ISSN: 2338-1345 – Vol. 7 No 2, 9-13 (2019), supplementary data (14-22) Journal online http://journal.bakrie.ac.id/index.php/APJSAFE

Asia Pacific Journal of Sustainable Agriculture Food and Energy (APJSAFE)

Preference Mapping of Organic Brown Rice in Different Storage Types#

Komang Rai Artha Wiguna, Ardiansyah, Wahyudi David*

Department of Food Science and Technology, Universitas Bakrie, Jakarta, Indonesia
**Corresponding author's E-mail address: wahyudi.david@bakrie.ac.id*
#this article has been presented at 16th Asean Food Conference 2019 Oct, 15-18, Bali, Indonesia
This article has separate supplementary data (tables and figures)

Abstract— Organic Brown Rice (OBR) is whole grain of organic rice with the inedible outer hull removed. Though it is evident that OBR is better than white rice, most consumers choose white rice because of its appearance. OBR has a shelf life of approximately six months, but hermetic storage, refrigeration or freezing can extend its lifetime. Sensory evaluation is one of the effective tools to measure the quality parameters in grains. This study is aimed at determining the dominant attributes that can be used as quality parameters and packaging appropriate for several varieties of OBR. Projective mapping was used to assess three varieties of OBR (Ciherang, Pandan Wangi, and Mentik Wangi). Three types of packaging, viz., Polyamide (PA) Vacuum (0.35±0.005 mm), Low Density Polyethylene (LDPE) Zipper (0.15±0.005 mm), and plastic boxes High Density Polyethylene (HDPE) (2.16±0.005 mm) were used in these studies. Thirty-four voluntarily naïve panelists (47% male and 53% female; age between 18-24 years) participated in these studies. MFA and HCA on Principal Component were used to obtain the properties position of OBR, as well as different storage times. The result shows that panelists were consistent and able to distinguish between varieties as well as different packaging during 12 weeks of storage. Aroma and colours become the dominant attributes in distinguishing OBR during 12 weeks of storage. PA Vacuum and HEPE packaging accounts for the lowest loss of moisture content and delays the increase of free fatty acid. This study proved that the sensory evaluation method can determine the quality of OBR.

Keywords—**Multifactor Analysis, napping, organic brown rice; storage; sensory evaluation.**

INTRODUCTION

Consumers purchase organic food items mainly because they believe them to be more environment-friendly, better in taste and healthier, than food crops cultivated with chemical pesticides and fertilizers (Tauscher et al 2003; Torjusen et al 2004; Stolz et al 2011; Pino et al 2012; Zagata 2012). Organic rice is one of the main organic food products consumed in Indonesia (David and Ardiansyah, 2017a; David and Ardiansyah, 2017b). Despite having nutritional and economic benefits, organic brown rice is not being widely consumed and is suspected of susceptibility to rancidity (Bergiono et al 2016; Amelia et al, 2017). The rancidity and unpleasant odour occur due to the activation of lipase in the outer layer of brown rice after contact with air (Chrastil, 1990; Zhout et al 2001). Factors influencing the storage life of brown rice are varieties, storage and packaging conditions. Different varieties of rice have different shelf lives (Garcia, 2013). Storage conditions such as refrigerators or freezers can significantly extend the storage life of brown rice (Sinija, 2017). Therefore, storage and packaging conditions are important contributory factors for improving brown rice quality during storage. Brown rice processing requires less energy than that of white rice, due to the elimination of polishing and grinding processes (Cuyno, 2003). Therefore, to understand the ability of the consumer to evaluate organic brown rice, this study attempts to evaluate the sensory quality of organic brown rice after three months of storage.

MATERIALS AND METHODS

A. Samples

Three varieties of OBR Ciherang, Pandan Wangi, and Mentik Wangi were used in this study (Fig. 1). OBR samples were obtained from organic rice farmers who already have organic certificate (045-LSPO-005-IDN-03-16) and located in Wonogiri, Centre of Java, Indonesia. Organic milled rice from Pandan Wangi varieties was used as a control of samples.

B. Study design

The Study design was divided into four stages. The first stage was the initial sensory evaluation of three varieties of OBR. The three OBR samples were stored at room temperature (±280C, RH = ±66%), with 2 kg of each variety stored in Polyamide (PA) Packaging Vacuum (0.35±0.005 mm), Low Density Polyethylene (LDPE) zipper (0.15±0.005 mm), and plastic boxes of High Density Polyethylene (HDPE) (2.16±0.005 mm). In the second stage, the evaluation of the fourth week of the three stored OBR varieties was done with different storage. The third and fourth stages were re-evaluated in the eighth and twelfth

weeks respectively. Thermohygro (HTC-2, China) was used to determine the condition of OBR during storage.

C. Measurement of quality during storage

Moisture content was measured by air-oven method (1050C for 24 h) (AOAC, 2005) as wet basis. Free fatty acid content was determined by using rapid method AACCI 58-15.01 with slight modification. Free fatty acid was extracted from 20 g of ground brown rice in 50 ml Benzene solution, and the extracted solution was titrated with potassium hydroxide (AACCI 58-15.01).

D. Sensory evaluation: Projective Mapping (Napping)

Sensory evaluation of OBR was carried out using Napping. A total 34 naïve panelists (47% male and 53% female, aged between 18-24 years), was used at each stage of the research. Panelists were recruited from among students of Universitas Bakrie, based on their interest to participate and availability. Rice was cooked with a ratio of rice and water (1: 2) using rice cooker for 40-45 minutes. OBR samples were served with 40 g of cooked rice and arranged to have a uniform appearance. OBR was presented to panelists labelled with three-digit random numbers, at room temperatures. Also, mineral water was available for rinsing between samples. Panelist were asked to try ten samples and to place them on white paper (60 cm x 60 cm), according to similarities or dissimilarities (Nestud and Lawless, 2010) They were asked to complete the task using their own criteria and were also told that there was no right or wrong answer. If the samples were close together, they were considered to have similarities and if different, then they should place them far from each other. Panelists were asked to determine OBR attributes including aroma, taste, texture, and colour (Meilgaard et al 1999) After completing the evaluation, the panelists were asked to write down the description of each sample.

E. Preference mapping (Pref Map)

Pref Map was used to correlate preference data with panelists' sensory perceptions. The "carto" function was used to generate the contour map plot. In this research, we used a PrefMFA to obtain the preference map (Worch, 2013; Le S and worck, 2014)

The preference data (Pf) was obtained based on the distance between each OBR sample to control. OBR sample distance value was converted by dividing the distance difference by paper dimension: the farther the distance to the control, the lower the value obtained and vice versa.

$$P_f = \frac{(60 - \text{the sample distance to the control}) \text{ cm}}{6}$$

F. Data analysis

Napping data were analyzed using Multiple Factor Analysis (MFA) with R v3.4.0, with added packages FactoMineR v1.35 and SensoMineR v1. (Le S, Hussin F. 2008; Husson et al, 2014) The X and Y coordinates of each sample on the tablecloth of each panelist were determined from the bottom corner. MFA was performed considering the coordinates of each panelist as separate group variables. Confidence ellipses were calculated using parametric bootstrapping (Dehlholm et al, 2012).

Analysis of variance (ANOVA) was performed on data from moisture content and free fatty acid content. Mean ratings were calculated, and significant differences were determined using Duncan test ($P \leq 0.05$).

Similarities between sample configurations in OBR samples were evaluated using the regression vector (RV) coefficient. It was also calculated between the first two axes of sample configuration MFA of Napping data during storage.

RESULTS AND DISCUSSIONS

Variations in OBR temperature and relative humidity during storage

Variations in OBR temperature and relative humidity during the 12 weeks of storage are shown in Fig. 2. The mean temperature of OBR at room temperature storage was 29.38±0.410C (29.14±0.370C in outside) with an average relative humidity of 66.36±0.91%.

Change quality parameters during storage

Changes in OBR moisture content and free fatty acid content for 12 weeks storage are shown in Table 1. Initial moisture content of three stored OBR varieties ranged from 11.83% to 14.39%. After 12 weeks' storage, all OBR samples had decreased moisture content ranging from 10.69% to 13.99%. OBR with LDPE packaging had the lowest decrease in moisture content (0.67% to 1.74%). Mentik Wangi had the lowest reduction in moisture content, compared to other varieties.

During storage, respiration activity in rice is continuous. The process of respiration is influenced by O2 that can produce CO2, H2O, and heat. The heat produced can increase the temperature of rice and the respiration rate. The higher respiration rate can result in increase in loss of dry weight during storage. The increasing relative humidity can increase water activity that can stimulate micro-organism growth. However, based on SNI 6128-2015, the decrease in moisture content of OBR during storage is still in the standard category of maximum moisture content of 14% (SNI 6128-2015).

Initial free fatty acid content of the three OBR varieties of storage ranged from 3.46 mg to 4.43 mg. After 12 weeks of storage, all OBR samples had increased free fatty acid content ranging from 5.33 mg to 9.66 mg. OBR samples with LDPE packaging had the highest increase in free fatty acid content (4.48 mg to 5.25 mg).

The increase of free fatty acid content of OBR is caused by fat hydrolysis and oxidation reactions. This is due to damage in the aleurone layer (phosphatidylcholine) during storage that can trigger fat oxidation reactions (Liu et al, 2015). Lipase enzymes can break down fats into free fatty acids and glycerol. The free fatty acids formed can be oxidized by

lipoxygenase enzymes that produce peroxide, aldehyde, and ketones (Astawan and Febrina, 2010). These three compounds can cause a rancid aroma.

Sensory evaluation of OBR 0th week

Sensory evaluation of OBR at the 0th week of storage is shown in Fig. 3. The first and second dimensions of the MFA explained 37.76% of the variance, while the first and fourth dimensions explained 61.65%. In the first and second dimensions, the panelists grouped OBR samples according to the three varieties. Mentik Wangi (356, 642, and 537) were described as being nutty and having caramel aroma and yellow color. Pandan Wangi (956, 865, and 578) were described as salty in taste, with mild and chewy texture, and wheat, milk aroma. Ciherang (433, 312, and 223) were described as corn, with sticky rice aroma, bitter taste, and green color. As against the different OBR samples, the control was described as having a sweet taste, with a soft, sticky texture, and white color.

In the third and fourth dimensions of the MFA, the panelists grouped OBR samples of Pandan Wangi varieties along with the Mentik Wangi varieties (865, 956, 356, and 578), all of which were described as corn, sticky rice, wheat aroma, hard, mild texture, and astringent taste. Ciherang varieties, according to the panelists, were different from the two other varieties in this research. This resulted in 34 panelists distinguishing between the three varieties of OBR samples.

Sensory evaluation of OBR 4th week

Sensory evaluation of OBR at 4th week storage is shown in Fig. 4. The first and second dimensions of the MFA explained 35.21% of the variance, while the first and fourth dimensions explained 60.65%. For the first and second dimensions, the panelists grouped OBR samples according to the packaging used. Samples (865, 356, 433, 642, and 578) using HDPE and LDPE packaging were described as chewy, heavy, hard textured, salty in taste, and having a creamy aroma. Samples (537, 223, 956, and 312) used PA Vacuum and LDPE packaging and were described as caramel, nutty, corn aroma, bitter taste, and green colour.

In the third and fourth dimensions of the MFA, the panelists grouped several OBR samples of Vacuum PA packaging along with HDPE and LDPE packaging. Samples (433 and 356) were described as heavy textured and with sticky rice aroma. Samples (956, 537, and 865) were described as buttery, nutty, with grassy aroma, bitter, umami taste, and green color. Samples (223 and 578) were described as sour tasting and having corn aroma and brown colour. Samples (642 and 312) were described as chewy, hard textured, and with pandan aroma. This indicates that the panelists found differences in the storage treatment in some OBR after 4 weeks of storage.

Sensory evaluation of OBR 8th week

Sensory evaluation OBR at 8th week of storage is shown in Fig. 5. The first and second dimensions of the MFA explained 44.35% of the variance, while the first and fourth dimensions explained 68.73%. For the first and second dimensions, again the panelists grouped OBR samples according to the three varieties. In contrast to 0th week, at 8th week, the panelists grouped samples of Pandan Wangi along with Ciherang varieties. Samples (956, 865, 578, 312, 223, and 433) were described as salty, bitter tasting, grassy, caramel, shrimp, sticky rice, vanilla, corn aroma, chewy, heavy texture, green, and brown color. The Mentik Wangi varieties according to the panelists were different from the two other varieties in this research. Samples (356, 537, and 642) were described as buttery, chocolate, spicy, and with rancid aroma.

In the third and fourth dimensions of the MFA, the panelists grouped OBR samples of Ciherang varieties along with the Mentik Wangi varieties. Samples (433, 356, 233, and 642) were described as creamy, vanilla, wheat, chocolate, spicy, grassy, and rancid aroma. The Pandan Wangi varieties, according to the panelists, were different from the two other varieties in this research. Samples (956, 865, and 578) were described as buttery, fish, caramel, shrimp aroma, bitter taste, chewy, heavy texture, and green color. This indicates that the panelists detected changes in the three OBR samples during 8 weeks of storage.

Sensory evaluation of OBR 12th week

Sensory evaluation of OBR at the 12th week of storage is shown in Fig. 6. The first and second dimensions of the MFA explained 41.92% of the variance, while the first and fourth dimensions explained 66.18%. For the first and second dimensions, the panelists grouped OBR samples according to the packaging used. In contrast to the 4th week, at the 12th week, the panelists grouped some Vacuum PA packaging along with HDPE packaging and some HDPE packaging along with LDPE packaging. Samples (356, 865, and 642) were described as chicken, spicy, rice bran, rancid aroma, and sour taste. Samples (537, 956, and 312) were described as potato, shrimp, chocolate, sticky rice, nutty, caramel aroma, heavy, hard texture, yellow, and green color. And samples (578, 433, and 223) were described as vanilla, buttery, grassy wheat, corn, soybean aroma, bitter taste, and fibrous texture.

In the third and fourth dimensions of the MFA, panelists grouped as in the first and second dimensions: some vacuum PA packaging together with HDPE packaging, and some HDPE packaging together with LDPE packaging. This indicates that the panelists again detected changes during 12 weeks of storage in the three OBR samples. Samples (578 and 642) were described as chewy texture, rice bran, wheat, egg, and rancid aroma. Samples (433, 223, and 537) were described as soybean, potato, creamy aroma, bitter taste, hard, and fibrous texture. Samples (865 and 956) were described as chicken, fish aroma, salty taste, and green color.

Preference mapping OBR during storage

Preference mapping of OBR during storage is shown in Fig. 7. In Preference Mapping 0th week (RV = 0.881) showed that there were three groups of OBR samples approaching control elevation: samples (642 and 537) with elevation 500-600, samples (956, 865, 356, and 312) with elevation 400-500, and samples (433, 578, and 223) with elevations of 300-400. According to the 34 panelists, the samples (642 and 537) were closer to the control because they had the greatest elevation. Based on Table 3, according to the 34 panelists, the samples (642 and 537) were closer to the control because the value of pandan aroma attribute is the highest compared to other OBR samples, while the samples (956, 865, 356, and 312) have an attribute value of pandan aroma and a chewy texture of rice. The samples (433, 578, and 223) have an attribute value of pandan aroma and bitter taste.

In the 4th week (RV = 0.928) showed that there were two groups of OBR samples approaching the controls, the samples (356, 956, 865, 223, 433, 312, 537, and 642) with elevations of 300 and samples (578) with elevation of 200. According to the panelists, samples (356, 956, 865, 223, 433, 312, and 537) were closer to the control. In contrast, according to panelists, sample (578) was more distant from controls because the attribute value of corn aroma and bitter taste was higher than in other OBR samples (Table 3).

In the 8th week (RV = 0.844) showed that there was one group of OBR samples approaching the controls, viz., the samples (537 and 356) with elevation 300. Sample (642) and samples (865, 578, 312, 956, 223, and 433) were further away from control because they had the lowest elevation between 200-300. (Table 12) makes the sample (642) different from the control and other OBR samples is the attribute value to the rancid aroma. This proves the previous explanation that the panelists were able to detect the rancid aroma in the sample (642: Mentik Wangi LDPE) at 8 weeks of storage. Consequently, the panelists consciously placed the sample (642) distant from the control. The samples (865, 578, 312, 956, 223, and 433) according to panelists were more distant from the controls, because the attribute values for the bitter taste were the highest compared to other OBR samples (Table 4).

The 12th week (RV = 0.898) showed that there was one group of OBR samples approaching the control sample (312, 433, and 356) with elevation between 300-400, while samples (223, 956, and 537) and samples (642, 865, and 578) had the lowest elevation between 200-300. Based on Table 4 according to the panelists who made the samples (312, 433, and 356) closer to the controls, the attribute values of the rancid and fish aroma were the lowest compared to other OBR samples.

Interestingly, it appears that samples (642 and 865) were close to each other and became one group. Both samples were OBR with LDPE packaging. Based on the analysis of free fatty acid content in Table 1, both samples had the highest free fatty acid content (8.92-9.66 mg). This is also evidenced by Table 4, where, according to the panelists, the attribute values of the rancid and fish aroma in both samples were the highest, compared to other OBR samples.

In Table 2, it is seen that the results on Napping at 0th week had similarities with the 4th week (RV = 0.882), 8th week (RV = 0.918), and 12th week (RV = 0.843). The 4th week had similarities with the 8th week of napping (RV = 0.852), and 12th week (RV = 0.861). The 8th week had similarities with the 12th week (RV = 0.882). This shows that the 34 naïve panelists were consistent in their grouping of OBR samples over a 12-week period.

Based on OBR sensory evaluation during 12 weeks of storage, the 34 naïve panelists were able to distinguish OBR samples based on the varieties and the storage treatment used. It can be seen based on the presence of dominant attributes on a weekly basis (Table 3 and 4). According to the 34 panelists, aroma and color are the main parameters in distinguishing all OBR samples over 12 weeks of storage.

CONCLUSIONS

PA Vacuum and HDPE packaging can maintain a decrease in water content and slow down the increase in free fatty acids in OBR samples. During 12 weeks of OBR sample storage, the 34 naïve panelists were consistent in their grouping of all OBR samples. In addition, overall, panelists were able to distinguish OBR samples based on varieties and the storage treatment used. Based on the OBR sample grouped by the panelists, aroma and colour were dominant attributes in all three varieties of OBR for 12 weeks of storage. *Ciherang* varieties had brownish color, and were nutty, corn, caramel, and soybeans aroma. The varieties of *Pandan Wangi* according to the panelists had a greenish color, pandan, creamy, corn, buttery, nuts, and fish aroma. The varieties of *Mentik Wangi* had a yellowish color, caramel, chocolate, potatoes, nuts, eggs, chicken, shrimp, and rancid aroma, while the control had a white color, pandan, creamy, vanilla, and grassy aroma.

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