Quality characteristics of organic and inorganic Maswangi rice variety
(Penilaian ciri-ciri kualiti beras organik dan bukan organik bagi varieti Maswangi)

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Abstract

The physical properties, physico-chemical properties, cooking characteristics and nutritional content of freshly harvested Maswangi rice were studied. Organic and inorganic paddy were obtained from Kg. Ewa, Langkawi, Kedah and Kubang Kerian, Kelantan respectively. These samples were evaluated in the form of paddy, milled rice and brown rice. The physico-chemical properties determined were amylose content, gelatinization temperature and gel consistency. The samples analysed had high gelatinization temperature while the mean amylose content was 24.4. Hard gel was detected in the rice samples. Variations in cooking time, elongation ratio, volume of expansion, water uptake ratio and solid loss were observed. The rice had elongation ratio of less than 2 which indicated that fresh rice samples did not elongate during cooking. Cooking properties showed that brown rice took a longer time to cook and had lower values in water uptake and volume expansion. Organic Maswangi milled rice contained 8.57% protein and 0.94% fat with 14.9% moisture content. Inorganic Maswangi had 8.16% protein and 2.56% fat. Brown rice of both organic and inorganic had higher nutritional quality than milled rice particularly with respect to fat, protein, mineral, thiamin, riboflavin and niacin contents.

Introduction

Rice, unlike most other cereals, is consumed as a whole grain. Therefore physical properties such as size, shape, uniformity, and general appearance are of utmost importance (Juliano et al. 1990). Furthermore, because most rice is milled, the important physical properties are determined primarily by the milled endosperm. Rice is a good source of insoluble fibre, which is also found in whole wheat, bran and nuts. Rice is rich in carbohydrates, which is the main source of energy, low in fat, contains some protein and plenty of B vitamins (Resurreccion et al. 1979).

Those looking to reduce their fat and cholesterol intakes can turn to rice because it contains only a trace of fat and no cholesterol. Rice is also gluten free, so it is suitable for celiac, and it is easily digested, and therefore a wonderful food for the very young and elderly.

Rice quality is influenced by characteristics under genetic control, environmental conditions and processing techniques (Jennings et al. 1979). In the latter case, characteristics are principally a function of handling, storage and distribution. The genetic makeup of a particular variety dictates to a large degree

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in terms of the grain quality characteristics. Plant breeders continually refine and improve genetic traits of new varieties required to produce the most desirable products. Selection for improved milling, cooking, eating, and processing qualities is an essential component of breeding programmes designed to meet industry standards or taste and cooking characteristics preferred by consumers in key export markets (Juliano and Bechtel 1985).

Marked differences in rice quality also occur as a result of the environmental conditions and cultural practices during growth. These factors may under some circumstances have a greater impact on quality than inherited traits. Factors influencing quality independent of genetics or the environment are those associated with handling, storage and presence of foreign material. Physically moving the rice with machines can damage the kernels and decrease head yields. Prolonged periods of storage under unfavourable conditions can result in objectionable flavours or odours.

Milling yield is one of the most important criteria of rice quality, especially from a marketing standpoint. A variety should possess a high turnout of whole-grain (head) rice and total milled rice (Webb 1985). Milling yield of rough rice is the estimated quantity of head rice and total milled rice that can be produced from a unit of rough rice. It is generally expressed as a percentage (Khush et al. 1979). Cooking and eating characteristics are largely determined by the properties of the starch that makes up 90% of milled rice. Gelatinization temperature, amylose content, and gel consistency are important starch properties that influence cooking and eating characteristics.

Most of the high-quality preferred varieties in the major rice-growing countries are aromatic. Aromatic or scented rice, a rice type that emits a special aroma when cooked, has been cultivated in many regions throughout Japan and in South and Southeast Asian countries from ancient days. Examples of such rice are the Basmati rice of India and Pakistan, Dulhabhog of Bangladesh, Khao Dawk Mali and Leuang Hawn of Thailand, Azucena and Milfor of the Philippines, Rojolele of Indonesia, Sadri varieties of Iran, Barah of Afghanistan, and Della of the United States.

In Malaysia, research on development of aromatic rice has been carried out and a variety known as Maswangi is currently planted both in inorganic and organic way Accordingly, this study aimed to evaluate the characteristics of local variety of aromatic rice of both freshly harvested organic and inorganic rice in terms of physical, milling, physico-chemical, cooking characteristics and chemical properties.

Materials and methods

Freshly harvested organic paddy and inorganic paddy were obtained from Kg. Ewa, Langkawi, Kedah and Kubang Kerian, Kelantan respectively. The paddy were dried and cleaned before analysis. At least three samples were obtained from these locations and each sample was analysed in duplicates.

Milling properties

Duplicate 125-g paddy samples were used for milling determination (Webb 1985). Moisture content was in the range of 12–14%. A Steinlite moisture meter was used to determine the moisture content. Paddy samples were dehulled with a Satake laboratory sheller. The samples were poured into the hopper. Samples with many partially filled grains of reduced thickness usually required two passes.

The resulting brown rice was weighed to obtain the percentage of hulls. The brown rice was milled in a McGill mill number 2 for 30 s with the prescribed added weight (680 g) on the pressure cover, followed by a second milling for another 30 s without the weight. The fraction removed may be considered bran in the first milling and that after the second milling, fraction of polish was obtained. The milled rice sample was collected in a jar and was sealed

immediately. The milled rice was allowed to cool for 2 h before weighing. This procedure minimizes grain cracking. The weight of the total milled rice was recorded. Whole grains (head rice) were separated from the total milled rice with a rice-sizing device.

Physical properties

The physical properties were determined according to the standard method described by Juliano (1985a). Rice samples (duplicate) were analysed for the mean length and width using a dial thickness gauge for 25 grains from each sample. Other characteristics analysed were head rice, through the use of a Satake testing rice grader with a suitable indented cylinder to remove broken rice which was shorter than three-fourth of whole grain length; whiteness was analysed using a whiteness meter Kett Model C-3. Grains were defined as damaged when they were distinctly discoloured and damaged by water, insects, heat or other means and determined by hand picking method from 50 g head rice of each sample. The bulk density was measured using a Hectoliter Weight.

Physico-chemical and nutritional analysis

Duplicate samples of brown and milled rice were taken and analysed for moisture, protein, crude fibre, fat, ash, phosphorous, potassium, sodium, calcium, iron, thiamine, niacin and riboflavin composition. Moisture, protein, fat and ash were determined using standard AOAC methods (AOAC 1990). Protein was determined by Kjeldahl nitrogen method using Kjeltec system 1026 (Germany). Fat was determined by Soxhlet extraction and ashing was done at 550 °C to constant weight.

The amylose content was determined according to simplified assay method as described by Juliano (1972). The gelatinization temperature was estimated from alkali spreading value of 10 rice grains soaked in 15 ml of 1.7% KOH for 23 h at room temperature (Little and Hilder 1958). The gel consistency was determined based on the length of cold horizontal gel in a 13 mm x 100 mm test tube according to the method of Cagampang et al. (1973). The rice samples were classified as hard (26–40 mm), medium (41–60 mm) or soft (61–100 mm).

Crude fibre was determined by Weende method using fibertec system (Tecator 1978). Minerals and vitamins were analysed by an accredited company Edtech Associates Sdn. Bhd. according to the method by AOAC (1993). Each analysis was carried out in duplicates. Carbohydrate was calculated by subtracting the values of moisture, protein, crude fibre, fat and ash, from 100.

Cooking characteristics

The cooking characteristics were determined by boiling 8 g of rice sample in a cylindrical wire basket with 43.5 mm in diameter and 98 mm in length following the small scale cooking method of Juliano (1982). Water uptake was calculated from the ratio of the weight of cooked rice to that of raw rice. Volume of expansion was recorded as a ratio of the height of the cooked rice to that of raw rice. Total solid was determined from the residues of 10 ml cooking liquid after drying at 100 °C for 2.5 h.

Cooking time for milled rice was estimated according to the method of Juliano (1982). The elongation ratio of presoaked rice after cooking was estimated based on the length of 10 cooked and raw kernels, according to the method of Juliano and Perez (1983). The elongation test consisted of measuring 25 whole-milled kernels that were soaked in 20 ml of distilled water for 30 min. Samples were placed in a water bath and the temperature was maintained at 98 °C for 10 min. The cooked rice was transferred to a petri dish lined with filter paper. Ten cooked whole grains were selected and measured in a photographic enlarger. The proportionate elongation is the ratio of the average length of cooked rice grains to the average length of raw rice grains.

Results and discussion
Milling properties
Table 1 shows the physical properties of analysed samples. One of the most important commercial characteristics of rice is the milling quality and total rice obtained from the tested samples ranged from 68.8–69.4%. These results are similar to those reported earlier on other Malaysian rice varieties which ranged from 68.0–69.2% (Ajimilah 1980). These figures estimated the quantity of head rice and total milled rice that can be produced from a unit of paddy (Khush et al. 1979). Milling recovery is sensitive to the mode of drying and is usually used to assess the overall effectiveness of the drying process. Other factors affecting the milling yields are variety, grain type and growing conditions.

The tested samples had high percentage of head rice yield and varied from 82.6–93.7%. Webb (1985) reported that a high percentage of broken grains is indicative of poor milling quality, whereas a high percentage of head rice is indicative of high quality. Results suggested that the tested samples are of high milling quality. According to Indudhara Swamy and Bhattacharya (1982), all rice markets discriminate greatly against broken rice because its value is only 30–50% as great as that of whole grain.

Chalkiness is undesirable in virtually all forms of rice and occurs when rice is harvested at too high moisture level.

Compared to inorganic rice, organic rice had low values for chalkiness. This indicated that inorganic rice tended to break more frequently at the pit left by the embryo when it is milled. According to Khush et al. (1979) that starch granules in the chalky areas are less densely packed than those in translucent areas and are more prone to breakage during milling. These rice samples with damaged eyes have poor appearance and low market value.

Physical properties
Moisture content has an important influence on several facets of rice quality. The moisture contents of Maswangi milled rice and brown rice were low and ranged from 11.9–14.7% (*Table 1*). The low levels of moisture were expected as moisture level is generally the factor most responsible for controlling the rate of rice deterioration. According to Webb (1985), moisture levels commonly accepted for safe storage of rice are 13% for less than 6 months and 12% for long-term storage.

No foreign matter was detected in the samples. Result indicated that impurities other than rice has been removed by the use of sieves and cleaning device during rice milling. It was observed in other study by Webb (1985), that the quantity and character of impurities in rice affect the value of rice lot. Other study also showed that foreign matter not only reduce the quantity of usable rice and lowering milling yields but also

Table 1. Milling and physical properties of brown rice and milled rice of Maswangi

	Organic rice		Inorganic rice	
	Brown rice	Milled rice	Brown rice	Milled rice
Moisture content (%)	14.7 ± 0.1	14.9 ± 0.5	12.0 ± 0.1	11.9 ± 0.5
Foreign matter (%)	NIL	NIL	NIL	NIL
Bulk density (kg/Hl)	67.5 ± 0.1	74.2 ± 0.3	73.8 ± 0.1	74.7 ± 0.4
Cracked grain (%)	NIL	NIL	NIL	NIL
Milling recovery (%)	NIL	NIL	NIL	NIL
Head rice (%)	88.8 ± 0.3	82.6 ± 0.5	96.5 ± 0.3	93.7 ± 0.4
Broken rice (%)	11.3 ± 0.3	17.4 ± 0.3	3.6 ± 0.3	6.4 ± 0.1
Damaged grain (%)	3.1 ± 0.3	0.9 ± 0.5	1.0 ± 0.1	0.5 ± 0.3
Chalky grain (%)	0.5 ± 0.3	0.5 ± 0.1	23.2 ± 0.3	3.7 ± 0.4
Whiteness no. (%)	22.8 ± 0.1	35.4 ± 0.5	23.1 ± 0.5	34.8 ± 0.4

damage the processing equipment (Juliano 1985: 91–111).

Factors which commonly affect bulk density are insect infestation, excessive foreign matter and high moisture content (Webb 1985). The average bulk density (a relative indicator of total milled rice) for the analysed rice was 66 kg/litre. This value is indicative of good overall quality of the rice grain and can be used to estimate the weight contained in the holding bins of known volume.

The milled samples had whiteness value ranging from 34.8–35.4 and this is related to the degree of milling. These rices are classified as well milled rice since Juliano (1985) reported that well milled rice has whiteness values between 38–48 and produced at 7–8% milling degree. The whiteness of rice increase sharply during milling but reaches a maximum beyond which it does not increase further with additional milling. In addition to that, the maximum whiteness reading with the Kett Whiteness Meter was also affected by inherent colour of a given variety and by its chalkiness (Ikehashi and Khush 1979).

Damaged rice in the analysed samples varied from 0.05 to 3.1. Damage to this rice might occur in the field before harvesting, during drying, or during subsequent storage and handling (Juliano 1985: 91–111).

Physico-chemical properties

The physico-chemical properties of rice such as apparent amylase content, crude protein content, gelatinization temperature (GT), and gel consistency are presented in *Table 2*. Amylose content, which is the major eating quality factor in rice (Juliano 1993), is an indicator of volume expansion and water absorption during cooking. Amylose has been reported by Juliano (1985: 59–174) to correlate with hardness, whiteness, and dullness of cooked rice. All analysed samples were grouped as high amylose.

Resurreccion et al. (1979) suggested that the amylose content of rice may vary according to the temperature during grain ripening whereby the amylose content generally decreases as the mean temperature increases. In addition, the amylose content is also influenced by the nitrogen fertilization whereby the value decreases slightly with the nitrogen fertilization but is not affected by the time of nitrogen application (Paule et al. 1979).

Results showed that the protein values ranged from 8.16–8.78%, with inorganic milled contained the lowest and organic brown rice the highest. These values fall within the mean protein range (6.3–9.2%) of rice samples from different Asian countries (Juliano 1993).

Table 2. Physico-chemical properties and cooking characteristics of brown rice and milled rice of Maswangi

	Organic rice		Inorganic rice	
	Brown rice	Milled rice	Brown rice	Milled rice
Protein (%)	8.57 ± 0.1	8.98 ± 0.5	8.16 ± 0.3	8.58 ± 0.5
Fat (%)	2.42 ± 0.1	0.94 ± 0.5	2.56 ± 0.1	0.49 ± 0.3
Free fatty acids (%)	10.27 ± 0.1	3.79 ± 0.5	5.80 ± 0.3	3.23 ± 0.3
Amylose content (%)	High	High	High	High
Gelatinization temperature	High	High	High	High
Gel consistency (mm)	–	Hard 27.5	–	Hard 25.8
Cooking time (min)	26.7 ± 0.5	16.5 ± 0.3	27.8 ± 0.3	17.5 ± 0.5
Elongation ratio	1.35 ± 0.5	1.8 ± 0.3	1.41 ± 0.3	1.67 ± 0.1
Volume of expansion	3.15 ± 0.5	3.69 ± 0.3	3.25 ± 0.1	3.8 ± 0.5
Water uptake ratio	2.80 ± 0.1	3.38 ± 0.3	2.82 ± 0.1	3.47 ± 0.1
Solid loss (g)	0.41 ± 0.5	0.73 ± 0.3	0.48 ± 0.3	0.74 ± 0.1

Results also indicated that the fat content varied with the minimum value of 0.49% and maximum value of 2.56%. The comparatively high level of fat content in brown rice is mainly contributed by the oil present in the bran layer. This bran layer was removed during the production of milled rice (Juliano 1993).

The gelatinization temperature (GT) of the endosperm starch, a useful test of cooking quality, refers to the cooking temperature at which water is absorbed and the starch granules swell irreversibly in hot water with a simultaneous loss of crystallinity and birefringence. Final GT ranges from 55–79 °C.

Environmental conditions such as temperature during grain development influence GT. A high ambient temperature during grain ripening results in starch with a higher GT (Champagne 1990). The GT of rice varieties may be classified as low (55–69 °C), intermediate (70–74 °C) or high (>74 °C). The physical cooking properties of rice are more closely related to the GT than the amylose content of the starch.

All the tested samples had high GT. Rice with a high GT becomes excessively soft and tends to disintergrate when overcooked (Rosniyana et al. 2004). Under standard cooking procedures, rice with a high GT tends to remain undercooked. Rice varieties with a high GT require more water and time to cook than those with a low or intermediate GT.

Gel consistency is a useful index for softness of cooked rice. A gel consistency test classifies high amylose rice into those with hard, medium or soft gel consistency; Soft gel is preferred over medium or high gel. From the study, it was found that all rice samples had hard gel and varied between 23–38 mm.

Perez (1979) suggested that differences in gel values may be due to the fat content, and the effect on gel consistency is probably caused by the formation of an amylose fatty acid complex. The higher fat content of the

outer layer of rice grain may explain the low values of gel consistency in brown rice and thus the degree of milling is very important factor affecting gel consistency.

Cooking characteristics

Among the rice samples, organic milled rice (16.5 min) exhibited the shortest cooking time while inorganic brown rice (27.8 min) the longest (*Table 2*). Brown rice required more time to cook as the bran layer interferes with the water diffussion into the grain during cooking (Rosniyana et al. 2002). The elongation ratio of all rice was less than 2 (1.57–1.90), which indicated that the rice samples did not elongate during cooking. The findings indicated that length expansion without increase in girth of rice samples did not occur and fresh samples of Maswangi may not have specialty characteristics (Rosniyana et al. 1994).

Water uptake ratio for inorganic milled rice (3.47) was the highest, while organic brown rice (2.80) had the lowest. In terms of volume of expansion, results varied from 3.15–3.80, with inorganic milled had a greater volume of expansion than other rice. Brown rice had lower values for both properties as it is limited by layers that enclose the endosperm (Sabularse et al. 1991). According to Juliano (1993), this layer around the starch granule serves as a physical barrier to water absorption. Also, the decrease in water uptake is attributed to the increase hardness of brown rice.

Some rice released more starch in cooking gruel than others and the results of this study showed that inorganic milled rice had the highest solid loss (0.74 ± 0.01) while organic brown rice had the lowest (0.41). The solid loss presence in the cooking gruel depends on the solubility of starch content in the rice and it is stated by Juliano (1993) that starch in cooking liquid is correlated with amylose content of the grain. Accordingly, brown and partially milled rice which had lower amylose content has significantly lower solid loss. This is

Table 3. Nutritional composition of brown rice and milled rice of Maswangi

Properties	Organic rice		Inorganic rice	
(mg/100 g sample)	Milled rice	Brown rice	Milled rice	Brown rice
Calcium	5.0 ± 0.5	48 ± 0.3	45 ± 0.3	54 ± 0.3
Potassium	69 ± 0.1	69 ± 0.1	49 ± 0.3	67 ± 0.5
Sodium	21 ± 0.1	47 ± 0.4	1.7 ± 0.5	45 ± 0.3
Magnesium	30 ± 0.3	152 ± 0.1	59 ± 0.1	174 ± 0.5
Iron	1.6 ± 0.1	7.5 ± 0.5	1.2 ± 0.5	6.4 ± 0.1
Phosphorous	123 ± 0.3	201 ± 0.1	89 ± 0.1	198 ± 0.5
Thiamine	0.23 ± 0.5	0.34 ± 0.3	0.34 ± 0.1	0.47 ± 0.3
Riboflavin	0.03 ± 0.5	0.04 ± 0.4	0.03 ± 0.3	0.03 ± 0.3
Niacin	1.5 ± 0.1	1.6 ± 0.5	1.9 ± 0.1	2.9 ± 0.5
Pyrodoxine	0.7 ± 0.5	0.45 ± 0.5	0.74 ± 0.1	0.60 ± 0.5

in agreement with the study conducted by Bhattacharya and Sowbhagya (1971). They stated that the amylose content of the starch that leached into the cooking water is influenced by the physical form of rice samples.

Minerals

Phosphorous is one of the major mineral constituents of rice and result showed that the level varied vastly from 89–201 mg/100 g (*Table 3*). The level of iron at 6.4–7.5 mg/100 g in brown rice is considerable nutritional significance (Tee et al. 1997). Potassium was found to be in varying amounts in the samples (49–89 mg/100 g sample). Magnesium was present within a range of 30–174 mg/100 g sample.

The mineral content may vary due to the influence of mineral content of the soil and the irrigation water for both organic and inorganic Maswangi rice samples (Juliano 1993). According to Kent (1985) the mineral content of rice is higher in brown rice than in milled rice as more minerals present in the outer layer of rice kernel than towards the centre, and there is considerable loss of minerals during milling and polishing of rice.

Vitamins

The samples contained varied amount of vitamins (*Table 3*). The riboflavin content was considered low (0.03–0.04 mg/100 g sample). An appreciable amount of niacin was present and the range varied between 0.15 and 2.9 mg/100 g sample. The samples had reasonable pyridoxine content (0.45–0.74 mg/100 g sample). Similarly with thiamine level, the range varied between 0.23 and 0.47 mg/100 g sample. The water-soluble vitamins were higher in the brown rice than in milled rice due to most of the vitamins were concentrated in the bran fraction. Milling process to remove the pericarp, seed coat, testa, aleurone layer and embryo to produce milled rice resulted in loss of vitamin (Juliano 1993).

Conclusion

Quality analysis of rice samples indicated that some differences existed in physical, physico-chemical and cooking characteristics of both organic and inorganic rice. Results also showed that rice of the same variety contained varying amount of nutrient composition. Brown rice had higher nutrient content than milled rice.

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Abstrak

Ciri-ciri fizikal, fiziko-kimia, memasak dan kandungan zat pemakanan bagi beras Maswangi yang baru dituai telah dikaji. Padi organik dan tak organik masing-masing diperoleh dari Kg. Ewa, Langkawi, Kedah dan Kubang Kerian, Kelantan. Sampel ini dinilai dalam bentuk padi, beras kisar dan beras perang. Ciri fiziko-kimia yang dinilai ialah kandungan amilosa, suhu penggelatinan dan konsistensi gel. Sampel yang dianalisis mempunyai suhu penggelatinan yang tinggi, manakala purata kandungan amilosa ialah 24.4. Gel yang keras dikesan pada sampel beras. Terdapat perbezaan dalam nilai masa memasak, isi padu mengembang, nisbah penyerapan air dan kehilangan pepejal larut. Nasi mempunyai nilai pemanjang kurang daripada 2 dengan beras baru tidak memanjang semasa masak. Ciri memasak menunjukkan beras perang mengambil masa yang lama untuk memasak dan mempunyai nilai dan isi padu mengembang yang rendah. Beras kisar untuk Maswangi organik mengandungi 8.57% protein dan 0.94% lemak pada lembapan 14.9%. Maswangi tak organik mengandungi 8.16% protein dan 2.56% lemak. Beras perang bagi beras organik dan tak organik mengandungi zat permakanan yang lebih tinggi daripada beras kisar terutama aspek kandungan protein, galian, tiamina dan riboflavin.