunduz province, Afghanistan and check varieties (Koshihikari and Super Basmati) from Japan. We conducted the research in the Laboratory of Crop Science of Ibaraki University, Japan during February in 2018, to clarify the physicochemical and morphological traits on different local rice varieties. The results demonstrated that local rice varieties (Sarda Barah, Garma Barah, Surkha Zurahti and Shah Lawangi) from Afghanistan including Super Basmati (Check) with long and slender grains, associated with significantly higher grain amylose and protein contents of 22.9 and 8.1%, respectively, which created in declined taste points. While, Koshihikari with short and medium grain types demonstrated the lowest grain amylose and protein contents of 17.7 and 5.5%, respectively, which amplified grain taste point. The micrographs observations revealed that there were no obvious alterations in the endosperm of translucent grains across varieties. In contrast, the endosperm of chalky grains in local rice varieties were differed compared to check varieties (Super Basmati and Koshihikari), irregularly developed starch granules together with single spherical shape and dent-portion on their surfaces with numerous airgaps were observed due to high temperature. Such irregular arrangement leads in lower grain weight and quality.

Keywords: Rice, Physicochemical properties, Grain morphology, Scanning electron microscope

Received: 05.05.2018 Accepted: 27.06.2018 Published (online): 27.08.2018

Introduction

Rice (*Oryza sativa* L.) is the world's single most significant food crop and the primary source of calories for around 50% of the human population (Wei et al., 2007). Around 90% of rice is produced and being consumed in Asia (Gealy et al., 2003). It is the second vital staple crop after wheat in Afghanistan (Hassanzoy et al., 2017; Sarhadi et al., 2009; FAO, 2017). Kunduz, Baghlan and, Takhar are the top three rice producing provinces in the country, which jointly considered to be the grain basket of Afghanistan, holding strategic significant for food security at the national level (Thomas and Ramzi, 2010). The rice yield has been increased in Afghanistan from 3.22 t/ha in 2008 to 3.50 t/ha in 2010 reported by ICARDA (2011). Unlike the rice cultivation area has been decreasing due to climate change (FAO, 2017). Although grain quality is a composite of physical and chemical specifications needed for a particular exertion by a specific customer class (Zhou et al., 2015). In particular, grain quality is one of the greatest significant traits, as it applies a great influence on the rice price in the market (Hosoya, 2013). Though preferences for some of the quality characteristics differ over countries and regions (Calingacion et al., 2014), the priority for some of the specifications is widely shared.

The chalky rice grain appears when the rice grain has a white part within the rice grain, and it is a consequential quality trait that decides rice price (Hosoya, 2013; Xi et al., 2016). The micrographs observation of chalky endosperm, compound starch granules were irregularly arranged with numerous airspaces, which could have resulted in poor grain weight and quality. While in the translucent endosperm, starch granules (polyhedral shape) were regularly filled (Xi et al. 2016; Shi et al., 2017). There is no information available on the physicochemical and morphological traits of selected local rice varieties in Afghanistan. To attain the enhancement elongate in local rice varieties in Afghanistan, it is decisive to deliver more information. Therefore, the study was conducted to determine some physicochemical properties and as well as morphological analysis on selected local rice varieties by using scanning electron microscope.

Materials and Methods

Milled rice samples

The rice samples of local varieties (Sarda Barah, Garma Barah, Surkha Zurahti and Shah Lawangi) in the form of milled rice were procured from Kunduz province and these varieties are grown enormously in the north of Afghanistan, additionally, to the upward-mentioned local rice varieties, Super Basmati (*indica*) and Koshihikari (*japonica*) varieties were procured from the Laboratory of Crop Science, the College of Agriculture, Ibaraki University, Japan.

Cite this article as : Noori, Z., Mujadidi, M.W., Amin, M.W. (2018). Physicochemical properties and morphological observations of selected local rice varieties in northern Afghanistan. Int. J. Agric. Environ. Food Sci., 2(3), 99-103. DOI: 10.31015/jaefs.18016
Available online at : www.jaefs.com

Physicochemical properties of milled rice

We measured the grain length and width of 15 milled rice grains to the nearest mm using a mini vernier caliper (Niigata, SK-M100, Japan) and followed the method of IRRI (2002). The milled rice for grain amylose, protein, and the taste point (as a reference) assays were measured by using a taste analyzer (RCTA11A; Satake Co. Ltd., Japan).

Preparation for scanning electron microscopy of cross-sections of milled rice

For the observations of endosperm of chalky and translucent grains (Figure 1), followed the method determined by Zakaria et al. (2002). Briefly, the milled rice grains for each of the six varieties were selected and rapidly were submerged into slush nitrogen (solid and liquid, -210 °C). After vacuum freeze-dried with a freeze vacuum dryer (-60 °C, 10^{-3} Pa, LFD-100NDPS1; Nihon Techno Service). Then grains carefully divided into halves by using a razor blade. The separated halves were attached on specimens, and the specimen's surface was coated with platinum (JUC-5000; JEOL, Japan), and then were observed by using scanning electron microscope (JSM6360A; JEOL, Japan). All the above-mentioned data were analyzed in the Laboratory of Crop Science, the College of Agriculture, Ibaraki University Ami-machi, Japan during February 2018.

Statistical Analysis

Data obtained for the physicochemical properties were analyzed by variance analysis (ANOVA) using Statistical Package for the Social Sciences (SPSS) software 13.0.

Results and Discussion

Physicochemical properties of milled rice

The physical parameters (grain weight, length, width, and type) results were summarized in Table 1. The grain weight ranged from 21.0 to 16.8 mg in all varieties. The maximum grain weight was recorded for Sarda Barah (21.0 mg) followed by Koshihikari, Garma Barah, Surkha Zurahti and Shah Lawangi, respectively, while the significant minimum grain weight was recorded for Super Basmati (16.8 mg) across all varieties (Table 1). There were variations in terms of grain length across all varieties. Thus, significant lower grain length was recorded in Koshihikari (4.8 mm). While the longer grain length was recorded in Super Basmati followed by Sarda Barah and Surkha Zurahti ranged from 7.4, 7.3, and 7.1 mm, respectively. In our previous study, there were differences in grain width and grain length in different varieties (Noori et al., 2017). In addition, grain width in Koshihikari (2.8 mm) significantly higher across all varieties, while lower grain width was recorded for Super Basmati (1.9 mm) followed by Surkha Zurahti, Sarda Barah, Garma Barah, and Shah Lawangi ranged from 1.9, 2.1, 2.1, 2.0, and 2.0 mm, respectively. Besides, grain size and shape are among the first rice quality indicator that breeders consider when progressing new varieties for release and marketable production (Rani et al., 2006). Grains were mainly long and slender, followed by medium-sized and shaped types (Juliano & Villareal, 1993). Furthermore, in the current study, according to the grain size and shape results, Koshihikari was classified as short and medium grain types. Whereas, the remain local rice varieties (Sarda Barah, Garma Barah, Surkha Zurahti and Shah Lawangi), including Super Basmati were as long and slender grains, respectively (Table 1). In Afghanistan, generally, consumers prefer rice (*indica*) with long, slender, and translucent grains, which has intermediate or high amylose and protein contents that cook into delicious food (Qabuli palaw).

Although average amylose content differed from 8% to 16% between places and from 5% to 22% among varieties (Jing et al., 2010), variations in amylose content is mostly described by variety (68%) and less by the environment (25%). Tsukaguchi et al. (2016) found high significant differences in grain protein content among different genotypes and the protein content was grew by applying nitrogen as topdressing. In the current study, the grain amylose content, protein content, and the taste point differed among rice varieties. Super Basmati was associated with significantly higher grain amylose (22.9%) and protein (8.0%) contents across all varieties, which created in declined taste point (60) and followed by local rice varieties (Sarda Barah, Garma Barah, Surkha Zurahti and Shah Lawangi), from Afghanistan (Table 2). While, Koshihikari demonstrated the lowest grain amylose and protein contents of 17.7 and 5.5%, respectively, which amplified grain taste point (69.3). Juliano & Villareal. (1993) found that, Koshihikari had lower amylose content and gave the softest cooked rice among other varieties.

Scanning electron microscope of cross-sections of milled rice

To observe the contrast between the endosperm of translucent and chalky grains, cross-sections of the central area of the milled rice grains were observed under a scanning electron microscope (Figure 1). The micrographs observation showed that there were no apparent variations in the endosperm structures of all varieties in translucent grains. Besides, regular starch granules with polyhedral shape were build-up without airgaps (Figure 2, T1-T3, Figure 3, T4-T6). In particular, in the translucent endosperms of all varieties, demonstrating that the grain developing process were more advanced compared to chalky grains. This result agrees with the previous findings of Liu et al. (2017) and Shi et al. (2017).

In contrast, there were obvious variations in the endosperm of chalky grains across all varieties. Briefly, irregular starch granules (round shape and small size), were loosely packed. Numerous dent-portions on the surface, airgaps and cell walls were observed among starch granules in the chalky endosperm of Sarda Barah (Figure 2, C1). Multiples single starch granules with round shape and small sizes had poorly developed with numerous dent-portions and airgaps on their surfaces and among starch granules were appeared in the chalky endosperm of Garma Barah (Figure 2, C2). The endosperm of chalky grain, which caused by high temperature during ripening period, the small starch granules with round shape were abnormally filled, and numerous airgaps were also appeared among amyloplasts (Ishimaru et al., 2009; Chen et al., 2016; Liu et al., 2017; Shi et al., 2017). In the chalky endosperm structure of Surkha Zurahti, abnormal starch granules (round shape and small size) were irregularly arranged with numerous airgaps among them (Figure 2, C3). Whereas, the endosperm structure of chalky grain in Shah Lawangi variety was quite differed compared to other varieties (Figure 2, C4). Furthermore, irregularly developed starch granules together with the single round shape and dent-portion on the surface and multiple sizes of starch granules with numerous airgaps were observed. It might be due to high temperature condition at ripening period. In Afghanistan, variation in temperature during the day may range from freezing at dawn to nearly

40 °C at noon (Saidajan, 2012).

Hosoya. (2013) found that, poor starch granules build-up in the endosperm of chalky rice implies that chalky rice grain is influenced by a shortage in assimilation products because of high temperature condition. These authors described that generally, assimilation products produced by photosynthesis in the leaf transfer to the grain via the transport system. Although high temperature rises respiration rate, which afterward declines the amount of assimilation products for individual grain (Vong and Murata, 1977).

Interestingly, the micrographs observation displayed that a few alterations of starch accumulation in the chalky grains were observed in the endosperms of Super Basmati and Koshihikari (Figure 2, C5-C6). Additionally, high density of large amyloplasts with round shape and airgaps among them were packed. Consequently, the micrographs result demonstrated the imperfect development of starch granules in the endosperm of chalky grains, which facilitates in lower grain weight and grain quality. Our results coincided by findings of Shi et al. (2017) and Chen et al. (2016) who displayed that the poor arrangement of starch granules, which influenced by high temperature condition, implies the reduction of lower grain weight and quality.

Conclusion

In conclusion, it is the first time that the physicochemical properties and morphological traits were explored in different local rice varieties from Afghanistan. Our results exhibit that Super Basmati including local rice varieties (Sarda Barah, Garma Barah, Surkha Zurahti and Shah Lawangi) from Afghanistan with long and slender grains, companioned with significantly higher grain amylose and protein contents, which coincided in decreased taste points. While, Koshihikari with short and medium grain types showed the lowest grain amylose and protein contents of 17.7 and 5.5%, respectively, which amplified grain taste point. The scanning electron micrographs displayed that, there were no obvious variations in the endosperms of translucent grains across all varieties. Furthermore, starch granules with polyhedral shape were regularly build-up without airgaps. Particularly, in translucent endosperms of all varieties, displaying that the grain filling process were more advanced compared to chalky grains. In contrast, the endosperm of chalky grains in local rice varieties were varied, irregularly developed starch granules together with the single round shape and dent-portion on their surfaces with numerous airgaps were observed due to high temperature. Such loose arrangement amplifies in lower grain weight and quality. But, there were no apparent alterations in the chalky endosperms of Koshihikari and Super Basmati.

Acknowledgments

The authors would like to thank the member of Crop Science Laboratory of Ibaraki University and especially from Assoc. Prof. Dr. Naomi Asagi for using the facilities for this research. We are grateful to Dr. Mohamed W. Negm (Assiut University, EGYPT) for some editing in the manuscript.

Table 1. Physical parameters of selected (milled grain) rice varieties.

Varieties	Grain weight (mg)	Grain length (mm)	Grain width (mm)	Size	Shape
1 Sarda Barah (*indica*)	21.0 a	7.3 a	2.1 bc	Long	Slender
2 Garma Barah (*indica*)	19.5 ab	7.1 ab	2.0 c	Long	Slender
3 Surkha Zurahti (*indica*)	19.4 ab	7.1 a	2.1 b	Long	Slender
4 Shah Lawangi (*indica*)	17.6 bc	6.7 b	2.0 c	Long	Slender
5 Super Basmati (*indica*)	16.8 c	7.4 a	1.9 d	Long	Slender
6 Koshihikari (*japonica*)	20.0 ab	4.8 c	2.8 a	Short	Medium

Same letters in two columns under the same title reveal no significant difference at the 5% probability level.

Table 2. Comparison of selected rice varieties on milled grain amylose content, protein content and taste point.

Varieties	Type	Varietal origin	Amylose (%)	Protein (%)	Taste point (as reference)
1 Sarda Barah	Local	Afghanistan	20.5 b	8.4 a	63.0 d
2 Garma Barah	Local	Afghanistan	20.0 b	8.2 ab	63.0 d
3 Surkha Zurahti	Local	Afghanistan	19.9 b	8.0 b	66.0 c
4 Shah Lawangi	Local	Afghanistan	18.9 c	7.9 b	67.4 b
5 Super Basmati	Improved	Pakistan	22.9 a	8.1 ab	60.0 e
6 Koshihikari	Improved	Japan	17.7 d	5.5 c	69.3 a

Same letters in two columns under the same title reveal no significant difference at the 5% probability level.

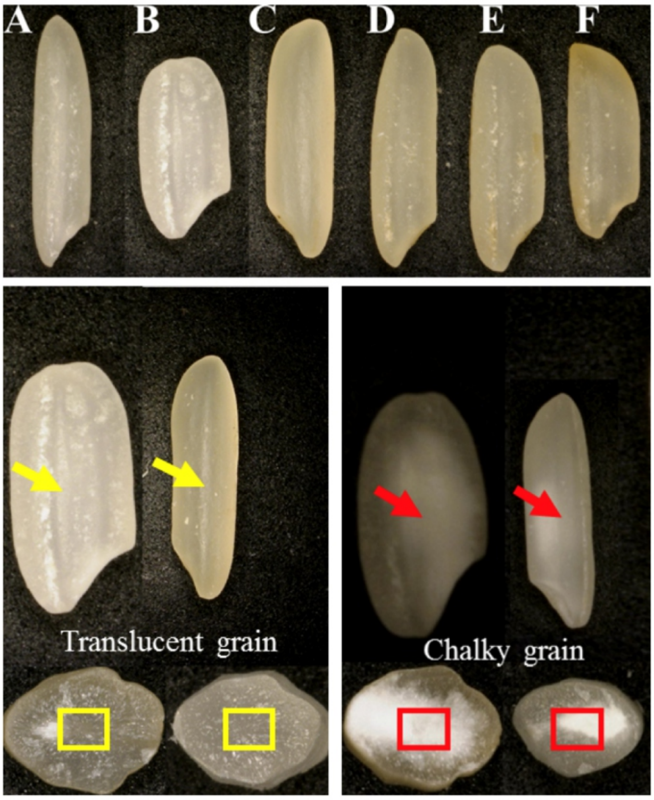

Figure 1. Comparison of grain shape and appearance of translucent rice grains (T) and chalky rice grains (C) of Super Basmati (A), Koshihikari (B), Sarda Barah (C), Garma Barah (D), Surkha Zurahti (E), and Shah Lawangi (F). Photographs of milled rice were taken by a microscopy (Keyence-VH500, Japan). Yellow and red rectangles on the central portions of cross-sections of milled rice grains reveal the chalky and translucent portions for scanning electron microscopic observations.

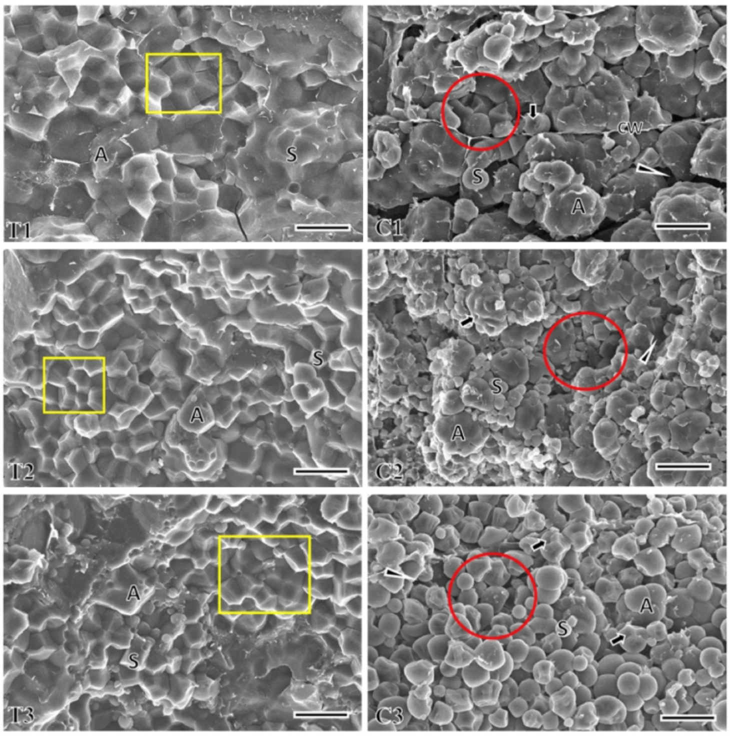

Figure 2. Scanning electron micrographs of the cross-sections of the central portion of milled rice grains of Sarda Barah (1), Garma Barah (2), and Surkha Zurahti (3). T: translucent grains, C: chalky grains. A: amyloplasts, CW: cell wall, S: starch granules, arrows: dent portion, arrowheads: airgap and Scale bars: 10-µm. Yellow rectangles reveal the polyhedral shape of starch granules grouping into amyloplasts without airgaps. Red circles reveal loosely developed starch granules together with the single round shape and multiple size and shape of starch granules with numerous airgaps.

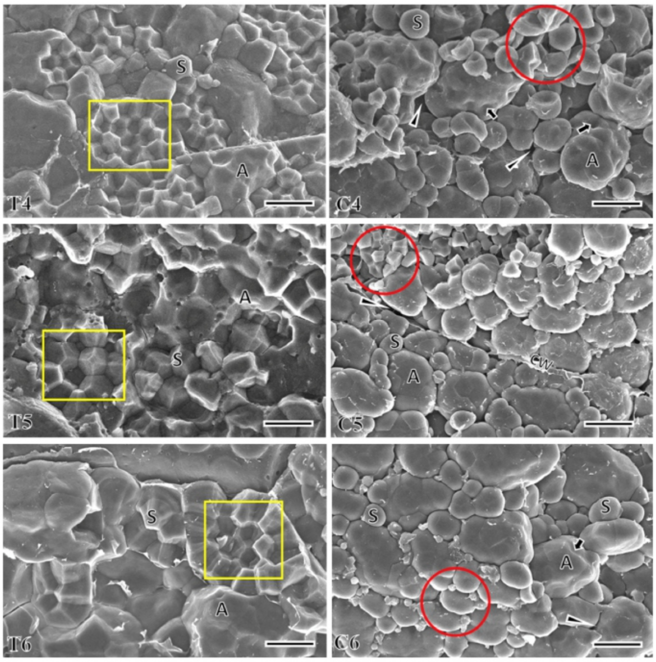

Figure 3. Scanning electron micrographs of the cross-sections of the central portion of milled rice grains of Shah Lawangi (4), Super Basmati (5), and Koshihikari (6). T: translucent grains, C: chalky grains. A: amyloplasts, CW: cell wall, S: starch granules, arrows: dent portion, arrowheads: airgap and Scale bars: 10-µm. Yellow rectangles reveal the polyhedral shape of starch granules grouping into amyloplasts without airgaps. Red circles reveal loosely developed starch granules together with the single round shape and multiple size and shape of starch granules with numerous airgaps.

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