Effect of milling degree on the sensory characteristics of various cooked rice dishes
(Kesan darjah pengilangan terhadap nilai rasa nasi dan masakannya)

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Key words: rice, milling degree, organoleptic properties, rice dishes

Abstract
A high quality locally developed rice variety (Q34) was milled at different milling degrees (MD), namely 2%, 4% and 6%. Brown rice (0%) and milled rice (8%) were also used in this study. Various rice dishes such as nasi lemak, tomato rice, fried rice, porridges and boiled rice were prepared from these rice. Sensory evaluation on boiled rice assessed the whiteness, stickiness, tenderness, aroma, flavour and overall acceptability. Porridges made from brown rice scored the highest mean for overall acceptability. For other rice dishes and boiled rice, the highest mean score for stickiness, tenderness and overall acceptability was obtained by milled rice. In most cases, stickiness, tenderness and overall acceptability of rice made from rice milled at different milling degrees were significantly different among all dishes.

Introduction
The rice milling operation involves dehusking (removal of hull from rough rice) to produce brown rice, whitening (removal of bran from brown rice) and polishing (removal of residual bran and aleuron) to improve the whiteness and palatability of the grains. Through these stages of processing, milled rice of varying quality (semi-polished rice) is produced according to the predetermined degree of milling. Milling degree is generally defined as the extent or degree of removing the different bran layers which cover the grain kernel as a result of whitening. A majority of consumers prefer well-milled rice with little or no bran adhering to the endosperm, which is usually referred as milled rice. In general, there are three degrees of milling: well-milled, reasonably well-milled and lightly milled.

The processing technology for brown and partially milled rice (semi-polished) of Malaysian rice varieties has been developed (Wahid et al. 1997). Milling affects the nutritional quality of rice whereby the process strips off the bran layer, leaving a core of mostly carbohydrates. The changes during milling are therefore of immense public concern to rice eaters and those who seek health foods. Complete or partial retention of rice bran during milling will therefore result in superior nutritional value and healthier foods.

Rice is consumed mainly as whole grain cereal. Generally, it is consumed in the milled form, boiled or steamed, but a limited amount is also being consumed in the form of brown rice. The edible portion of rough rice, which is the brown rice, consists of about 8% protein, 75% carbohydrate and a
small amount of fat and ash at 14% moisture content (Juliano 1979).

Food uses of semi-processed rice (brown rice and partially milled rice) have been explored in other countries and have been used in baby foods, bread, cakes and breakfast cereals, etc. (Bor et al. 1991). In recent years, there is an increasing emphasis on food and nutrition in the national policies. Malaysian consumers are also becoming aware of the nutritional values of foods they eat. In Malaysia, utilization of partially milled rice for rice mixes and premixes are gaining popularity, especially amongst customers in the urban areas. The trend towards increased development of foods with special benefits is at the moment very much in focus (Brigitte 1997). In addition to the boiled form, the preparation of semi-processed rice can be diversified into various dishes.

Preliminary studies have been carried out to develop various rice dishes such as fried rice, nasi lemak, tomato rice and other savoury products with some modifications to the recipes and methods of preparation (Ajimilah and Rosniyana 1994). Semi-processed rice especially the brown rice takes longer time to cook and although the ratio of water uptake is lower, it requires more water to cook.

In this study, brown rice and partially milled rice were used to make various rice dishes. Partially milled rice was produced at different milling degrees (MD) of the brown rice. At present, there may be data on the sensory characteristics of rice made from milled rice, but the information published on the sensory characteristics of Malaysian rice dishes made from semi-polished rice is not available. The objective of this study was to determine the sensory characteristics of various rice dishes made from semi-processed rice. In addition, it will contribute to the knowledge on the development of products from semi-processed rice.

**Materials and methods**

**Sample preparation**

About 1.5 t of brown rice, partially milled rice (2%, 4% and 6% MD) and milled rice were processed in a 2-t rice commercial scale milling plant situated at MARDI station, Bukit Raya, Kedah. The paddy used to produce the five types of rice was a high quality locally developed rice variety, Q34 and the production of these rice was carried out in duplicate.

**Processing of brown rice**

Paddy at a moisture content of 14% (w.b.) was dehusked by a rubber roll huller. The mixture comprising brown rice and paddy was separated by a paddy separator. Brown rice consisted of head rice and broken grains were conveyed to the rotary sifter and indented cylinders to separate the broken grains. The damaged, discoloured and immature grains in the head rice were removed by passing the grains through a colour sorter.

**Processing of partially milled rice**

At commercial mill, brown rice obtained from the paddy separator was milled by a horizontal abrasive whitener, model Satake. From predetermined whiteness values of partially milled rice obtained from laboratory mill, the partially milled rice at 2%, 4% and 6% milling degrees (MD) at the commercial mill were produced through the adjustments of a steel weight-load and flow rates (Wahid et al. 1997). A well-polished rice (milled rice) was also produced through the adjustment of 8% MD. The rice was conveyed to the rotary sifter and indented cylinders to separate the broken grains.

**Preparation of rice dishes**

Four rice dishes namely fried rice, nasi lemak, tomato rice and porridge were prepared from milled rice, brown rice and partially milled rice of 2%, 4% and 6% MD. Freshly prepared semi-processed rice was used to avoid deterioration of rice due to delay in handling. Boiled rice of both milled
rice and semi-polished rice were prepared by washing the rice twice with tap water and cooked in an electric cooker at a rice-to-water ratio of 1:1.8. Rice dishes made from semi-processed were prepared from standard recipes used for milled rice.

**Sensory evaluation**
The cooked-rice characteristics frequently assessed are aroma, tastes, tenderness or hardness, cohesiveness or stickiness, appearance and whiteness (Juliano 1979). Sensory evaluation scores were determined by using a 7-point hedonic rating scale ranging from 1 to 7 respectively (Del Mundo 1979). Score 1, indicates not perceptible while 7, denotes very strong for aroma and flavour. For whiteness, 1 denotes brown and 7, white. The tenderness is rated 7 as very tender while 1 as very tough. Score 1 and 7 indicate well-separated and very sticky for stickiness of rice respectively. Twenty taste panellists assessed the samples for overall acceptability, which covered those factors.

The prepared rice dishes from both milled rice and semi-processed rice were also evaluated organoleptically by 20 panellists. The attributes of rice dishes determined were tenderness or hardness, stickiness or cohesiveness and overall acceptability.

**Data analysis**
The data were statistically analysed by the analysis of variance. The Duncan Multiple Range Test was used to detect differences between the cooked-rice characteristics and different milling degrees. (Gomez and Gomez 1984). The results for all cooked rice were analysed separately.

**Results and discussion**

**Organoleptic evaluation of boiled rice**
Boiled rice characteristics frequently assessed are aroma, flavour or taste, tenderness or hardness, cohesiveness or stickiness and whiteness or colour (Juliano 1982). The average score for these characteristics and overall acceptability are shown in **Table 1**. Results showed that there was a significant difference in whiteness of cooked rice at different milling degrees. The highest score for whiteness was obtained by boiled rice made from milled rice followed by 6% MD, 4% MD, 2% MD and brown rice. This was also observed by Webb (1985), who reported that consumers like well-milled rice with little or no bran adhering to the endosperm. The important property of milled rice in connection with degree of milling is whiteness. Degree of milling is a measure of the extent to which the bran layers and germs have been removed from the rice endosperm. Thus, whiteness of the rice increased with the increase in the milling degree where milling pressure is required to remove or minimize the bran colour.

The highest score for most tenderness for boiled rice was prepared from milled rice and partially milled rice at 6% milling.

### Table 1. Mean organoleptic scores for boiled rice prepared from rice at different milling degrees

<table>
<thead>
<tr>
<th>Sample</th>
<th>Aroma</th>
<th>Flavour</th>
<th>Tenderness</th>
<th>Stickiness</th>
<th>Whiteness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milled rice at 8% MD</td>
<td>3.1c</td>
<td>1.9c</td>
<td>5.6a</td>
<td>4.2a</td>
<td>6.0a</td>
</tr>
<tr>
<td>PMR at 6% MD</td>
<td>4.2b</td>
<td>2.3b</td>
<td>5.2a</td>
<td>4.1a</td>
<td>4.7b</td>
</tr>
<tr>
<td>PMR at 4% MD</td>
<td>4.0b</td>
<td>2.8b</td>
<td>4.2b</td>
<td>4.0a</td>
<td>3.7c</td>
</tr>
<tr>
<td>PMR at 2% MD</td>
<td>4.1b</td>
<td>3.5a</td>
<td>3.6c</td>
<td>3.0b</td>
<td>2.5d</td>
</tr>
<tr>
<td>Brown rice at 0% MD</td>
<td>5.0a</td>
<td>3.2a</td>
<td>3.5c</td>
<td>3.3b</td>
<td>1.3e</td>
</tr>
</tbody>
</table>

Mean values in each column with the same letter are not significantly different by Duncan Multiple Range Test at 5%

PMR = Partial milled rice
MD = Milling degree
Sensory characteristic of various cooked rice dishes

degree and there were no significant differences between the rice. Boiled rice from partially milled rice at 4% MD was rated as slightly tender (4.2). The tenderness of partially milled rice at 2% MD and brown rice was slightly tough and was rated significantly lower than all the other rice (3.5–3.6). The index of cooked rice texture can be measured by the gel consistency of milled rice starch (Perez 1979). One factor affecting the gel consistency is the fat content of rice. The effect of lipids on gel consistency is probably caused by the formation of an amylose-fatty-acid complex (Juliano 1985). The highest fat content was found in brown rice followed by brown rice milled at 2%, 4%, 6% and 8% MD (Rosniyana et al. 1994). Brown rice produced hard gel upon cooling due to the fat content. Because of the higher lipid content of the outer layer of rice grain (bran and aleurone), the degree of milling is a very important factor affecting gel consistency. Accordingly, the soft gel produced by milled rice is preferred over the hard gel of brown rice.

One of the attributes of cooked rice commonly determined is cohesiveness or stickiness. Q34 is an intermediate amylose type, which produces less sticky cooked rice (Rosniyana and Shariffah Norin 1998). The score of 4.2 (slightly sticky) for stickiness of milled rice was not significantly affected by 4% and 6% MD. Statistically, the score for stickiness (3.0–3.3) significantly decreased for both brown and partially milled rice at 2% MD. The cooked rice was slightly separated than milled rice and partially milled rice at 4% and 6% MD. The stickiness of cooked rice is influenced by the protein content of rice, whereby high protein rice is tender and separated upon cooking (Suzuki 1979). The influence of milling degree on the protein content was observed by Rosniyana et al. (1994), who reported that excessive polishing of rice could result in a considerably low protein content in milled rice. Thus, brown rice and partially milled rice at 2% MD had lower score for stickiness which may be due to high protein content.

Statistically, the aroma of boiled rice from milled rice differed significantly from the aroma of partially milled and brown rice. The aroma of brown rice was rated slightly strong (5.0) while milled rice had a moderately weak aroma (3.1). The aroma of boiled rice from partially milled rice (2–6% MD) was rated significantly higher (slightly weak) than from milled rice but significantly lower than from brown rice. Most of the chemical constituents that give the characteristic aroma to boiled rice are affected by the degree of milling (Tsugita et al. 1980). These compounds decrease with an increase in the milling degree of brown rice. The correlation between the aroma evaluation test and gas chromatographic analysis suggested that the volatiles of the surface layer of rice grain have an important role in the formation of the aroma of cooked rice (Tsugita et al. 1979). Accordingly, the results indicated that most of the volatile components of milled boiled rice might be removed during milling.

The flavour of boiled rice from brown rice was not significantly different from that of partially milled rice at 2% MD but was significantly different from those of partially milled rice (4% and 6% MD) and milled rice. The flavour of score 2 for milled rice was not perceptible. The panellists also indicated that the partially milled rice (4% and 6% MD) had very weak flavour. Brown rice and partially milled at 2% MD were moderately weak in flavour. The bran layer and rice germ of brown rice were described as having a sweet, slightly toasted, nutty flavour. Compounds responsible for the characteristic taste of rice bran are not known. The sweet taste is ascribable to relatively high sugar content of bran and the germ (Linda 1990). The total sugar content varied from 8–25% while the reducing sugars ranged from 1–11.6%. Bitter taste, presumably associated partly with saponins, is also identified in rice bran. However, the stages of rice milling have an influence on
the composition of the bran and germ removed (Juliano and Bechtel 1985). The flavour attribute of boiled rice thus depended on the milling degree of rice grain.

**Organoleptic evaluation of rice dishes**

Similar to boiled rice, the tenderness of fried rice, *nasi lemak* and tomato rice made from brown rice was rated the lowest as shown in Table 2. The rice dishes were rated as very tough (2.0–2.3) by the panellists. There was a significant increase in the tenderness of these rice dishes made from partially milled and milled rice compared with the tenderness of rice dishes made from brown rice. As mentioned earlier for boiled rice, the lipid content of the bran layer was removed during the milling process and the gel consistency of cooked rice was influenced by the fat content. A similar trend was observed for rice dishes made from brown rice, which had the lowest mean score for stickiness (2.0–2.7), as compared to rice dishes made from partially milled and milled rice. The rice dishes from partially milled and milled rice improved in stickiness since a significant increase in stickiness was observed as compared to brown rice. The lower protein content of partially milled and milled rice resulted in rice dishes with slightly separated to moderate sticky rice (2.8–5.0).

Porridge made from all rice did not differ significantly in tenderness and stickiness Table 2. The panellists found that the tenderness of porridge (4.5–4.8) was slightly tender to moderately tender. The stickiness was rated slightly sticky (4.0–4.3). These attributes were acceptable to panellists probably due to the ingredients used and the time taken to cook the porridge. Compared to other dishes, the liquid used was still present in the final product. It was suggested by Bechtel and Pomeranz (1977) that the cuticle, located in the seed coat of the pericarp in brown rice reduces the rate of water absorption. However, during preparation of porridge, the outer layer of brown rice was removed and resulted in an increase in water absorption. Also, the disruption may occur by the longer cooking time which resulted in starch expansion and tissue splitting.

**Overall acceptability of boiled rice and rice dishes**

The average scores for the overall acceptability of boiled and rice dishes prepared from brown rice, partially milled rice and milled rice are shown in Figure 1. Milled rice had the highest mean score (6.0–6.9) for boiled rice and all rice dishes except porridge. Scores ≥6.0 are taken as being liked moderately by the panellists. People tend to consume highly milled rice because of their perceived improved palatability (Ajimilah et al. 1997). Milling which removed the bran layer will improve the digestibility of rice. In addition, the cooked rice was moist and tender and does not harden upon cooling. The mean range

<table>
<thead>
<tr>
<th>Rice sample</th>
<th>Fried rice</th>
<th>Nasi lemak</th>
<th>Tomato rice</th>
<th>Porridge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tenderess</td>
<td>Stickiness</td>
<td>Tenderess</td>
<td>Stickiness</td>
</tr>
<tr>
<td>Milled rice at 8% MD</td>
<td>5.2a</td>
<td>3.0a</td>
<td>3.0a</td>
<td>4.7a</td>
</tr>
<tr>
<td>PMR at 6% MD</td>
<td>4.7b</td>
<td>2.9a</td>
<td>3.0a</td>
<td>4.2a</td>
</tr>
<tr>
<td>PMR at 4% MD</td>
<td>4.7b</td>
<td>2.8a</td>
<td>3.3a</td>
<td>4.0a</td>
</tr>
<tr>
<td>PMR at 2% MD</td>
<td>3.6c</td>
<td>2.6a</td>
<td>3.0a</td>
<td>3.7b</td>
</tr>
<tr>
<td>Brown rice at 0% MD</td>
<td>2.0d</td>
<td>2.0b</td>
<td>2.3b</td>
<td>2.7c</td>
</tr>
</tbody>
</table>

Mean values in each column with the same letter are not significantly different by Duncan Multiple Range Test at 5%

PMR = Partial milled rice

MD = Milling degree
for overall acceptability of rice dishes and boiled rice prepared from semi-processed were 2.4–6.9. The results showed that the overall acceptability for all rice dishes (except porridges) improved with increased milling degree, since milled rice is preferred over semi-processed rice. The differences between overall acceptability of boiled rice, fried rice and tomato rice made from milled rice and partially milled rice at 6% MD were not significant. This trend was also observed in fried rice and tomato rice prepared from milled rice and partially milled rice 4% MD.

Porridges from brown rice had the highest score (7.0) for overall acceptability and the product was rated as liked very much. A comparison of porridge made from milled rice with partially milled rice (2–6% MD) showed that there were no significant differences between the two rice. Differences in overall acceptability were observed between both rice and brown rice. The highest score obtained by brown rice was mainly due to the nutty texture of the rice grain and the liquid used was still present in the final product. The panellists commented that the product texture was similar to porridge made from wheat or barley.

**Conclusion**
The sensory characteristics of cooked rice were affected by different milling degrees. There was a desirable increase in the tenderness and stickiness of cooked rice as the milling degree increased. Brown rice had the highest scores for both aroma and flavour and these attributes were significantly different from partially milled and milled rice. The highest rating for overall acceptability (7.0) was porridge prepared from brown rice. Stickiness, tenderness and overall acceptability of various rice dishes such as *nasi lemak*, tomato rice and fried rice made from milled rice were given the highest scores by the panellists. However, differences between overall acceptability of these rice dishes made from milled rice and partially milled rice (4 and 6% MD) were not significant. Since the panellists could not detect the differences, it is recommended that consumers should consumed more partially milled rice at 4% and 6% MD since these rice have higher nutritional contents for combating several diseases compared to milled rice.
Acknowledgement
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References
Abstrak
Padi bermutu tinggi keluaran tempatan (Q34) telah dikisar pada darjah pengilangan yang berbeza iaitu 2%, 4% dan 6%. Beras perang (0%) dan beras kisar (8%) telah juga digunakan dalam kajian ini. Pelbagai aneka masakan seperti nasi goreng, nasi lemak, nasi tomato, bubur nasi dan nasi biasa telah disediakan daripada beras ini. Bagi nasi biasa, penilaian rasa telah dijalankan terhadap ciri keputihan, kelekitan, kelembutan, aroma, rasa dan penerimaan keseluruhan. Bubur nasi yang diperbuat daripada beras perang telah menunjukkan skor purata tinggi bagi penerimaan keseluruhan. Bagi masakan lain dan nasi biasa, skor purata tinggi bagi kelekitan, kelembutan dan penerimaan keseluruhan telah dicapai oleh beras kisar. Pada keseluruhannya, kelekitan, kelembutan dan penerimaan keseluruhan bagi nasi yang dihasilkan daripada darjah pengilangan berbeza adalah berbeza secara ketara antara semua masakan.

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