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Quality evaluation of retailed packed Malaysian milled rice sold in the market

(Penilaian mutu beras kisar Malaysia dibungkus secara runcit yang dijual di pasaran)

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Key words: milled rice, physical, chemical, cooking properties

Abstract

A total of 30 samples of local milled rice obtained from all the states in Peninsular Malaysia were studied. Evaluation assessed the grading criteria, physical properties, physico-chemical properties and cooking characteristics of milled rice. A total of 21 samples were graded as super rice, while 9 samples were categorised as premium rice which had a mean value of 19.8% broken rice. Rice was of long grain (7.0 mm) and the mean value for grain width was 1.88 mm. The rice was rated good for odour and insect was not present in all samples. The samples analysed had an intermediate and high gelatinization temperature while the mean amylose content was 24.4%. Hard gel was detected in all rice samples. Variations in cooking time, elongation ratio, volume of expansion, water uptake ratio and solid loss were observed. All rice had elongation ratio of less than 2 which indicated that they did not elongate during cooking.

Introduction

Paddy has to undergo a milling process before it can be consumed. The effect of milling on each variety is a great concern to the rice millers because it will influence the final product obtained. The millers demand good, clean, uniform grains that give high milling and a high percentage of whole kernel grain.

However, the milling quality of any paddy variety is influenced by the quality of paddy due to genetic and environmental factors, the post harvest treatment, type of milling system used and the processing conditions. Physical factors of grain such as white belly, white core, immature grain, damaged grain and grain size affect the milling quality of paddy.

In Malaysia, the market value of rice is based solely on the physical characteristics of the grain. Long grains fetch better price than medium or shorter grains. However, these characteristics do not reflect the quality of their cooked products. Cooking, eating and processing quality of rice are largely a function of starch characteristics, especially its amylose content, gelatinization temperature and pasting response. Other factors which are also significant are protein, aroma and grain elongation.

Current rice grades are categorised only as Super, Premium and Standard as compared to the nine categories in the previous grades (A1, A2, A3, A4, B1, B2, B3, B4 and broken rice grain). The main distinguishing feature between Premium and Standard grades is the grain size. The top grades, namely, Super are high quality rice, with high milling quality and low broken content (15%) having the specialty

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characteristics such as aromatic smell and superior quality (long grain). The Premium grade consists of ordinary white rice, which contains more than 60% longer grains with good milling quality and broken rice content must be lower than 45%. Those ordinary rice-containing medium grains attained through normal milling standards and consist of not more than 45% broken rice are graded as Standard.

In this study local milled rice from all the states in Peninsular Malaysia were used. Currently, data on the physical properties of local rice already exist (Ajimilah 1980) but the published information on cooking characteristics is not available. Cooking characteristics are measured by cooking time, elongation ratio, volume of expansion, water uptake ratio and solid loss. The main objective of this study was to evaluate the physical properties, physico-chemical properties and cooking characteristics of Malaysian milled rice. The milled rice was also graded to determine whether the packed milled rice was categorised according to the Malaysian Standards.

Materials and methods

A total of 30 retail packs, (5–10 kg) of milled rice were used in this study. Rice samples were obtained from shops and supermarkets in different locations in Peninsular Malaysia. At least three samples were obtained from these locations and each sample was analysed in duplicates. Their labellings indicating their grades were noted. Analytical methods used are described below.

Physical properties

The physical properties were determined according to the standard method described by Juliano et al. (1990). Rice was analysed for 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 Kett Model C-3 whiteness meter while colour was measured, with a Minolta Chroma Meter Model CR200 which expressed the L*, a*,b* notational system. 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 properties

Analyses for moisture and fat were carried out according to the methods of AOAC (1990). Protein was determined by Kjeldahl nitrogen method using Kjeltec System 1026 (Tecator 1978). Crude fibre was determined by Weende method using Fibertec system (Tecator 1978).

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 expressed in mm in a 13 mm x 100 mm test tube according to the method of Cagampang et al. (1973). The consistency of rice samples was classified as hard, medium and soft when the lengths of gel expansion were 26–40 mm, 41–60 mm and 61–100 mm respectively.

Cooking characteristics

The cooking characteristics were determined by boiling 8 g of rice sample in a cylindrical wire basket of 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 (1984).

Results and discussion

Physical properties

The mean values for various physical qualities of milled rice are given in *Tables 1* and *2.* Moisture content of rice sampled from the shops and supermarkets ranged from 11.0–13.4%. Being a stored product, the moisture level of rice was expected to be low and its role is important on the keeping qualities of rice during storage. Moisture levels commonly accepted for safe storage of rice are 13% for storage duration of less than six months and 12% for long-term storage. Moisture is a grading factor under Malaysian Rice standards where rice with more than 14% moisture content is designated as sample grade.

Foreign matter for the samples was either denoted as negligible (Neg.) or Nil. Foreign matter is defined as all matter other than rice which can be removed readily by the use of appropriate sieves and cleaning devices. However, impurities found in the

Table 1. Grading criteria of milled rices

Sample	Moisture content (%)	Foreign matter (%)	Broken (%)	Damaged grain (%)	No. of paddy
MKA1	11.7 ± 0.1	Neg	15.9 ± 2.5	0.6 ± 0.1	3
MKA2	11.7 ± 0.1	Nil	12.6 ± 0.7	0.8 ± 0	2
MKA3	11.9 ± 0	Nil	12.9 ± 0.5	1.0 ± 0.3	3
MKA4	11.8 ± 0.1	Nil	11.0 ± 0.1	1.4 ± 1.1	8
MKA5	12.1 ± 0.1	Nil	24.1 ± 0.4	2.5 ± 1.0	6
MKA6	11.0 ± 0	Nil	29.4 ± 1.1	1.5 ± 0.1	2
MKB1	11.0 ± 0	Neg	13.9 ± 1.1	0.4 ± 0.3	6
MKB2	13.4 ± 0.1	Nil	9.3 ± 0.1	1.7 ± 0.4	10
MKC1	11.0 ± 0	Neg	13.7 ± 3.0	0.7 ± 0.1	6
MKD1	11.7 ± 0.1	Nil	10.4 ± 0.6	0.7 ± 0.1	8
MKD2	11.2 ± 0.1	Nil	11.8 ± 1.1	1.2 ± 0.1	5
MKD3	11.7 ± 0.1	Nil	11.6 ± 1.3	2.3 ± 0.1	0
MKD4	11.5 ± 0	Nil	15.1 ± 0.1	2.9 ± 0.4	1
MKE1	11.3 ± 0.1	Neg	14.7 ± 1.0	0.3 ± 0.1	2
MKE2	11.0 ± 0	Nil	8.6 ± 0.6	0.2 ± 0	Nil
MKE3	11.0 ± 0	Nil	20.0 ± 0.6	Neg	Nil
MKF1	12.3 ± 0.1	Neg	10.7 ± 1.9	0.4 ± 0.3	5
MKF2	11.5 ± 0.1	Neg	15.0 ± 0.5	0.4 ± 0.3	3
MKF3	11.1 ± 0.1	Nil	7.1 ± 0.8	0.9 ± 0.1	3
MKG1	12.1 ± 0.1	Nil	27.2 ± 1.7	0.5 ± 0.1	1
MKI1	11.8 ± 0.1	Nil	15.0 ± 0.6	1.1 ± 0.1	1
MKI2	12.7 ± 0.1	Nil	19.7 ± 1.3	0.7 ± 0.1	2
MKJ1	12.4 ± 0.1	Nil	19.8 ± 0.7	1.4 ± 0	2
MKJ2	11.7 ± 0.1	Nil	6.4 ± 1.2	0.3 ± 0.1	1
MKJ3	11.0 ± 0.1	Nil	12.8 ± 1.7	1.4 ± 0	Nil
MKK1	11.7 ± 0.1	Nil	17.1 ± 0.1	Neg	Nil
MKK2	11.0 ± 0.1	Nil	20.9 ± 3.0	0.1 ± 0.1	3
MKK3	11.4 ± 0	Nil	9.6 ± 0.8	0.4 ± 0.3	5
MKK4	11.5 ± 0.1	Nil	11.8 ± 0.6	2.8 ± 0.6	4
MKK5	11.7 ± 0.1	Nil	11.9 ± 0.8	4.5 ± 0.4	2

Table 2. Physical qualities of milled rices

Sample	Bulk density (kg/HI)	Whiteness	Colour			Odour (mm)	Insect	Length (mm)	Width (mm)	Wt. of 1,000 grains (g)
			L	a	b					
MKA1	78.3 ± 0.2	42.4 ± 0.4	62.55	−0.61	+27.91	Good	Nil	7.27	1.81	18.5 ± 0.5
MKA2	80.7 ± 0.1	44.3 ± 0.5	75.64	−4.50	+14.65	Good	Nil	7.27	1.81	18.5 ± 0.5
MKA3	80.3 ± 0.1	48.1 ± 0.8	76.44	−4.45	+13.76	Good	Nil	7.52	2.01	19.4 ± 0.6
MKA4	79.4 ± 0.1	44.4 ± 0.3	75.70	−4.45	+14.39	Good	Nil	7.29	1.98	20.6 ± 0.3
MKA5	79.6 ± 0.2	44.9 ± 0.2	74.90	−4.17	+15.45	Good	Nil	7.26	1.99	20.5 ± 0.7
MKA6	80.6 ± 0.1	43.9 ± 0.6	76.07	−4.20	+16.20	Good	Nil	7.01	1.93	19.6 ± 0
MKB1	78.6 ± 0.2	NA	70.14	−3.95	+13.79	Good	Nil	7.00	1.94	19.8 ± 0.5
MKB2	75.6 ± 0.1	44.2 ± 0.2	70.16	−3.97	+13.47	Good	Nil	7.30	2.03	20.2 ± 0
MKC1	78.5 ± 0.1	NA	70.15	−4.00	+12.93	Good	Nil	7.14	1.96	18.6 ± 0.5
MKD1	85.3 ± 0.6	41.1 ± 0.6	70.05	−0.24	+10.10	Good	Nil	7.22	2.00	19.6 ± 05
MKD2	81.9 ± 0.1	48.4 ± 0.6	67.46	−4.14	+12.96	Good	Nil	7.11	1.97	19.2 ± 0.5
MKD3	80.4 ± 0.1	47.2 ± 0.1	75.07	−4.74	+14.42	Good	Nil	7.01	1.99	20.2 ± 0.3
MKD4	78.6 ± 0.1	39.9 ± 0.6	75.77	−4.68	+16.45	Good	Nil	7.03	1.96	19.2 ± 1.7
MKE1	80.5 ± 0.1	46.6 ± 0.5	76.50	−4.87	+14.72	Good	Nil	7.20	1.72	19.8 ± 0.5
MKE2	81.7 ± 01	44.4 ± 3.2	74.19	−4.41	+14.99	Good	Nil	7.25	1.82	19.8 ± 0.0
MKE3	81.4 ± 0.1	47.5 ± 0.6	78.20	−4.71	+14.58	Good	Nil	7.13	1.76	19.7 ± 0.1
MKF1	78.4 ± 0.1	39.5 ± 0.1	74.95	−4.47	+14.52	Good	Nil	7.09	1.86	19.2 ± 0.5
MKF2	78.9 ± 0.1	46.1 ± 0.3	76.28	−4.40	+15.19	Good	Nil	7.23	1.85	20.1 ± 0.7
MKF3	77.2 ± 0.1	42.8 ± 0.1	73.25	−3.98	+15.38	Good	Nil	7.21	1.87	20.1 ± 0.1
MKG1	79.4 ± 0.1	44.5 ± 0.3	75.83	−4.34	+15.26	Good	Nil	7.51	1.76	20.5 ± 0.1
MKI1	81.9 ± 0.1	46.4 ± 1.6	75.68	−4.50	+15.98	Good	Nil	7.40	1.79	20.4 ± 0.4
MKI2	83.4 ± 0.1	45.5 ± 1.3	75.67	−4.30	+14.77	Good	Nil	6.98	1.72	20.4 ± 0.4
MKJ1	83.4 ± 0.1	43.7 ± 0.4	74.72	−4.34	+17.16	Good	Nil	7.09	1.73	19.2 ± 0.0
MKJ2	77.8 ± 0.1	44.6 ± 1.1	74.34	−4.18	+14.31	Good	Nil	7.31	1.82	20.4 ± 0.3
MKJ3	81.3 ± 0.1	42.3 ± 0.1	72.66	−4.20	+14.75	Good	Nil	7.52	1.72	19.4 ± 0.0
MKK1	78.4 ± 0.1	46.8 ± 0.1	77.15	−4.21	+15.31	Good	Nil	7.18	1.81	20.0 ± 0.0
MKK2	82.3 ± 0.1	45.0 ± 0.4	76.53	−4.47	+16.37	Good	Nil	7.18	1.81	18.5 ± 0.40
MKK3	80.3 ± 0.1	47.9 ± 0.2	75.91	−4.55	+13.85	Good	Nil	7.21	2.01	20.4 ± 0
MKK4	81.9 ± 0.1	45.9 ± 0.1	74.01	−4.53	+15.53	Good	Nil	7.13	2.02	21.2 ± 0.3
MKK5	82.4 ± 0.1	47.0 ± 0.7	76.04	−4.51	+15.33	Good	Nil	7.32	2.01	20.7 ± 0.4

samples were similar to rice size, shape and density that made it difficult to remove by screening, sieving or aspiration.

Grading of milled rice involved discharging the head rice and broken rice from the respective bins in preset quantities into a mixer, then weighing and packing. According to the Malaysian Standards, 21 of the total samples (30) analysed can be graded as Super grade with broken rice ranging from 6.4–15.0%. Other rice samples (9) were graded as premium rice which had a mean value of 19.8% broken rice. It was reported by Juliano (1985a) that a high percentage of broken grains are indicative of poor milling qualities. All rice markets discriminate greatly against broken rice since its value is only 30–50% of whole grain. It is therefore, important to determine accurately the amount and types or classes of broken grains in a sample of milled rice.

Damaged grains of the analysed samples ranged from 0.1 ± 0.1 to 4.5 ± 0.4% in 28 of the milled rice samples while that in MKE3 and MKK1 samples had negligible damaged grains. Webb (1985) defined damaged grains as grains and pieces of kernels of rice, which are distinctly discoloured or damaged by water, insects, heat or by other means. Damaged rice samples might occur in the field prior to harvesting, during drying operations, or subsequent storage and handling.

The average number of paddy found in the samples was 3. Juliano (1985a) reported that the paddy present may be difficult to remove because they have approximately the same size, shape and density as milled rice. Moreover, they cannot be recovered by proper rescreening or recleaning.

Bulk density, to measure the weight of a known volume of rice is particularly useful as a relative indicator of total milled yields. The average bulk density for the analysed rice was 80.28 kg/litre. The values varied considerably as it is influenced by such factors as amount of dockage and grain type.

Important property of milled rice that relates to the degree of milling is whiteness. The milled rice samples recorded whiteness values ranging from 41.1 ± 0.6 to 48.4 ± 0.6. Juliano (1985a) reported that well milled rice has whiteness values between 38–48 and produced at 7–8% milling degree. Accordingly, the analysed samples were grouped as well milled rice. The highest value of whiteness found in MKD2 sample was mainly due to the milling process. The whiteness of rice increases 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).

The lightness value (L*) of rice samples varied from 62.55–78.20. Variations for hue appear in milled rice might occur as a result of under milling, delayed drying and storage under unfavourable conditions as suggested by earlier study (Indudhara Swamy et al. 1971). Measurements of changes in lightness have been used to monitor changes in rice during storage. The colour of milled rice ranged from white to dark grey or rosy. Rosy colour occurred when rice is milled with larger quantities of weed to red rice, where the bran from the red rice stained the endosperm of cultivated variety. Primo et al. (1970) reported that during storage the b* and a* values generally increased, while the L value generally decreased. Results suggested that samples with lower L values and higher b* and a* might indicate aged milled rice; however, a different study should be conducted to confirm the results.

The odour of the samples was rated good and this can be associated with clean and sound milled rice. No insect infestation was observed in all the samples. As infestation is common to badly damaged rice, results suggested that milled rice were in good conditions.

The physical dimensions, weight and uniformity of rice grains are primary quality factors in marketing and processing of end-use products. Length is a measure of the milled rice in its greatest dimension. According to length, rice can be classified into long (>6.2 mm), medium (5.20–6.19 mm) and short (<5.5mm) (Jennings et al. 1979). All rice was found to be classified under long grain as the length varies between 6.98–7.52 mm. The average value for grain width was 1.88 mm. From the consumers' point of view, medium to long slender grains are preferred (Ajimilah 1980).

The grain weight (size) of the samples, determined by measuring the weight of 1,000 grain representative sample, ranged between 18.5–20.7 g. Accordingly, the samples were classified as a moderately heavy since the weighed samples were below 20.0 g.

Physico-chemical properties

The physico-chemical properties of milled rice are presented in *Table 3*. The protein content of milled rice was relatively low, ranging from 8.8 ± 0.01% to 8.46 ± 0.04%. According to Juliano (1985b), protein contents are significantly influenced by variety, environment, crop, season and nitrogen fertilization.

Low fat content was detected among the samples with mean value of 0.38%. Amongst those samples studied, MKI2 (0.21 ± 0.01%) had the lowest while MKC1 (0.62 ± 0.02%) had the highest fat content. It was reported by Rosniyana et al. (1994) that the fat content is low in the milled rice, as much of the fat, which is found in the bran and embryo, is lost during milling.

The crude fibre content of milled rice ranged from 0.17 ± 0.01% to 0.33 ± 0.01% Most of the fibres are concentrated in the bran fraction (Juliano 1985b). The adoption of abrasive or friction milling process to remove the pericarp, seed coat, testa, aleurone layer and embryo to produce milled rice results in the loss of fibre (Rosniyana et al. 1997)

Cooking and eating characteristics of milled rice are influenced by the ratio of amylose and amylopectin. It was observed that all rice samples had intermediate amylose contents ranging from 20.24 ± 0.35% to 24.31 ± 0.23%. 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 decreased as the mean temperature increased. In addition, the amylose content was also influenced by the nitrogen fertilization whereby the value decreased slightly with the nitrogen fertilization but was not affected by time of nitrogen application (Paule et al. 1979).

Other properties of starch which is equally important in characterizing milled rice is the gelatinization temperature. With the exception of MKA1, MKA2 and MKE3 samples which were classified as having intermediate gelatinization temperature (70–74 °C), the other rice samples were found to have high gelatinization temperature (>74 °C). Studies have shown that the degree of starch crystallinity, molecular size, branching of amylopectin fraction and the diffraction intensity of the amylose in rice are related to its gelatinization (Juliano and Bechtel 1985). Champagne et al. (1990) reported that a high ambient temperature during grain development results in a starch with higher gelatinization temperature.

Gelatinization temperature was estimated by the extent of alkali spreading of soaked milled rice in alkali solution. Rice with alkali spreading values between 4.0–5.0, which indicating only partial disintegration, were indicative of an intermediate gelatinization temperature. While rice with high gelatinization temperature remained largely unaffected by the alkali solution having alkali spreading values ranging from 3.0–3.6.

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;

Table 3. Physico-chemical properties of milled rices

Sample	Protein (%)	Fat (%)	Crude fibre (%)	Amylose content (%)	Alkali spreading value	Gelatinization temperature	Gel consistency (mm)
MKA1	7.47 ± 0.02	0.40 ± 0.01	0.22 ± 0.02	20.98 ± 0.19	5.0	Intermediate	30 ± 1
MKA2	7.56 ± 0.04	0.53 ± 0.02	0.21 ± .01	21.78 ± 0.23	4.0	Intermediate	28 ± 1
MKA3	7.28 ± 0.0	0.23 ± 0.01	0.24 ± 0.01	20.24 ± 0.06	3.2	High	26 ± 0
MKA4	7.76 ± 0.01	0.25 ± 0.01	0.23 ± 0.02	23.38 ± 2.24	3.0	High	23 ± 0
MKA5	7.45 ± 0.04	0.45 ± 0.01	0.21 ± 0.0	21.55 ± 0.11	3.4	High	28 ± 0
MKA6	7.48 ± 0.05	0.49 ± 0.01	0.22 ± 0.01	22.05 ± 0.57	3.2	High	29 ± 2
MKB1	7.38 ± 0.10	0.48 ± 0.01	0.26 ± 0.02	20.93 ± 0.55	3.6	High	27 ± 1
MKB2	6.88 ± 0.01	0.48 ± 0.01	0.21 ± 0.0	24.22 ± 0.55	3.0	High	28 ± 0
MKC1	7.63 ± 0.22	0.62 ± 0.02	0.25 ± 0.02	22.66 ± 0.01	3.1	High	26 ± 1
MKD1	6.89 ± 0.22	0.37 ± 0.01	0.26 ± 0.01	23.24 ± 0.31	3.8	High	29 ± 0
MKD2	7.40 ± 0.19	0.35 ± 0.02	0.21 ± 0.02	22.50 ± 0.60	3.4	High	29 ± 0
MKD3	7.71 ± 0.04	0.25 ± 0.01	0.17 ± 0.01	23.42 ± 0.65	3.8	High	25 ± 2
MKD4	7.26 ± 0.03	0.52 ± 0.01	0.23 ± 0.0	21.62 ± 0.11	3.4	High	29 ± 0
MKE1	7.40 ± 0.02	0.43 ± 0.01	0.23 ± 0.01	23.53 ± 0.26	3.5	High	28 ± 0
MKE2	7.74 ± 0.04	0.33 ± 0.01	0.24 ± 0.01	23.05 ± 0.19	3.1	High	38 ± 1
MKE3	7.61 ± 0.10	0.33 ± 0	0.26 ± 0.01	23.61 ± 0.08	4.2	Intermediate	36 ± 3
MKF1	7.39 ± 0.01	0.28 ± 0	0.22 ± 0.01	21.74 ± 0.56	3.2	High	34 ± 4
MKF2	7.73 ± 0.08	0.34 ± 0.01	0.33 ± 0.02	21.66 ± 0.03	3.0	High	32 ± 1
MKF3	8.31 ± 0	0.34 ± 0.01	0.33 ± 0.02	21.14 ± 0.02	3.2	High	32 ± 0
MKG1	7.63 ± 0.02	0.43 ± 0.04	0.25 ± 0.02	20.49 ± 0.44	3.6	High	32 ± 1
MKI1	7.40 ± 0.02	0.38 ± 0.02	0.26 ± 0.01	22.85 ± 0.07	3.6	High	27 ± 1
MKI2	6.81 ± 0.02	0.21 ± 0.01	0.21 ± 0.02	22.88 ± 0.20	3.0	High	27 ± 3
MKJ1	7.64 ± 0.44	0.42 ± 0.01	0.17 ± 0.01	21.62 ± 0.28	3.0	High	27 ± 0
MKJ2	7.48 ± 0.09	0.39 ± 0	0.23 ± 0.0	21.42 ± 0.01	3.1	High	27 ± 0
MKJ3	8.05 ± 0.04	0.39 ± 0	0.23 ± 0.01	24.31 ± 0.23	3.4	High	29 ± 0
MKK1	7.70 ± 0.03	0.46 ± 0	0.24 ± 0.01	20.59 ± 0.35	3.1	High	30 ± 0
MKK2	8.46 ± 0.04	0.44 ± 0.02	0.26 ± 0.01	23.82 ± 0.29	3.2	High	29 ± 1
MKK3	7.60 ± 0.02	0.33 ± 0.01	0.22 ± 0.01	22.29 ± 0.01	3.0	High	30 ± 1
MKK4	7.43 ± 0.03	0.25 ± 0	0.33 ± 0.02	21.34 ± 0.16	3.2	High	32 ± 1
MKK5	7.80 ± 0.10	0.25 ± 0.02	0.33 ± 0.02	22.61 ± 0.54	3.6	High	29 ± 1

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 was probably caused by the formation of an amylose fatty acid complex. Some rice may show hardening effect during progressive aging where the gel consistency of aged samples was significantly reduced as compared to unaged samples (Rosniyana et al. 2002).

Cooking characteristics

Among the rice samples, MKA1 (17.2 min) exhibited the shortest cooking time and MKI2 (18.88 min) the longest *(Table 4)*. Differences in cooking time of different rice are subjected to variety differences, especially related to gelatinization temperature (Juliano and Perez 1983). Bhattacharya and Sowbhagya (1971) stated that water uptake and therefore, cooking time was highly influenced by size and shape of grain.

The elongation of all rice was less than two (1.57–1.90), which indicated that the rice samples did elongate during cooking. The findings indicated that length expansion without increase in girth of rice samples did not occur and samples may not have specialty characteristics.

Table 4. Cooking characteristics of milled rice

Sample	Cooking time (min)	Elongation ratio	Volume of expansion	Water uptake ratio	Solid loss
MKA1	17.23 ± 0.02	1.60	3.60 ± 0.01	3.31 ± 0.03	0.41 ± 0.03
MKA2	17.73 ± 0.06	1.70	3.58 ± 0.02	3.30 ± 0.02	0.53 ± 0.01
MKA3	17.45 ± 0.06	1.70	3.67 ± 0.01	3.33 ± 0.01	0.62 ± 0.01
MKA4	17.45 ± 0.03	1.70	3.61 ± 0.01	3.31 ± 0.01	0.44 ± 0.00
MKA5	17.73 ± 0.05	1.63	3.77 ± 0.01	3.31 ± 0.01	0.46 ± 0.01
MKA6	18.30 ± 0.01	1.73	3.60 ± 0.06	3.27 ± 0.01	0.55 ± 0.01
MKB1	18.23 ± 0.02	1.65	3.51 ± 0.01	3.18 ± 0.03	0.54 ± 0.01
MKB2	17.73 ± 0.01	1.66	3.67 ± 0.01	3.35 ± 0.01	0.54 ± 0.01
MKC1	17.23 ± 0.02	1.69	3.58 ± 0.02	3.22 ± 0.02	0.57 ± 0.01
MKD1	18.00 ± 0.00	1.68	3.72 ± 0.01	3.36 ± 0.02	0.45 ± 0.02
MKD2	17.30 ± 0.05	1.69	3.63 ± 0.01	3.37 ± 0.02	0.46 ± 0.01
MKD3	17.45 ± 0.00	1.62	3.72 ± 0.02	3.38 ± 0.01	0.48 ± 0.00
MKD4	17.73 ± 0.01	1.57	3.66 ± 0.02	3.38 ± 0.01	0.49 ± 0.00
MKE1	17.30 ± 0.00	1.60	3.64 ± 0.02	3.38 ± 0.00	0.45 ± 0.00
MKE2	18.38 ± 0.02	1.66	3.66 ± 0.06	3.45 ± 0.03	0.38 ± 0.00
MKE3	18.38 ± 0.05	1.70	3.66 ± 0.06	3.45 ± 0.06	0.39 ± 0.00
MKF1	18.10 ± 0.05	1.71	3.74 ± 0.02	3.33 ± 0.02	0.46 ± 0.01
MKF2	18.30 ± 0.01	1.73	3.78 ± 0.02	3.47 ± 0.05	0.47 ± 0.00
MKF3	18.00 ± 0.04	1.64	3.39 ± 0.01	3.29 ± 0.06	0.49 ± 0.00
MKG1	18.40 ± 0.02	1.62	3.68 ± 0.02	3.33 ± 0.01	0.44 ± 0/02
MKI1	18.38 ± 0.02	1.80	3.53 ± 0.01	3.33 ± 0.01	0.30 ± 0.00
MKI2	18.80 ± 0.04	1.90	3.63 ± 0.03	3.37 ± 0.02	0.37 ± 0.01
MKJ1	18.73 ± 0.00	1.80	3.68 ± 0.03	3.36 ± 0.02	0.47 ± 0.00
MKJ2	18.40 ± 0.05	1.78	3.72 ± 0.02	3.31 ± 0.01	0.39 ± 0.00
MKJ3	18.30 ± 0.02	1.69	3.57 ± 0.01	3.30 ± 0.02	0.47 ± 0.00
MKK1	18.23 ± 0.04	1.62	3.79 ± 0.01	3.27 ± 0.01	0.52 ± 0.01
MKK2	18.23 ± 0.05	1.73	3.72 ± 0.02	3.30 ± 0.02	0.47 ± 0.01
MKK3	18.15 ± 0.02	1.66	3.74 ± 0.04	3.32 ± 0.02	0.58 ± 0.02
MKK4	18.45 ± 0.01	1.67	3.39 ± 0.01	3.30 ± 0.00	0.47 ± 0.01
MKK5	18.00 ± 0.05	1.64	3.75 ± 0.01	3.40 ± 0.01	0.43 ± 0.01

Water uptake ratio for MKF2 (3.47 ± 0.02) was the highest among the rice, while MKB1 (3.18 ± 0.02) exhibited the lowest. These may be attributed to varietal differences. Bhattacharya and Sowbhagya (1971) showed that different rice varied widely in apparent water uptake on cooking for any given period. Time constant for water reported by Metcalf and Lund (1985) indicated similar observations. Other study by Rosniyana et al. (2002) stated that water uptake is significantly higher for aged rice where aged rice is more resistant to disintegration during cooking and the cell wall seems more resistant to disruption during grain swelling.

In terms of volume of expansion, results varied from 3.39–3.79, with MKK1 had a greater volume of expansion than other rice. It was observed by Rosniyana et al. (2002) that volume of expansion depends on the age of the rice. Aged rice had higher volume of expansion than new rice since aging provides hardening resiliency of cell walls, thereby resisting high pressures developed inside the cell during the cooking process.

Some rice released more starch in cooking gruel than others and results showed that MKA3 (0.62 ± 0.01) had the highest solid loss while MKI1 (0.30 ± 0.01) had the lowest. Differences in solid loss in rice had been reported by Sabularse et al. (1991) who stated that solid loss was affected by the length of grain, as indicated by higher amounts of starch present in cooking liquid of long grain varieties than shorter grain rice. Similar observations were also found in this study. Other study by Priestley (1977) reported that starch in cooking gruel is correlated with amylose content of the grain. Solid loss of rice is influenced by aging process and it reduces significantly in stored rice as reported by Rosniyana et al. (2002).

Conclusion

The Malaysian milled rice was labelled accordingly and complied to the Malaysian Standard. Twenty-one and nine samples were analysed as super and premium rice respectively. The rice was long grain with mean value of 7.0 mm. It was also suggested that the physical quality of milled rice was desirable as indicated by the absence of insect found and also the good odour of rice tested.

The chemical composition and physico-chemical properties of 30 rice samples showed considerable variations. All rice had intermediate amylose content while high gelatinization temperature was found in 27 rice samples. Rice samples also contributed to differences in cooking characteristics, whereby all samples did elongate during cooking and the solid present in cooking liquid was higher in long grain than the shorter ones.

Future work

A variation in the various qualities was shown to exist among the rice samples. It would, however, be desirable to extend this study to greater number of samples. It is worthy for further investigations on samples with respect to variety and other parameters. This is useful for quality selections which may contribute in the development of rice products.

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Abstrak
Sejumlah 30 sampel beras kisar tempatan yang diperoleh dari semua negeri di Semenanjung Malaysia telah dikaji. Penilaian menentukan kriteria penggredan, ciri fizikal, ciri fisiko-kimia dan sifat memasak beras kisar. Sebanyak 21 sampel digredkan sebagai beras super, manakala 9 sampel dikategori sebagai beras premium yang mempunyai nilai purata beras hancur sebanyak 19.8%. Semua beras ialah beras panjang (7.0 mm) dan mempunyai nilai purata 1.88 mm bagi lebar beras. Beras mempunyai bau yang baik dan serangga tidak didapati di dalam semua sampel. Sampel yang dianalisis mempunyai suhu penggelatenan sederhana dan tinggi, manakala nilai purata kandungan amylose ialah 24.4%. Gel konsistensi keras dikesan bagi semua sampel beras. Perbezaan dalam masa memasak, nisbah memanjang, nisbah isi padu mengembang, nisbah penyerapan air dan kehilangan pepejal telah dikesani. Semua beras mempunyai nisbah memanjang kurang daripada 2 dan ini menunjukkan beras tidak memanjang semasa memasak.

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