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Quality Evaluation of Flat Rice Noodles (*Kway Teow*) Prepared from Bario and Basmati Rice

(Penilaian Kualiti Mi Beras Rata (Kway Teow) yang Disediakan daripada Beras Bario dan Basmati)

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ABSTRACT

*In the present study, rice noodles (*kway teow *or flat rice noodles) prepared from Bario rice, a locally grown, popular, organic rice variety of Malaysia was compared with rice noodles prepared from Basmati rice (imported from Pakistan). The quality criteria evaluated included determination of physical (colour and texture), cooking and sensory qualities. Additionally, microbial quality of fresh and stored noodles (stored for 3 days with 0 day as control) was also determined. The results showed tensile strength and elasticity modulus of rice noodles to decrease on storage with Basmati rice showing the lowest value for both the parameters analyzed (24.11 and 7.89 kPa, respectively). The cooking loss of rice noodles increased on storage in both rice varieties with Basmati rice showing higher range of 5.9-7.14%. With regard to colour, significant differences was observed between storage days for the parameters analyzed (L*, a* and b*). Overall, L* value of noodles prepared from Bario as well as Basmati rice showed a decrease on storage (became darker). With regard to microbial quality, aerobic plate count as well as yeast and mold counts increased significantly during storage. The results on sensory qualities showed colour (6.67), appearance (6.8) and texture (6.67) of fresh rice noodles to be significantly higher in Bario rice compared with Basmati rice. From the results, it was concluded that both Bario and Basmati rice can be explored effectively for preparing '*kway teow*' or the flat rice noodles, which is envisaged to hold high promise in local market.*

Keywords: Cooking quality; rice varieties; storage of noodles; tensile strength

ABSTRAK

Dalam kajian ini, mi beras (kway teow atau mi beras rata) disediakan daripada beras Bario, sejenis varieti beras organik yang popular ditanam di Malaysia telah dibandingkan dengan mi beras yang disediakan daripada beras Basmati (yang diimport dari Pakistan). Ciri kualiti yang dinilai termasuk penentuan ciri fizikal (warna dan tekstur), kualiti memasak dan ciri sensori. Selain itu, kualiti mikrobiologi mi segar dan kesan penyimpanan (disimpan selama 3 hari dengan 0 hari sebagai kawalan) juga ditentukan. Keputusan menunjukkan kekuatan tegangan dan modulus keanjalan mi beras basmati berkurangan semasa penyimpanan dengan memberikan nilai paling rendah bagi kedua-dua parameter yang dianalisis (24.11 dan 7.89 kPa, masing-masing). Kehilangan semasa memasak mi beras meningkat dengan masa penyimpanan bagi kedua-dua jenis beras dengan beras Basmati menunjukkan julat yang lebih tinggi iaitu 5.9-7.14 %. Ciri warna (L, a* dan b*) pula menunjukkan perbezaan yang bererti semasa penyimpanan. Secara keseluruhan, nilai L* mi beras yang disediakan daripada Bario dan juga beras Basmati menunjukkan penurunan semasa penyimpanan (warna menjadi semakin gelap). Kualiti mikrobiologi iaitu kiraan plat jumlah aerobik, pertumbuhan yis dan kulat meningkat secara bererti dengan masa penyimpanan. Keputusan penilaian sensori menunjukkan skor warna (6.67), rupa bentuk (6.8) dan tekstur (6.67) mi beras Bario segar adalah lebih tinggi berbanding dengan mi beras Basmati. Kesimpulannya kedua-dua beras samada Bario atau Basmati berpotensi untuk digunakan dalam penyediaan 'kway teow' atau mi beras rata dan dijangka akan mendapat sambutan yang tinggi di pasaran tempatan.*

Kata kunci: Kekuatan tegangan; kualiti memasak; masa penyimpanan mi; varieti beras

INTRODUCTION

Today, consumers' expectation and demand has increased tremendously for healthy and nutritious food of traditional origin. In addition, consumers are constantly looking for novel food products wherein local produce (cereals, grains & legumes) are incorporated. This has rendered food manufactures to explore and formulate new food products (with improved taste, texture and appearance) based on the local traditional knowledge available.

Rice noodles are traditionally prepared popular dish, broadly consumed in most of the South-East Asian Countries (Fiedler et al. 2009; Juliano & Hicks 1996). The main ingredients for rice noodles are rice and water, mixed at appropriate concentrations. Rice noodles have a very smooth texture, soft mouth feel and are white in colour. It is reported that adequate functional and cooking properties are essential to produce a high quality rice/starch based noodle (Chen et al. 2003; Cui 2005; Purwani et al.

2006). As the quality of noodles (cooked or uncooked) are generally assessed by its physical (colour and texture), cooking and sensory qualities, it is highly imperative to provide these details when developing a noodle from an unreported rice variety.

In the present study, we prepared flat rice noodles using Bario rice variety (local) and compared their overall qualities with noodles prepared from Basmati rice (imported rice). These types of rice noodles are popular as 'kway teow' in Malaysia, Singapore, Indonesia and Thailand. These rice noodles are usually fried or are served fresh to be mixed with sauce or chilli paste. Some of the popular dishes prepared using flat rice noodles include char kway teow, chee cheong fun, char hor fun and pad thai.

The Bario rice (White) used in this study is considered as an exotic local variety of rice with a distinctive taste, soft texture and exhibiting a mild and delicate aroma on cooking. This rice is as an organic produce and are grown at high altitudes (1100 m above sea level) without any use of artificial fertilizers. Bario rice used in this study compiles with BRCS (Bario Rice Certification Scheme) Malaysia (Kevin et al. 2007). Whereas, Basmati rice are preferred by consumer's for their pleasant aroma, long grains and unique taste (Bashir et al. 2007; Bhattacharje et al. 2001). It is envisaged that the results generated from this study will be useful to popularize the flat rice noodles prepared from these two exotic rice varieties for better marketability at international levels and opening further scope of improving the shelf life.

Materials and Methods

SAMPLES AND NOODLE PREPARATION

The rice varieties used in the present study were purchased from the local Supermarket (Penang, Malaysia). Bario rice was origin from Sabah, Malaysia, while Basmati rice was imported from Pakistan. Rice grains without any apparent physical or insect damage were selected for analysis.

For preparation of noodles, approximately 300 g of rice grains were individually weighed (in replicates of 3) and soaked overnight (16 ± 1 h) in 300 mL potable quality water (to soften the grains). Further, it was blended in a Waring blender (Panasonic Model MX-898, Malaysia) for 10 min until a thick and uniform batter was formed. Cooking oil (0.5 mL, sunflower) was brushed onto a baking pan (6 × 2 inch round pan) and the batter (120 mL) was poured gradually and smoothly onto the oiled baking pan. The baking pan was placed in a steamer (Well Company Model 288128, China) closed with a lid and steamed for 5-6 min or until cooked. Once completed, the freshly steamed noodles were again coated with cooking oil. This process was repeated again (until 3 more layers are formed) with another 120 mL of batter poured on top of the first layer of noodles and then steamed for another 5-6 min. The last layer of batter was steamed for 8-9 min. On cooling, the baking pan was removed from the steamer and the fresh noodles prepared were cut into 15 × 1 cm (l/b) slices. The noodles prepared were used immediately for various analysis (0 day), while those noodles placed in air tight containers and were stored at room temperature (25 ± 1°C) for 3 days for storage analysis.

PHYSICAL ANALYSIS

Colour Measurement Colour analysis was carried out on rice noodles using a colourimeter (Minolta Spectrophotometer model CM-3500d, USA). Initially, the colourimeter was calibrated by using the zero calibration plate, followed by the white calibration plate. Ten individual measurements of L*, a* and b* values were taken for each noodle. L*, a* and b* values were chosen as it represents lightness (brightness), a* (redness when positive and greenness for negative) and b*(yellowness when positive and blueness when negative). Colour analyses were performed on the samples between day 0 (control) up to day 3 (storage).

Tensile Strength and Elasticity The texture of cooked noodles was determined using a Texture Analyzer, -TX2 model (Stable Micro Systems, Surrey, England), which was pre-calibrated using a 5 kg load cell. For tensile strength analysis, the settings included: Mode, measure force in tension; option, return to start; pre-test speed, 1 mm/s; test speed, 3.0 mm/s; post test speed, 15 mm/s and distance, 100 mm. Initially, the cooked noodles were maintained at room temperature for 10 min and were tested by placing one end into the lower ring arm slot and the other end to the upper arm. From the force and displacement curve obtained from the TA machine, information's such as tensile strength and elasticity of the noodle strands were calculated.

Tensile strength was calculated as $\sigma = F/A$,

where σ is the tensile strength (Pa), F is the maximum load or peak force (N) where else, A represents the cross sectional area of the noodle strand (m^2).

The elasticity modulus (EM) of noodle strands was calculated based on the formula:

$$\mathrm{EM} = \frac{Flo}{tA\underline{o}} \times \frac{1}{v},$$

where, F/t is the initial slope (N/s) of the graph (Force vs Time), lo is the initial length of the noodles between the limit arms (15 mm), A<u>o</u> represents the original cross section are of the noodles and v is the movement rate of the upper arm (0.0003 m/s).

COOKING PROPERTIES

Cooking Loss The cooking losses of noodles were determined following the method described by AACC (2000) with slight modifications. In brief, approximately 250 mL of potable water in a beaker was brought to a boil on a hot plate. When the water started boiling, 25 g of noodles, (cut into 3 × 5 cm length) was placed in the beaker and cooked for 5-6 min until no white core was observed (visually). Cooking process was confirmed by pressing a single noodle between two sterile and clean glass plates. The noodles were then drained, rinsed and cooled with water. An evaporating dish containing 20 mL of the filtrate was then dried in an oven at 105˚C (Memmert UL 40) until a constant weight was attained.

$$\text{Cooking loss}\left(\%\right)=\frac{\begin{array}{c}\text{Weight of drained residue}\\ \text{in cooking water}\left(\text{g}\right)\end{array}}{\begin{array}{c}\text{Weight of noodles}\\ \text{before cooking}\left(\text{g}\right)\end{array}}\times 100.$$

Rehydration Ratio The rehydration ratio of noodles was evaluated based on the method described by Von Loesecke (1945) with slight modifications. In brief, a strainer is used to hold 3 g of noodles, which is then dipped into boiling water in a 250 mL beaker. The noodles were cooked for approximately 10-12 min, before being drained in a strainer (for 2 min.). After this, the noodles surface was dried using a paper towel to remove the excess water adhering to the noodles. Rehydration ratio was calculated as the weight of the cooked noodles compared with the weight of the dried noodles.

MICROBIOLOGICAL QUALITY EVALUATION

Aerobic Plate Count (APC), Yeast and Mould Counts (TYMC) Determination of APC and TYMC was based on spread plate method described by Jay (1986). Freshly prepared rice noodles (10 g) was homogenized in a stomacher bag with 90 mL of sterile peptone water (BPW, Merck) in a stomacher blender (Stomacher® 400 Circulator, Seward Ltd., West Sussex, UK). Appropriate serial dilutions were prepared and 0.1 mL of each dilution was spread on Merck Plate Count Agar plates using disposable spreader (SPL Labware). Further, agar plates containing samples were inverted upside down followed by incubation at 37°C for 48 h. After incubation, the colonies were counted manually and the results were expressed as log CFU/g of rice sample. The same procedure was repeated for stored noodles wherein samples were collected on day 1, 2 and 3.

For TYMC, potato dextrose agar (PDA, Merck) was used. In brief, 25 g of rice noodle samples were mixed with sterile peptone-water solution (0.1%, 225 mL) in a stomacher bag and homogenized (in stomacher blender). Serial dilutions of the sample were prepared up to 10^{-4}, after which, 1 mL from each dilution was transferred onto corresponding Petri plates and were spread-plated. The plates were incubated for 5-6 days at 25±1°C. The same procedure was repeated for stored noodles wherein samples were collected on day 1, 2 and 3.

Water Activity Water activity (aw) was measured based on the method described by Cuevas- Rodriguez et al. (2006). For measuring water activity, headspace equilibrium was first attained before 5 g of each rice noodle was tempered at 25°C using a Hydrometer Aqua Lab Model CX-2 (Decagon Devices Inc., Pullman, WA, USA). Readings were then taken in triplicates.

Sensory Evaluation Sensory quality examination of the fresh noodles was carried out with the help of 30 trained panelists comprising of both technical staff and students of Food Technology Division, University Science Malaysia (USM). The sensory laboratory consisted of isolated sensory booths to minimize the panelists bias as well as maximize their sensitivity for evaluation. Hedonic ratings using 9-point scale was adopted to determine the sensory quality. Panelist were required to evaluate the noodles based on the colour, odour, appearance, texture, overall appearance and overall acceptability. The 9 point scale used included: like extremely, like very much, like moderately, like slightly, neither like nor dislike, dislike slightly, dislike moderately, dislike very much and dislike extremely. The higher ratings indicated good quality attributes (1 indicated dislike extremely and 9 indicated like extremely).

STATISTICAL ANALYSIS

All the results generated in this study were analyzed using SPSS version 17.0 (SPSS Inc., Wacker Drive, Chicago, IL, USA). Triplicates of readings were used and presented as mean ± standard deviation (S.D.). Tukey's HSD post-hoc test was performed and statistical significance was considered at $p < 0.05$.

RESULTS AND DISCUSSION

PHYSICAL ANALYSIS

Colour Measurement Colour is one of the important parameter used by the consumers to evaluate visual quality and are useful for better marketability of noodles (Asenstorfer et al. 2010). Colour is a clear indicator of quality, as fresh noodles are expected to maintain white coloured appearance. It has been reported that high quality noodles to be characterized by the presence of consistent and long with white and translucent colour (Fu 2008). Based on the results obtained in the present study (Table 1), the L* value of rice noodles decreased in fresh noodles prepared from both Bario or Basmati rice samples. With an increase in storage days, the noodles got darker. The L* value reduced from 69.13 (day 0) up to 64.21 (day 3) in Bario rice. Whereas, in noodles prepared from Basmati rice, the L* value decreased from 77.13 (day 0) to 73.98 (day 3). It has been reported that after being stored for two to five days, fresh noodles have a tendency to darken (Hatcher et al. 2010), which holds true for our observations too. Darkening usually happens due to the protein content of noodles. The higher the protein content, the higher is the tendency for noodles to get darkened after storage and this is attributed to the oxidation process occurring between protein and phenol compounds (Asenstorfer et al. 2010).

TABLE 1. Changes in colour values of rice noodles after 3 days of storage

Colour parameters	Storage days							
	0		1		2		3	
	Bario	Basmati	Bario	Basmati	Bario	Basmati	Bario	Basmati
L*	69.13 ± 0.91^{d}	77.13 ± 0.55^{c}	67.09 ± 0.3^{c}	75.24 ± 0.17^{b}	66.18 ± 0.08^{b}	74.87 ± 0.23^{b}	64.21 ± 0.13^{a}	73.98 ± 0.07^{a}
a*	0.97 ± 0.05^{a}	0.23 ± 0.22^{a}	1.02 ± 0.28^{a}	0.32 ± 0.32^{ab}	1.16 ± 0.14^{b}	0.44 ± 0.21^{b}	1.56 ± 0.34^{c}	0.74 ± 0.45^{c}
b*	12.21 ± 0.09^{a}	10.57 ± 0.12^{a}	13.39 ± 0.23^{b}	12.51 ± 0.31^{b}	15.24 ± 0.48^{c}	13.91 ± 0.46^{c}	18.75 ± 1.1^{d}	16.21 ± 0.39^{d}

Values are mean ± standard deviation (n= 3 ± s.d.). Same letter superscripted in the same row are not significantly different from each other at p< 0.05

With regard to a* value, there was no significant difference recorded between day 0 and 1 for noodles prepared from either Bario or Basmati rice varieties. The b* values were significantly different between storage days. For Basmati rice, the b* increased from 10.57 to 12.51 to 13.91 and 16.21 after 3 days of storage at room temperature 25±1°C. Colour analysis is done and measured throughout storage as it provides vital information to food manufactures on the stability and strength of colour (Hatcher et al. 2010).

Tensile Strength and Elasticity Texture is an important attribute of cooked noodles as it determines consumer acceptance of the product (Dexter et al. 1985; Hatcher 2010). In the present study, texture of cooked noodles was assessed as tensile strength and elasticity (Figure 1(a)). In this study, noodles prepared from Bario rice had higher tensile strength as compared with Basmati rice (46.33 and 36.33 kPa, respectively, on day 0). After 3 days of storage at room temperature, less force was required to tear noodles prepared from both Bario and Basmati rice. Tensile strength assesses the capability of noodles to endure a longitudinal force without tearing. The cooking quality of noodles can also be determined based on the results of tensile strength as it indicates how the noodles can stay intact during cooking (Bhattacharya et al. 1999; Ross 2006). Amylose content of rice varieties is reported to have significant effect on the strength of noodles. The higher the amylose content, the higher will be the tensile strength (Fari et al. 2011; Guo et al. 2003), which holds true in this study as well (22.63 for Bario rice and 9.43 for Basmati rice).

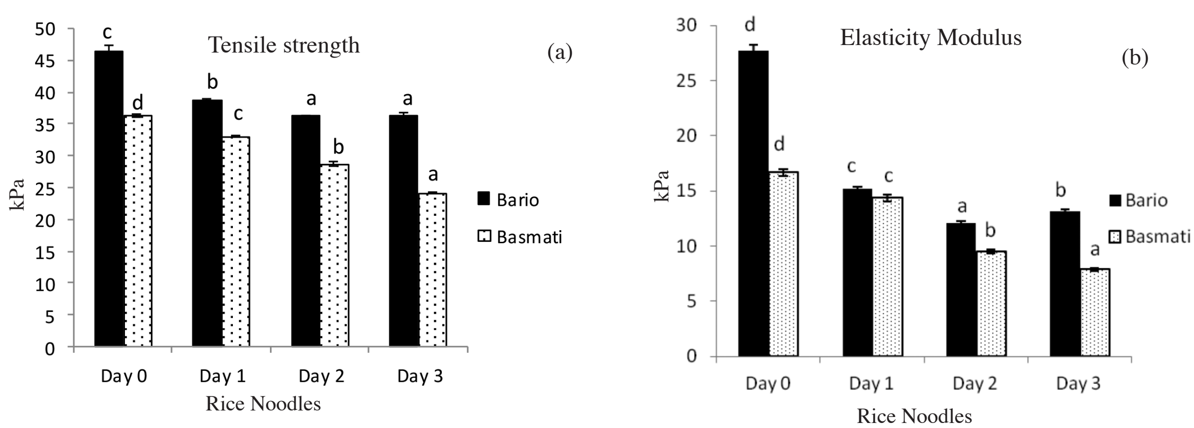
Elasticity is defined as the ability of deformed noodles to return to its initial shape and size when the force creating the deformation is removed. The results from this study showed noodles prepared from Bario rice has higher elasticity modulus as compared with Basmati rice (13.19 and 7.89 on day 3 of storage) (Figure 1(b)). Overall, elasticity modulus of rice noodles prepared from the two rice varieties decreased significantly after storage. Previously, high quality noodles have been correlated with high elasticity modulus (Chen et al. 2002), which is applicable for our results too.

COOKING PROPERTIES

Cooking Loss Cooking loss is an important attribute in noodles as it evaluates the amount of irrecoverable solids in cooking water. It is highly vital that the structural integrity of noodles need to be maintained throughout the cooking process. In the present study, noodles prepared from Basmati rice had a higher value for cooking loss, which was found to increase on storage (Figure 2(a)). After 3 days of storage, Basmati rice noodles had a cooking loss of 7.14%, while Bario rice cooking loss was 3.89%. High cooking loss is unacceptable as there can be high amount of solubilized starch present, which leads to cloudy boiling water and 'sticky' mouth feel with lower tolerance (Chakraborty et al. 2003; Chen et al. 2002; Jin et al. 1994).

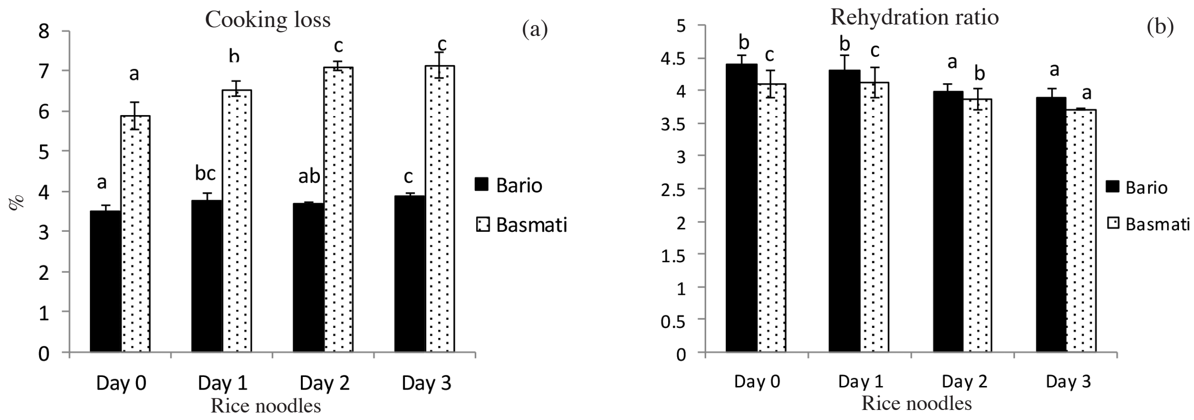
REHYDRATION RATIO

Rehydration ratio for Bario and Basmati rice noodles is shown in Figure 2(b). Overall, no significant differences were observed on storage of noodles prepared from Bario rice on day 0 and 1, but significant differences were recorded between day 1 and 2. With regards to Basmati rice, significant difference was observed only for day 2 and 3. Bario rice noodles had a higher rehydration ratio (3.89) compared with Basmati rice noodles (3.71) after 3 days of storage at room temperature. High rehydration ratio tends to make noodles sticky whereas low rehydration ratio can render the noodle to be hard with unrefined texture (Collado et al. 2001; Yoenyong-buddhagal & Noomhorm 2002). In addition, in this study, as the decrease in rehydration ratio of rice noodles over 3 day storage period is small, noodles were found to be still acceptable in terms of overall quality. Our results on decrease in rehydration ratio of rice noodles on storage time are in agreement with previous findings (Collado et al. 2001; Zhang 2006) on instant rice noodles.



Values are mean ± standard deviation, same letter superscripted in the same column are not significantly different from each other at p< 0.05

FIGURE 1. (a) Tensile strength of stored rice noodles and (b) elasticity modulus of stored rice noodles



Values are mean ± standard deviation, same letter superscripted in the same column are not significantly different from each other at $p < 0.05$

FIGURE 2. (a) Cooking loss of stored rice noodles and (b) rehydration ratio of stored rice noodles

MICROBIAL QUALITY EVALUATION

The results obtained for microbial quality evaluation is depicted in Figure 3(a). Based on the results, the APC of noodles prepared from both Bario and Basmati increased significantly during storage. Overall, Basmati rice had a higher APC as compared to Bario rice. The APC for Bario rice ranged between log 2.63 CFU/g on day 0 and log 6.02 CFU/g on day 3 whereas, for Basmati rice the APC content ranged from log 3.54 to log 6.89 CFU/g. The acceptable amount of total microbes in fresh rice noodles should be less than or equal to log 7 CFU/g (ANZFA 2001; Thai Industrial Standard 2005). Based on results of APC, both Bario and Basmati noodles were still acceptable even after 3 days of storage at room temperature.

The TYMC for Basmati rice was higher compared with Bario rice (Figure 3(b)). Initial TYMC for Bario rice was log 0.98 and log 1.12 CFU/g for Basmati rice. By the 3rd day, the TYMC in Bario rice noodles was log 2.56 CFU/g and log 2.87 CFU/g for Basmati rice, respectively. Generally, yeast and molds optimum temperature of growth is around 25-37°C, where it grows luxuriantly. This temperature range is commonly encountered in most of the South East Asian countries. Thai Industrial Standard (2005) states that acceptable amount of TYMC for fresh rice noodles should be equal or less than log 2 CFU/g. However, in the present study, after being stored for 2 days at room temperature, both samples were above the recommended amounts and hence the noodles are recommended to be consumed within 48 h of preparation.

WATER ACTIVITY

As microbial growth can be controlled by monitoring the water activity (aw) levels in rice, it is very important to provide details on this parameter. The aw for noodles prepared from Basmati rice was higher compared with Bario rice (Figure 4). The aw in noodles prepared from Bario rice varied between 0.80 and 0.83, whereas, noodles prepared from Basmati rice had a water activity of 0.82-0.87 (0-3 days of storage, at room temperature of 25±1°C, respectively). Growth of majority of spoilage microorganisms can be inhibited if the aw is below 0.90.

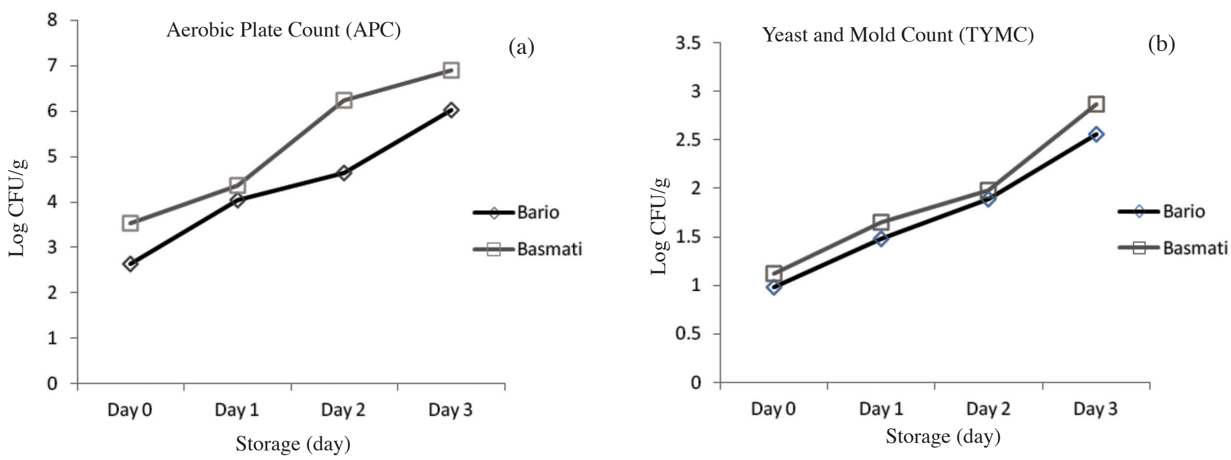


FIGURE 3. (a) Aerobic plate count analysis of rice noodles (3 days of storage) and (b) yeast and mold count analysis of rice noodles (3 days of storage)

It has been stated by California Food Safety Law (2012) that rice noodles are not acceptable when the water activity is above 0.85. In this study, Bario rice noodles was still acceptable even after 3 days of storage, however Basmati rice exceeded the aw limit on the 2nd day.

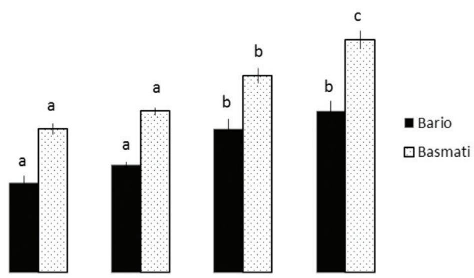
Sensory Evaluation Sensory quality evaluation is vital whenever a new food product is developed. This is also important when consumer acceptability towards a food product needs to be predicted (Hutchings 1999; Lawless & Heymann 2010). The results obtained on sensory evaluation in terms of colour, odour, appearance, texture, appearance and overall acceptability is presented in Figure 5. From the results, colour acceptability score for Bario rice was 6.67 and Basmati rice was 5.87. Determining visual colour as a part of sensory quality is important because the first parameter of a food product, assessed visually by a consumer is the colour (Blouin et al. 1981; Hutchings 1999). Odour has an effect on the amount of food consumed by consumers (Stevenson et al. 1999). The acceptable odour of rice noodles prepared from Basmati rice was slightly higher than Bario rice (5.87 and 5.73, respectively). Generally, the odour of rice noodles is very subjective, however in the present study this parameter was evaluated based on the experience of trained panelists wherein they classified odour based on the smell and which they preferred better. In terms of appearance, Bario rice scored high (6.8) as compared with Basmati rice (4.3).

Texture has been recognized as the second most assessed sensory property of food (Bourne 2002; Rakosky 1989). Bario rice had more preferred texture and a higher acceptability score of 6.67 compared with 4.8 of Basmati rice. In terms of overall appearance and acceptability, Bario rice faired much better implying that it was the more preferred noodles compared with Basmati rice.

CONCLUSION

Overall, based on the results generated in this study, colour, textural and cooking properties as well as microbial counts of rice noodles started to deteriorate after 3 days of storage. Rice noodles prepared from Bario rice had good tensile properties. Basmati rice had a low rehydration ratio but high cooking loss. For sensory analysis, panelists preferred Bario rice noodles over Basmati rice noodles as it scored higher overall acceptance and appearance. The suitability of Bario rice in the preparation of fresh rice noodles needs to be explored further owing to its good

Water Activity



Values are mean ± standard deviation, same letter superscripted in the same column are not significantly different from each other at $p \leq 0.05$

FIGURE 4. Water activity of rice noodles samples stored for 3 days

Sensory Evaluation

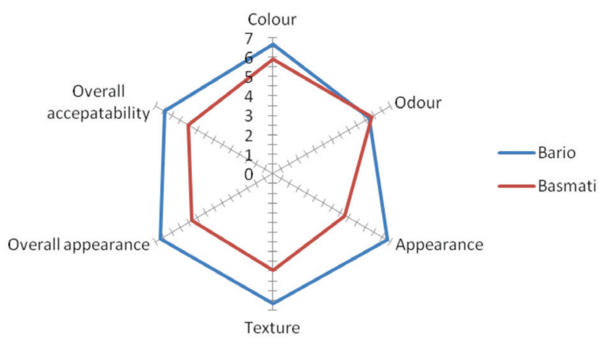


FIGURE 5. Sensory evaluation of rice noodles

cooking and physical properties. In addition, the noodles prepared can be considered economical as only water, rice flour and minimal quantity of cooking oil needs to be used. Improvement in preservation of rice noodles quality especially during extended storage needs to be explored by selecting suitable packaging materials or by incorporating various natural preservatives or pre-treatments, which may be useful to extend their shelf life.

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