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Impact of Using Hermetic Packaging and Preservative on Physical Properties of Rice Bran During Storage

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ABSTRACT

Rice bran is one of the feed ingredients used in various types of animal rations in Indonesia. In addition to containing anti-nutrients, rice bran has also a low storability. This research was conducted to study the impact of using hermetic packaging and a preservative containing calcium propionate (ProsidTM MI 208) application on the physical properties of rice bran during storage. The factorial completely randomized design (CRD), 3 x 4 with 4 replications was applied. The first factor was storage time 0 (W0), 30 (W30), and 60 (W60) days; the second factor was burlap sack + 0 ppm calcium propionate (P1), burlap sack + 160 ppm calcium propionate (P2), hermetic sack + 0 ppm calcium propionate (P3), and hermetic sack + 160 ppm calcium propionate (P4). The variables measured were moisture content (MC), bulk density (BD), tapped density (TD) dan true density (TDS). The obtained data were analyzed using if there was a significant difference, followed by Duncan's multiple range test. The results showed that storage time significantly ($P<0.05$) increased the MC and decreased the BD, TD, and TDS values. The increasing MC and the decreasing BD, TD, and TDS values of the rice bran during storage were higher ($P<0.05$) in the burlap sakcs than in the hermetic sacks packaging both with and without the addition of calcium propionate. The combination of using hermetic sacks with the application of calcium propionate could further increase to maintain of the physical properties of rice bran from the damage. The use of a hermetic sack and the application of calcium propionate could maintain the quality of rice bran and increase the resistance of rice bran to damage during 60 days of storage.

Key words: Calcium propionate, Hermetic sack, Physical properties, Rice bran

Introduction

Rice bran is a by-product of the process of milling rice grain into rice (Astawan and Febrinda, 2010). Rice bran is high in fiber, antioxidants, and essential vitamins and minerals. Rice bran is commonly used as a feed ingredient due to it contains high nutrients and is relatively easy to obtain (Mila and Sudarma, 2021; Akbarillah *et al*., 2007). The availability of rice bran in Indonesia depends on the season, therefore it is very important to store rice bran to maintain its availability and quality throughout the year (Azis *et al*., 2014). Rice bran is easily contaminated by beetle, fungi, and other microorganisms, thereby reducing its quality (Joris *et al*., 2021). The use of appropriate packaging types become necessary things to maintain the quality from the emergence of bad conditions during storage time (Mulyawan *et al*., 2019).

Technologically, the use of appropriate packaging types and the application of a preservative agent could maintain the quality of rice bran during storage. One of the materials commonly used to package rice bran is a burlap sack. Burlap sack is made from plant fiber that has high durability and resistance when piled and hooked and can adjust its shape when used (Soekartawi, 1989). Burlap sack has several weaknesses such as being porous, cannot be vacuumed, and easily contaminated by unwanted materials (Ramahariah *et al*., 2013). To overcome the burlap sack weaknesses, the use of a hermetic sack is one of the alternative solution. Contrary to a burlap sack, a hermetic sack is airtight, impermeable to gasses, and has a sufficient thickness so that it has more reliable to maintain the quality of feed ingredients during storage (Yewle *et al*., 2021; Destiana, 2016). While the use of calcium propionate can inhibit the growth of molds and other microorganisms (Pongsavee, 2019). Calcium propionate is an organic salt formed from the reaction between calcium hydroxide and propionic acid and has the molecular formula $(CH_3CH_2COO)_2Ca$ (NCBI, 2022). The way propionic acid works in preserving is by lowering the pH of the product so that microbes cannot live to damage the product. The optimum pH value for propionate activity is around 5, although in several types of products this compound is also active at a pH of 6 or slightly higher (Utama *et al*., 2019).

Damage during the storage process can be detected physically, chemically, and biologically. Based on that background this study was conducted to examine the use of packaging types and calcium propionate application on moisture content and the physical characteristics of rice bran during storage.

Materials and Methods

The materials used were a spatula, a plastic funnel, an analytical balance, a ruler, a 100 ml measuring glass, and a thermohygrometer. While the samples used were rice bran aged 3 days and calcium propionate containing calcium propionate (ProsidTM MI 208). The types of packaging used were burlap sacks (made from jute fiber) and hermetic sacks (Grainpro hermetic super grain bag).

Storage and sampling. A total of 24 kg of rice bran samples were taken from the rice milling factory in Cibitung Tengah Village, Tenjolaya District, Bogor Regency. Rice bran was divided into 48 packages (24 burlap sacks and 24 hermetic sacks) weighing 500 grams per sample. Based on the treatment, 0 ppm (control) and 160 ppm calcium propionate were applied to the rice bran sample. All treatment samples were stored on a laboratory table, in a closed room, with glass windows and air-perforated iron doors. Temperature and humidity were measured by a thermohygrometer. Rice bran samples were analyzed on days 0, 30, and 60. Before taking measurements, each sample was opened and mixed until homogeneous.

Analysis of the number of beetles. The number of beetles was carried out descriptively on samples on days 0, 30, and 60. Each sample was opened and put into a container, then observed descriptively by comparing all beetles in each treatment of each sack package. The number of beetles in each sack package was classified into: - = none, + = 1-100 individuals, ++ = < 100-200 individuals, +++ = < 200-300 individuals, ++++ = > 300 individuals.

Samples analysis. The moisture content (MC) was measured by the oven method according to the AOAC (2005). The procedure for testing physical properties was carried out according to the method of Khalil (1999) using the terminology of bulk density, tapped density, and true density referring to Amidon (2017). Bulk density measurement was carried out by pouring 50 g of sample into a 100 ml measuring glass to determine the volume. The results of the measurement of material mass and volume were recorded and calculated by the formula:

$$\text{Bulk density (BD)} = \frac{\text{Mass of material (g)}}{\text{(Volume of space occupied (l)}}$$

Tapped density measurement was conducted by tapping up the measuring glass containing the sample in the BD procedure for 10 minutes, then calculated by the formula:

$$\text{Tapped density (TD)} = \frac{\text{Mass of material (g)}}{\text{The volume of final space after compacting (l)}}$$

True density was measured using Archimedes' law principles. As much as 30 g of material was put into a 100 ml measuring glass, added 50 ml of distilled water, and stirred until smooth, and read the change in the final volume was. True density was calculated by the formula:

$$\text{True density (TDS)} = \frac{\text{Mass of material (kg)}}{\text{Change in aqua dest volume (l)}}$$

Experiment design and data analysis. A factorial completely randomized design (CRD) 3 x 4 with 4 replications was applied in this study. The first factor was storage time 0 (W0), 30 (W30), and 60 (W60) days; the second factor was burlap sack + 0 ppm calcium propionate (P1), burlap sack + 160 ppm calcium propionate (P2), hermetic sack + 0 ppm calcium propionate (P3), and hermetic sack + 160 ppm calcium propionate (P4). The obtained data were analyzed by using analysis of variance (ANOVA) if there was a difference followed by Duncan's multiple distance test using SPSS software 22 version.

Results and Discussion

Storage room condition

Figure 1 and 2 shows that the lowest temperature during storage was 26°C and the highest temperature was 29.1°C, while the lowest humidity was 69% and the highest was 92 %. The experiment was conducted from December to February, it was the rainy season that caused the storage room conditions was very humid. In addition, the altitude of the research location was ± 192 m above sea level which affected the geographical conditions of the area of high daily temperatures. The room temperature and relative humidity range during the study were not ideal for storing feed ingredients. Based on Imdad and Nawangsih (1999) the temperature of 25-30°C was an ideal environment for insect growth and according to Syarief and Halid (1993), the safe humidity limit for storing agricultural products was less than 70%.

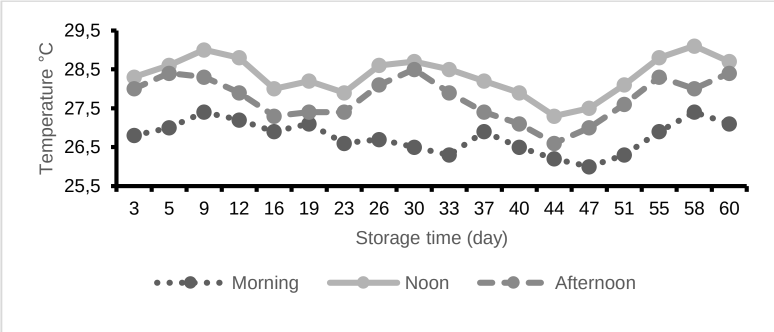

Figure 1. Storage room temperature from 9 December 2021 - 4 February 2022.

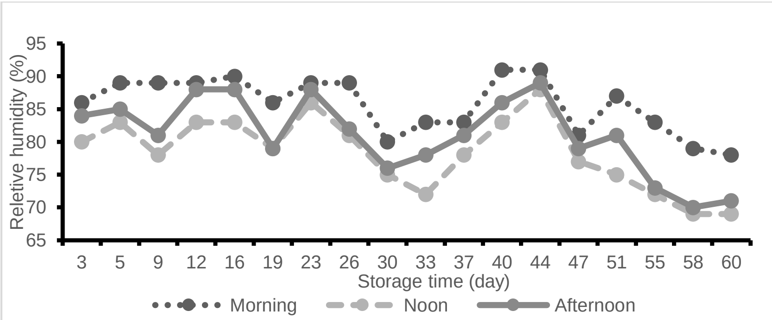

Figure 2. Storage room relative humidity from 9 December 2021 - 4 February 2022.

Number of beetles

The calculation of the number of beetles in this study is discussed descriptively due to a standard method for this analysis is not found. The results (Table 1) showed that there were no beetle species were found at day 0 in all packaging types (W0P1-P4). Several beetles in the form of beetles and larvae were found after 30 days of storage in burlap sacks both with (W30P2) and without (W30P1) calcium propionate addition. The population continued to increase until 60 days of storage (W60P1 and W60P2). In contrast, populations of beetles and larvae were not found in hermetic sacks both with and without calcium propionate addition during 30 (W30P4 and W30P3) and 60 (W60P4 and W60P3) days of storage.

Burlap sacks have the characteristics of a low level of sack wall density (porous) compared to hermetic sacks, so they are more susceptible to beetle attacks (Ramahariah *et al*., 2013). The beetles found in this study were *Tribolium castaneum*, the same species of beetle found by other researchers in the storage of rice (Dharmaputra *et al*., 2014) and rice bran (Permana *et al*., 2012). The beetles have the characteristics of a reddish brown, flat body shape with a length ranging from 3-4 mm (Haines, 1991). These beetles can produce about 38-450 eggs throughout their life cycle of 20-80 days (Manueke *et al*., 2015; Pires *et al*., 2019). The beetle *T. castaneum* is the main pest that lives and breeds on rice, rice bran, or grains (Rimbing, 2015; Permana *et al*., 2012; Dharmaputra *et al*., 2014) and is widespread in the area tropical and subtropical (Sreeramoju *et al*., 2016). The number of beetles will continue to increase during the storage time (Kamsiati *et al*., 2013; Booroto *et al*., 2017; Dharmaputra *et al*., 2014). The damage caused by beetle attacks is in the form of damage to physical and chemical properties (Sutrisno *et al*., 2013; Ralahalu *et al*., 2020). Beetles eat and damage the physical structure of feed ingredients, such as holes, and crumbles, and trigger the growth of other microorganisms (Untung, 1993). Factors that affect the degree of damage to rice bran by beetles include population, rice bran varieties, and storage time (Soekarna, 1982). Therefore, storage for 2 months could reduce the quality of rice bran due to beetle attacks.

The addition of calcium propionate in burlap sack packaging did not affect the presence of the beetle. This indicated that the calcium propionate did not have any capability to protect rice bran from insect attack. According to Mahanani and Inrianti (2021), the population of beetles increased due to storage time dan relative humidity. Pratiwi and Ananda (2021) reported that at a temperature of 20–30ºC and relative humidity of 60–70% the insect (*C. ferrugineus*) was found grow well and at a temperature of 40ºC and relative humidity of 35% was suppressed and more mortality. The room temperature and relative humidity recorded during the research in this experiment were 26-29.1ºC and 69–91%.

The zero-finding number of insects in hermetic sacks packaging in this study both at 30 days (W30P3 and W30P4) and at 60 days (W60P3 and W60P4) storage time might be due to the hermetic sacks could maintaining anaerobic conditions, caused insects could not get a certain amount of oxygen for growth. Some researchers reported that reducing the oxygen and increasing the carbon dioxide levels inside the hermetically sealed storage ecosystem could suppress the growth of insects (Jonfia-Essien *et al*., 2008), resulting in insect mortality (De Groote *et al*., 2013), and this could control the activity and the number of live insects in the product (Dijkink *et al*., 2022).

Rice bran moisture content

The experiment results showed that the moisture content (MC) of rice bran during the storage period ranged from 10.11% to 14.88% and significantly (P<0.05) varied (Table 1). This indicated that the changes in moisture content during the storage period were different among the treatment packaging type. The moisture content of rice bran during storage periods in the burlap sacks significantly (P<0.05) increased from 10.12% at 0 days (W0P1-P2) to 11.98–12.13% at 30 days (W30P1-P2) and further increased to 14.70–14.88% at 60 days (W60P1-P2). In the hermetic sacks, the moisture content of rice bran significantly (P<0.05) increased from 10.11-10.22% at 0 days (W0P3-P4) to 10.90–11.15% at 30 days (W30P3-P4) and then increased to 12.04–12.22% at 60 days (W60P3-P4). The rice bran moisture content in the hermetic sacks was found significantly (P<0.05) lower than in the burlap sacks both at 30 days (10.90–11.15% versus 11.98–12.13%) and at 60 days storage (12.04–12.22% versus 14.70–14.88%). This experiment also revealed that the application of 160 ppm calcium propionate did not affect the rice bran moisture content both in the burlap and hermetic packaging type.

These findings have shown that the use of a hermetic sack could maintain airtightness that might prevent the absorption of moisture from the ambient air. These results were in line with the reports of Weinberg *et al*. (2008), Dewayani *et al*. (2013), and Yewle *et al*. (2021) which stated that the use of hermetic packaging could inhibit the increase of moisture content and maintain the material quality during storage.

The moisture content of the material during storage could be influenced by the temperature and humidity of the storage room (Ralahalu *et al*., 2020), and respiration activity (Nurrahman, 2005). During the study, the temperature varied from 26.0°C to 29.1°C (Figure 1) with humidity varying between 69-91% (Figure 2). The moisture content of rice bran in this research was still at the normal level, which was less than 14%, except in burlap sack packaging at 60 days of storage, the moisture content was 14.70% in W60P1 and 14.88% in W60P2. The high moisture content would be a potential for microbial growth (Ferdian *et al*., 2019). Based on the Indonesian National Standard, the maximum recommended moisture content of rice bran is 12% (SNI, 1996).

Characteristics of physical properties

Based on the results of Table 2, shows that storage time and the combination of the type of packaging and administration of calcium propionate had a significant interaction (P<0.05) on affected the decrease of bulk density (BD), tapped density (TD), and true density (TDS) values of rice bran. This indicated that the changes in physical property values during storage time were different among the treatment. BD values were found to decrease (P<0.05) due to storage time from 322.16–322.38 gl^{-1} at 0 days (W0P1-P4) to 311.39-317.98 gl^{-1} at 30 days (W30P1-P4) and further decreased to 292.95–311.15 at 60 days (W60P1-P4). The highest decrease of BD value was found both at the 30 and 60 days storage time in burlap sack + 0 ppm calcium propionate packaging (W30P1 and W60P1), while the smallest decrease was found both at 30 and 60 days storage time in hermetic sack in 160 ppm calcium propionate (W30P4 and W60P4). The data also revealed that the BD values were lower (P<0.05) in the burlap sack than in the hermetic sack packaging both at 30 days (311.39-312.56 versus 315.83-317.98) and 60 days (292.95-302.11 versus 303.42-311.15) storage time.

In line with the BD values, the TD values also were found to decrease due to the storage time. The TD values decreased (P<0.05) from 565.66-565.92 gl^{-1} at 0 days (W0P1-P4) to 521.23-541.33 gl^{-1} at 30 days (W30P1-P4) and further decreased to 498.31–524.97 at 60 days (W60P1-P4). The highest decrease of TD value was found in burlap sack + 0 ppm calcium propionate (W30P1 and W60P1) both at the 30 and 60 days storage time and the smallest decrease was found in hermetic sack + 160 ppm calcium propionate (W30P4 and W60P4) both at 30 and 60 days storage time.

Table 1. Number of beetle and moisture content of rice bran during storage

Storage time	Packaging type	Number of beetle	Moisture content (%)
W0	P1	-	10.12 ± 0.12^{d}
	P2	-	10.15 ± 0.16^{d}
	P3	-	10.11 ± 0.22^{d}
	P4	-	10.22 ± 0.12^{d}
W30	P1	++	12.13 ± 0.31^{b}
	P2	++	11.98 ± 0.14^{b}
	P3	-	11.15 ± 0.23^{c}
	P4	-	10.90 ± 0.42^{c}
W60	P1	+++	14.70 ± 0.31^{a}
	P2	+++	14.88 ± 0.13^{a}
	P3	-	12.22 ± 0.14^{b}
	P4	-	12.04 ± 0.22^{b}

W0 = 0 days, W30 = 30 days, W60 = 60 days; P1 = burlap sack + 0 ppm calcium propionate, P2 = burlap sack + 160 ppm calcium propionate, P3 = hermetic sack + 0 ppm calcium propionate, P4 = hermetic sack + 160 ppm calcium propionate; - = no beetle, + = 1 - 100 beetle, ++ = < 100 - 200 beetle, +++ = < 200 - 400 beetle.

[a,b,c,d] Different superscripts on the same column indicate statistical differences (p<0.05) among treatments (p<0.05).

Table 2. Physical properties value of rice bran during storage in various packaging.

Storage time	Packaging type	BD (gl^{-1})	TD (gl^{-1})	TDS (kgl^{-1})
	P1	322.27±0.12[a]	565.87±0.60[a]	1.40±0.17[a]
W0	P2	322.38±0.21[a]	565.76±0.48[a]	1.41±0.19[a]
	P3	322.16±0.14[a]	565.92±0.59[a]	1.39±0.20[a]
	P4	322.22±0.20[a]	565.66±0.77[a]	1.43±0.18[a]
	P1	311.39±1.19[c]	521.23±1.10[e]	1.27±0.01[cd]
W30	P2	312.56±1.31[c]	523.64±2.45[d]	1.30±0.00[bc]
	P3	315.83±0.57[b]	531.83±0.95[c]	1.30±0.01[b]
	P4	317.98±0.56[b]	541.33±2.01[b]	1.33±0.01[b]
W60	P1	292.95±4.19[e]	477.03±1.45[h]	1.13±0.02[f]
	P2	302.11±1.20[d]	498.31±0.31[g]	1.19±0.05[e]
	P3	303.42±3.11[d]	517.19±1.26[f]	1.25±0.16[d]
	P4	311.15±1.59[c]	524.97±0.85[d]	1.27±0.01[cd]

W0 = 0 days, W30 = 30 days, W60 = 60 days, P1 = burlap sack + 0 ppm calcium propionate, P2 = burlap sack + 160 ppm calcium propionate, P3 = hermetic sack + 0 ppm calcium propionate, P4 = hermetic sack + 160 ppm calcium propionate, BD = bulk density, TD = tapped density, and TDS = true density.

[a,b,c,d,e,f,g,h] Different superscripts on the same column indicate statistical differences (p<0.05) among treatments (p<0.05).

Following the BD and TD values, the TDS values decreased (P<0.05) during storage time. At 0 days (W0P1-P4) the TDS values were 1.39-1.40 kgl^{-1}, at 30 days (W30P1-P4) became 1.37-1.3 kgl^{-1} and at 60 days (W60P1-P4) further decreased became 1.13-1.27 kgl^{-1}. The TDS values of the burlap sack in 0 ppm calcium propionate packaging (W30P1 and W60P1) were found as the highest decrease both at 30 days and at 60 days storage time. The hermetic sack in 160 ppm calcium propionate (W30P4 and W60P4) was found as the smallest decrease both at 30 days and 60 days storage time.

This experiment's results agreed with the report by Jaelani *et al*. (2016) who found that the value of the physical properties of feed decreased during storage time. According to Khalil (1999), changes in moisture content will affect the changes in BD, TD, and TDS values, and the value would continue to decrease along with the increase in moisture content. In line with the results of this study which showed an increase in the values of the moisture content during storage was followed by a decrease in the physical properties value of rice bran. The decrease of the BD, TD, and TDS value during storage could also be from an increase in the percentage of husks as a result of beetle activity consuming easily digested materials and leaving difficult-to-digest materials such as husks (Laylah and Samsuadi, 2014; Tumuluru *et al*., 2011).

The higher physical properties values in the hermetic sacks compared to the physical properties' values in the burlap sacks during storage time, according to Destiana (2016) and Rachmat (2008) presumably due to the anaerobic environment in the hermetic sack packaging could not support the activity of microflora and pests that caused the damage of rice bran quality was not as high as that in burlap sack packaging. Hermetic sack packaging is part of modified atmosphere packaging (MAP) that can suppress respiration rates, decline microbial growth, reduce enzyme damage, and extend shelf life (Julianti and Nurminah, 2006; Sutrisno and Purwanto, 2011). On the contrary, the environmental condition in burlap sack packaging was aerobic which could support respiratory activity and the development of the number of microflora and pests that occurred during storage periods. Ardiansyah (2012) reported that the weakness of burlap sacks is that they have relatively larger pores, causing the rice bran to easily absorb moisture from the outside air. Furthermore, this could trigger higher damage to rice bran in burlap sack packaging (Yewle *et al*., 2021).

The application of 160 ppm calcium propionate significantly (P<0.05) suppressed the decrease in the physical properties of rice bran during storage (Table 3). The results showed that the decrease of the value of BS, TD, and TDS of rice bran in the packaging with the addition of calcium propionate (P2 and P4) was significantly smaller (P<0.05) than in the packaging without calcium propionate (P1 and P3). This might be due to the activity of organic acids that could effectively inhibit respiratory activity (Kusumegi *et al*., 1998; Stratford *et al*., 2020), and beetle development (Yoshihara *et al*., 1980). The increasing self-life of wheat bran due to the propionic acid addition was reported by Adisti *et al*. (2021).

The shelf life of a feed ingredient is very important in the livestock business (Akbar *et al*., 2017). Shelf life can be controlled by packaging, including control of light, oxygen concentration, moisture content, heat transfer, contamination, and attack of living organisms (Harris and Karnas, 1989). The packaging process is also meant to facilitate the transportation and storage of products that do not deteriorate quickly (Dwinarto *et al*., 2018).

Conclusions

Hermetic sack packaging could maintain the physical properties of rice bran during storage. The using combination of a hermetic sack with the addition of calcium propionate could further increase the resistance and the shelf life of rice bran in 60 days of storage.

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