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Physicochemical, Vitamin B and Sensory Properties of Rice Obtained by System of Rice Intensification (SRI)

(Ciri Fizikokimia, Vitamin B dan Sensori Beras melalui Sistem Keamatan Padi (SRI))

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ABSTRACT

Organic rice using different cultivation methods namely system of rice intensification (SRI) and local organic rice (BOT) were studied and compared with conventional non organic rice (BBO). One kg of the SRI organic rice was obtained from research plot in Tunjung, Kelantan. Physical and cooking properties were determined using the average weight of 100 kernel, length-breadth ratio (L/B ratio), minimum cooking time, water uptake ratio and percentage of gruel solid loss. Amylose content was determined by iodine-binding method. Thiamine and niacin content were determined by HPLC. Results of the study showed that weight of non organic rice (21.2 mg) was significantly higher ($p \leq 0.05$*) than SRI organic rice (19.7 mg) or conventional (19.4 mg). Minimum cooking time of SRI organic rice was 19.5 min. The amylose content of conventional rice was the highest (16.6%) followed by SRI organic rice (15.6%) and conventional organic rice (15.3%). Vitamin *B_1* and *B_3* contents of organic rice were higher than non-organic rice. The means sensory score of all attributes of SRI cooked rice were the highest. Thus it can be concluded that rice cultivated using SRI resulted in comparatively better physicochemical characteristics and sensory quality compared with other methods.*

Keywords: Physicochemical; sensory; system of rice intensification; vitamin B

ABSTRAK

Beras organik melalui kaedah penanaman berbeza iaitu sistem keamatan padi (SRI) dan konvensional telah dikaji dan dibandingkan dengan beras bukan organik konvensional. Satu kg sampel beras organik SRI diperoleh dari plot kajian SRI di Tunjung, Kelantan. Ciri fizikal dan memasak ditentukan melalui purata berat 100 biji beras, nisbah panjang-lebar, masa memasak minimum, nisbah penyerapan air dan peratus kehilangan pepejal kanji. Kandungan amilosa ditentukan dengan kaedah pengikat-iodin. Kandungan thiamin dan niasin ditentukan dengan kaedah HPLC. Berat sebiji beras bukan organik (21.2 mg) adalah lebih tinggi ($p \leq 0.05$*) daripada beras organik SRI (19.7 mg) atau beras konvensional (19.4 mg). Masa memasak minimum beras organik SRI adalah paling lama iaitu 19.5 min. Kandungan amilosa beras bukan organik paling tinggi (16.6%) diikuti beras organik SRI (15.6%) dan konvensional (15.3%). Kandungan vitamin *B_1* dan *B_3* bagi beras organik adalah lebih tinggi berbanding beras bukan organik. Min skor sensori bagi semua atribut sampel nasi SRI adalah paling tinggi. Beras yang ditanam melalui SRI mempunyai ciri fizikokimia dan kualiti sensori yang lebih baik berbanding beras konvensional atau beras organik konvensional.*

Kata kunci: Fizikokimia; sensori; sistem keamatan padi; vitamin B

INTRODUCTION

Rice (*Oryza sativa* L.) is a staple food for most of the world population. In Malaysia, rice cultivation is one of the leading crop and the source of employment and livelihood of the farmers. According to BERNAS (2007), Malaysian used approximately 2.2 million t of rice per year. However, the rice production in Malaysia is not enough to meet the demand of rice in the country. Hence, Malaysia has to import about 30% of its annual requirements. Shekhar and Jayesh (2007) reported that United Nation predicted the demand of rice will be increased to 38% in 30 years while the production of rice seemed to decline.

The decrease in rice yield is mainly due to insufficient amount of water to irrigate the rice field. Likewise the source of water is scarce in the dry and semi arid area. Thus many farmers had switched to the crop that requires less water (Shekhar & Jayesh 2007). Natural disasters such as drought, floods and cyclones and rainfall patterns affect the yield of rice production (Latif et al. 2005).

System of rice intensification (SRI) is a newly approached rice cultivation system in Malaysia. Claims have been made that SRI can increase the rice yield while reducing the need for water for rice production and management cost (Chapagain & Yamaji 2010) as well as maintaining the soil fertility (Latif et al. 2005). A study conducted in Andra Pradesh, India showed an increased in rice yield to 8.1 t ha by SRI as compared with 5.67 t per ha by conventional method (Shekhar & Jayesh 2007). Many evidences indicated that SRI increased the yield of rice using less water as summarized by Satyanarayana et al. (2007) from the independent assessments done where

SRI is adopted. Meanwhile, for conventional agriculture, more chemical fertilizers are needed as the soil are getting degraded and environment deteriorated resulting in declining of crop yield (Conacher & Conacher 1998; Liu et al. 1996; Reganold 1995). Shekhar and Jayesh (2007) explained that excessive use of agrochemicals such as chemical fertilizers damaged the soil biota. Hence, SRI can be seen as an alternative method to replace the conventional method in rice cultivation.

The public concerns towards a healthy lifestyle has increased the demand for healthier foods. They are aware that chemicals such as fertilizers and pesticide used during cultivation and food processing are harmful to health (Saba & Messina 2003). These perceptions lead to the increasing demand of quality organic food products. The quality is measured based on the taste and appearance effect on health, convenient and process. Organic food products fulfil all the properties and accepted due to more pleasant taste and healthier as well as the process is less damaging to the environment as compared with conventionally processed food products (Gracia & de Magistris 2008).

In Malaysia, low cost organic rice can be produced by SRI and marketed with low price due to an increase in rice yield, low management cost while at the same time maintaining soil fertility. This will encourage more farmers to adopt SRI in rice cultivation. To date, no reported data on physicochemical and sensory properties of rice cultivated by SRI. Thus, the objectives of this study were to compare the physicochemical and sensory properties of organic rice cultivated by system of rice intensification (SRI) and conventional with conventional non-organic rice.

Materials and Methods

SAMPLES COLLECTION AND PREPARATION

Rice Medium grain polished white rice was selected for all samples. Three samples of 1 kg organic rice cultivated by SRI and conventional (BOT) were procured from the research plot in Tunjung, Kelantan and Kahang, Johor, respectively. Conventional non-organic rice (BBO) was procured from the local stores. Moisture content of samples was 13-14%. Samples were stored in polyethene bags at 4°C until further analysis.

Cooked Rice Samples were prepared by cooking 100 g raw rice kernel into 300 mL boiling water in a rice cooker with lid for 20 min. After cooking, rice water was drained and cooked rice were kept in airtight containers and stored at -20°C until further analysis.

Rice Powder Samples were ground into fine powder using hammer mill machine (MF 10 Basic IKA WERKE, Germany) then passed through 100 μm sieves. Rice powder were kept in air-tight container and stored at 4°C until further analysis.

Methods

PHYSICAL PROPERTIES

The physical properties of rice were determined according to the method by Singh et al. (2005) with modification. One hundred head rice kernels of milled rice from each variety were counted randomly in triplicate and weighed separately. Length- and breadth-wise arrangement of 10 randomly selected milled rice from each variety with similar size, shape and length was done and their cumulative measurements (in mm) were taken. The ratio of length to breadth (L/B ratio) was determined by dividing length by breadth.

COOKING PROPERTIES

Cooking properties of rice were determined according to the method by Singh et al. (2005). Minimum cooking time was determined by weighing 2 g of head rice samples from each variety into a test tube. The samples were cooked in 20 mL distilled water in a boiling water bath. After 10 min and every min after, 10 cooked rice were taken and pressed between two glass plates. Minimum cooking time was recorded when there was no white core left. Water uptake ratio was determined by weighing 2 g of rice samples from each variety into 20 mL distilled water in a boiling water bath for minimum cooking time. The slurry was drained and the cooked rice were pressed in filter paper sheets to remove the excess water. The cooked samples were weighed and water uptake ratio was calculated. Length- and breadth-wise arrangement of 10 randomly selected cooked rice from each variety with similar size, shape and length was done and their cumulative measurements (in mm) were taken. The ratio of length to breadth was determined by dividing length by breadth. Gruel solid loss was determined by cooking 5 g of rice sample from each cultivar in 100 mL distilled water for a minimum cooking time. The gruel was transferred to 100 mL beaker with several washing and distilled water was added to 100 mL. The aliquot having leached solids was evaporated at 110°C until completely dry. The solids were weighed and percent gruel solids were reported.

CHEMICAL PROPERTIES

Determination of Amylose Content The amylose content was determined according to the method of Mariana et al. (2010) with modification. Rice flour samples (100 mg) were homogenized with 1 mL of 95% ethanol and 9 mL of 1 M NaOH. The sample was heated for 10 min in a boiling water bath to gelatinize the starch. The sample was cooled and transferred to 100 mL volumetric flask and distilled water was added to 100 mL. To an aliquot of 5 mL, 1 mL of 1 M acetic acid and 2 mL of iodine solution (0.2% of iodine in 2% potassium iodide) were added. The solution was made up to 100 mL with distilled water and left to stand under dim light for 20 min. The absorbance of the solution was measured at 620 nm by using a UV-Vis spectrophotometer (Model UNICAM, England). Amylose content of the sample was determined using a standard curve for amylose.

DETERMINATION OF VITAMIN B

Extraction of Vitamin B Vitamin B_1 (thiamine) of rice powder and cooked rice were extracted according to the method by Ndaw et al. (2000). Briefly, 10 mL of 0.1 M hydrochloric acid was added to 1 g of sample. The mixture was autoclaved at 121°C for 30 min. After the solution was cooled, it was adjusted to pH4.5 with 2.5 M sodium acetate. Vitamin B_3 (niacin) was extracted according to method by Augustin (1966). Briefly, 10 mL of 1 N sulphuric acid was added to 1 g sample. The mixture was autoclaved at 121°C for 30 min. Then, the mixture was allowed to cool before it was adjusted to pH6.8 using 1 N NaOH solution. An aliquot of 1 mL of the extract was filtered into vial using Milipore membrane filter for chromatographic separation.

Preparation of HPLC Vitamin B was determined according to the method by Mithu et al. (2008) with some modification. A high pressure liquid chromatography (Model UFLC Shimadzu, Kyoto, Japan) with a SymmetryShield™ RP 18 (3.9 × 150 mm, i.d., 5 µm) column were used. The mobile phase consisting methanol : glacial acetic acid : water, 24.5 : 0.5 : 75 (v/v/v) was used. A series of freshly prepared standard solution consisting of thiamine and nicotinic acid were prepared with distilled water. The separation was performed at flow-rate of 1 mL/min with the retention time of 12 min. The volume of injected sample was 20 mL.

Sensory Evaluation Cooked rice was prepared according to the method of Yu et al. (2009) with some modifications. Briefly, 200 g sample were rinsed 3 times with water and cooked in 500 mL of distilled water in an electric rice cooker (Model SR-M22UA Panasonic, Malaysia) for 30 min. Then, cooked rice were left warm in the rice cooker while the sensory assessment were carried out. Randomly selected of fifty students from the School of Chemical Science and Food Technology, Universiti Kebangsaan Malaysia served as panellists in the study. Each panellist was given 30 g of sample served in a coded plastic plate. They were asked to rate the score of aroma, colour, softness, stickiness and overall acceptance on a 7-hedonic scale.

STATISTICAL ANALYSIS

Data was reported as mean and analyzed by a one-way analysis of varians (ANOVA) test using Statistical Packages for the Social Sciences (SPSS) software version 18.0 (SPSS Inc., Chicago, Illinois, USA). The level of significance used was $p \leq 0.05$.

RESULTS AND DISCUSSION

PHYSICAL AND COOKING PROPERTIES

The weight of single-kernel rice of conventional non-organic (BBO) rice was significantly ($p \leq 0.05$) higher (21.2 mg) than SRI organic rice (19.7 mg) or conventional organic rice (BOT) (19.4 mg) as shown in Table 1. Rosniyana et al. (2006) reported that the range of weight of single-kernel of 30 samples of milled rice in Malaysia were 18.5 to 20.7 mg. Adu-Kwarteng et al. (2003) claimed that rice grain weight below 20 mg indicated the presence of immature, damage or unfilled grain. The length- breadth ratio of SRI, BOT and BBO were not significantly different ($p > 0.05$). SRI had the highest length-breadth ratio (4.87) followed by BOT (4.65) and BBO (4.60). The range of length-breadth ratio of 30 samples of milled rice in Malaysia were 3.52 to 4.27 as reported by Rosniyana et al. (2006). The minimum cooking time of SRI was the highest (19.5 min) and significantly different ($p \leq 0.05$) from BOT (16.5 min) or BBO (16.0 min). Rosniyana et al. (2010) reported that the minimum cooking time of *Maswangi* organic rice and non-organic rice was 16.5 min and 17.5 min, respectively. Water uptake ratio of SRI, BOT and BBO were not significantly different ($p > 0.05$) which were 3.75, 3.77 and 3.82, respectively. According to Sarbularse et al. (1991), low cooking time is probably due to the milling process of the rice as the process will break the starch and expose the endosperm structure of rice. As a result, water uptake ratio will increase. The length-breadth ratio of cooked rice of SRI was the highest (4.32) but not significantly different ($p > 0.05$) from BOT (3.97) and BBO (3.84). SRI had the highest percentage of gruel solid loss (11.1%) followed by BOT (10.7%) and BBO (8.1%). Salleh and Meullenet (2007) claimed that solid leached is affected by the degree of milling and cooking time. During cooking, starch in rice absorbed moisture and swell due to gelatinization process. Continuous heating in the presence

TABLE 1. Physical and cooking characteristics of rice varieties

Varieties	Hundred kernel weight (g)	L/B of rice ratio	Minimum cooking time (min)	Water uptake ratio	L/B of cooked rice ratio	% Gruel solid loss
SRI	19.7^{b}	4.87^{a}	19.5^{a}	3.75^{a}	4.32^{a}	11.1^{a}
BOT	19.4^{b}	4.65^{a}	16.5^{b}	3.77^{a}	3.97^{a}	10.7^{a}
BBO	21.2^{a}	4.60^{a}	16.0^{b}	3.82^{a}	3.84^{a}	8.1^{b}

$^{a\text{-}b}$ Means with different letters within a column are significantly different ($p \leq 0.05$)
SRI System of rice intensification
BOT Conventional organic rice
BBO Conventional non-organic rice

of water caused the solid to leach into the gruel. According to Narpinder et al. (2005), solid leached is affected by the length-breadth ratio. As the length-breadth ratio increased, solid leached also increased due to the increase in the surface area of rice contact with water. Nierle et al. (1981) suggested that high value in solid leached is probably due to the protein, fats and mineral contents in rice that leached into the gruel during cooking.

CHEMICAL PROPERTIES

AMYLOSE CONTENT

The amylose content of all samples is shown in Table 2. The BBO rice had the highest amylose content (16.6%) and significantly different ($p \leq 0.05$) with SRI (15.6%) or BOT (15.3%). All samples can be categorized as low amylose content. Rosniyana et al. (2010) reported that *Maswangi* organic and non-organic had high amylose content where the values were not stated. Rosniyana et al. (2006) claimed that amylose content in 30 samples of milled rice in Malaysia were 20.24 to 23.61%. Narpinder et al. (2005) suggested that the cultivars with higher amylose content required less cooking time. Based on these findings, BBO had the highest amylose content and less cooking time as compared with other samples. Cooking behaviour of rice is indicated by amylose content, grain size and shape and alkali spreading value. The intermediate amylose rice is most preferred compared with high amylose rice. This is due to intermediate amylose rice are dry, fluffy and retain their soft texture even after cooling or retrograded. Meanwhile, high amylose rice with high gelatinization temperature are dry and fluffy but become hard after retrograded (Adu-Kwarteng et al. 2003).

VITAMIN B

Vitamin B_1 (thiamine) and B_3 (niacin) of rice are shown in Table 2. There were no significant different ($p>0.05$) in thiamine in all raw and cooked samples. SRI had the highest thiamine (0.23 mg/100 g sample) followed by BOT (0.19 mg/100 g sample) and BBO (0.18 mg/100 g sample). SRI and BBO had the highest niacin (0.02 mg/100 g sample) compared with BOT (0.008 mg/100 g sample). The thiamine and niacin content in cooked rice were lower than raw rice. According to Ellie and Sharon (2005), thiamine is easily destroyed by light, heat and processes such as grinding, canning, blanching and during storage. Niacin is stable to heat, light and moisture. In this study, the rice were cooked with excess water and treated with heat. Mithu et al. (2008) reported that thiamine and niacin content in brown rice were 0.182 mg/100 g and 1.728 mg/100 g of sample, respectively. Milled rice has lower thiamine and niacin content than brown rice. The major loss of vitamins in the milled rice was due to the milling process done on the brown rice to remove the husk and bran layers of rice to produce white rice.

SENSORY EVALUATION

Sensory evaluation is a technique to measure the characteristic and acceptance of the products being produced (Aminah 2000). Aroma of cooked rice was the first attribute being measured by the panellists while it is still hot. It is an important attribute of rice as it is the factor that will determine the market price of the rice and shows the local and national identity (Melissa et al. 2008). The sensory scores for aroma, colour, softness, stickiness and overall acceptance are shown in Table 3. The SRI cooked rice had the highest scores of all attributes and showed significantly different ($p \leq 0.05$) from the two varieties. The amylose content affects the texture of rice than physical characteristics such as gelatinization temperature and gel consistency. Rice with high amylose content are hard and dry in term of their texture compared with rice with lower amylose content (Aliawati 2003). Based on the result, SRI cooked rice had the higher score of softness and lower value of amylose content than BBO.

CONCLUSION

Different rice cultivation showed different physicochemical characteristics. SRI rice had lower weight, water uptake ratio and amylose content than non-organic conventional rice and highest value in other physical characteristics and thiamine and niacin contents. Sensory evaluation of cooked rice showed that SRI had the highest score for aroma, colour, softness, stickiness and more accepted than BOT and BBO cooked rice. Thus it can be concluded that SRI rice tasted significantly ($p \leq 0.05$) better than the other rice studied.

TABLE 2. Amylose content, thiamine and niacin content of rice varieties

Varieties	Amylose content (%)	Thiamine (mg/100 g of rice)		Niacin (mg/100 g of rice)	
		Raw rice	Cooked rice	Raw rice	Cooked rice
SRI	15.6^{b}	0.23^{a}	0.11^{a}	0.02^{a}	0.004^{a}
BOT	15.3^{b}	0.19^{a}	0.10^{a}	0.008^{b}	0.007^{a}
BBO	16.6^{a}	0.18^{a}	0.09^{a}	0.02^{a}	0.008^{a}

$^{a-b}$ Means with different letters within a column are significantly different ($p \leq 0.05$)

ND Not detected

SRI System of rice intensification

BOT Conventional organic rice

BBO Conventional non-organic rice

TABLE 3 Mean (n=50) sensory scores of different attributes of cooked rice

Attributes	Sample		
	SRI	BOT	BBO
Aroma	5.32[a]	4.08[b]	4.66[b]
Colour	5.78[a]	3.70[c]	5.30[b]
Stickiness	5.22[a]	4.56[b]	4.30[6]
Softness	5.50[a]	4.82[b]	4.00[c]
Overall acceptability	5.52[a]	4.40[b]	4.40[b]

For the sensory attributes, a 7-point Hedonic scale was used (7=Like extremely, 1=Dislike extremely)
[a–c] Values with different letters in a row are significantly different ($p \leq 0.05$)
SRI System of rice intensification
BOT Conventional organic rice
BBO Conventional non-organic ric

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