International Journal of Membrane Science and Technology, 2023, Vol. 10, No. 2, pp 3630-3640

Pneumatic press machine Rice bran oil Extractor for a Pilot scale and its potential for the SME Scale: Performance of Yield and Anthocyanin Content

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Abstract: Rice is a food crop that serves as a source of energy. As an edible food, the rice skin is separated, which produces solid waste in the form of rice bran. Generally, the rice bran produced from the rice milling process is 8-12%. Rice bran is only used for animal feed. Rice bran contains various vitamins and antioxidants, one of which is anthocyanins. The benefits of anthocyanins include natural pH indicators, natural dyes usually used in food and beverages, and anticancer. Extraction in this study using a pneumatic press machine for pilot scale and the other aim of this research were study the potential of SME (small and medium enterprises) Scale. The analysis of rice bran oil is conducted by the Spectrophotometric method. The variables used in the extraction process in this study were pressures of 3, 4, 5, 6, and 7 bars and stabilization time of 8, 11, 14, 17 and 20 minutes with a pressure of 7 bar on the yield and the content of anthocyanins. The obtained yield is at the 7 bar, which was 6.45%. The yield shows that the pressure is related to the yield of rice bran oil. It shows that the highest anthocyanin content was obtained at the optimum stabilization time is 20 minutes with an anthocyanin content of 36.9 mg/kg. The capacity of this press machine is 5 kg, so by using the ratio of rice bran: solvent (1: 7), if the maximum raw material that can be processed is 625 gr and 4375 gr solvent, a yield of 40.3125 gr will be obtained. This value shows the potential for using a pneumatic press machine as a pilot scale extractor for SME (Small Medium Entreprise) needs

Keywords: Anthocyanin, Extract, Pneumatic Press, Rice Bran, Yield.

1. INTRODUCTION

Rice is a food crop that functions as an energy source that people of Indonesia generally consume. Rice to be consumed must first be separated from the skin, which can produce solid waste. Solid waste from rice separation is referred to as rice bran[1][2]. Generally, the rice bran produced from the rice milling process is as much as 8-12%. Rice bran is still limited to only being used for animal feed[3]. Rice bran can be extracted into rice bran oil. Rice bran oil is a healthy food oil widely used in the food and cosmetic industries[4]. The content of unsaturated fatty acids in rice bran is very high, reaching 80%, with the main components oleic acid at 42.4% and linoleic acid at 36.4%. Rice bran also contains various vitamins and antioxidants [5]. Besides that, Rice bran contains anthocyanin (one of the antioxidant groups) as much as 5.55 mg/g of material[6] [7]. This is similar to the by-products of processing of palm oil mills. For every ton of processed fresh fruit bunches, it produces about 1 ton of liquid waste with a pollution load. Then it becomes an important requirement to obtain effective treatment in order to preserve the environment and maintain the economy.

Rice bran oil is extracted from rice bran. Rice bran oil can be consumed and contains vitamins, antioxidants, and nutrients that the human body needs[8]. World bran oil prices range from US$12-14 per liter, with the main markets being Japan, Korea, China, Taiwan, and Thailand. This means bran oil has been widely used as the best-qualified edible oil. Worldwide bran oil production ranges from 1.0 to 1.4 million tons per year. The primary producers are India, China, Japan, and Myanmar. India itself is capable of producing rice bran oil 700-900 thousand tons of bran oil per year [4]. Rice bran oil is known to contain a variety of active ingredients such as tocopherols, tocotrienols, Û-oryzanols and unsaturated fatty acids. RBO can be used as an additive in cosmetics, cooking oil, emulsifiers and others[9].

Anthocyanin is a pigment compound that is soluble in water[7]. In general, anthocyanins are in the form of aglycones, commonly called anthocyanidins. Anthocyanins can act as antioxidants because they are phenolic compounds that can counteract free radicals[10]. The benefits of anthocyanins include natural indicators of pH, natural dyes commonly used in food and beverages, and anticancer [7], [11]. According to [8] Rice Bran Oil is a natural source with bioactive components that are beneficial for health. The bioactive components are tocopherol (Vitamin E), tocotrienols, oryzanol, phenolic compounds, and anthocyanins [8][5]. Several compounds derived from natural plant materials can function as bioadditives, either those contained in these materials or the results of their chemical modification. For example, the anthocyanins contained in rice bran can function as antioxidants[9]. Another example of glycerol from the by-product of processing vegetable oil into methyl esters, according to[12] can affect the biodegradability of nanocomposites from cornstarch. Glycerol as a good water retainer prepared for the growth of microorganisms that require certain humidity.

It is known that oil extraction using several methods can have an effect on quality[13]. The pneumatic press is found as an alternative in solvent extraction. Even though the solvent extraction method is considered more effective, the mechanical extraction method, especially the cold press method, is considered to produce healthier oil because it is rich in bioactive compounds such as essential fatty acids, phenolics and tocopherols.[13], [14]

Pneumatic press machine is done by adjusting the pressure applied by the pneumatic press machine and then pressing the sample several times to produce optimal extract results. The advantage of this extraction method is that it reduces labor and creates a greater yield than other methods because it removes oil and fat from the cells using graded pressure, the higher the pressure [15]. In this study, the extraction method combined the maceration and pneumatic press methods.

Another technology that can be used to extract oil is the ultrasonicator, this equipment is known to shorten time, as well as its use as a reactor which can shorten reaction time and achieved a higher yield of polyphenols [16]. In addition, the heating process also needs to be considered.

This study has a general objective, to obtain the performance of the rice bran oil extraction process by the maceration method using hexane solvent and a pneumatic press machine on the yield and anthocyanin content on a pilot plan scale and its potential for SME scale

2. MATERIAL AND METHODS

2.1. Material and Equipment

The materials used in this study were rice bran, N-hexane, and aquadest or distilled water[14][17]. The equipments used in this research are a pneumatic press machine, glass beaker, stirrer, frying pan, oven, rotary evaporator.

2.2 Procedure

The choice of method in this study was manufacturing rice bran extract using a press pneumatic machine (3, 4, 5, 6, and 7 bar) with a weight of 200 grams of rice bran and a stabilization time of 10 minutes. Another variation is the Press extraction process with each stabilization time of 8, 11, 14, 17, 20 minutes and the pressure is 7 bar.

The roasted rice bran obtained after the stabilization process goes through a homogenization process. By adding 1.4 liters of N-hexane with a ratio of 1:7, the extraction treatment was carried out using the combination of Maceration for 3h and the Pneumatic Press methode. Next is to pour a hexane solvent and rice bran into a pneumatic hydraulic press that had been placed on the furing clothes.

After being pressed using a pneumatic press, the extraction results were filtered using filter paper in an Erlenmeyer to take the filtrate[18]. Then the results of the filtrate are separated between rice bran oil and the solvent using a rotary evaporator for 10-15 minutes. Furthermore, the results from the rotary evaporator were analyzed using spectrophotometry [7] to determine the anthocyanin content in rice bran oil.

The potential for SME scale was studied by literature review for comparation by several method such as maceration, soxhlet, ultrasonicator

2.3. Analysis Method

2.3.1 Analysis of Rice Bran Oil Extract Yield

Calculate the rice bran oil yield using equation (1)

$$\text{Yield} = \frac{A}{B} \text{ x } 100\% \qquad (1)$$

Where

A = Weight of rice bran oil after purification

B = Weight of rice bran oil before purification

2.3.2. Analysis of Anthocyanin Content of Rice Bran Oil

Spectrophotometry is an analytical method using the basic calculation of the absorption size of monochromatic light at a certain wavelength. A spectrophotometer is used for the Determination of a compound by measuring the absorbance of a sample[19] . A spectrometer produces light from a spectrum with a particular wavelength, and a photometer is a device for measuring the intensity of light that is transmitted or absorbed. The advantage of spectrometers over photometers is that the wavelength of white light can be selected more. In the filter photometer, various filters of various colors have specifications that pass specific wavelengths. It is impossible to obtain a genuinely monochromatic wavelength in a filter photometer. The wavelength range of 30-40 nm. In a spectrophotometer, the selected wavelength can be obtained with the help of a light-parsing device such as a prism. A spectrophotometer comprises a continuous visible spectrum source, a monochromator, an absorber cell for the sample solution or blank, and an apparatus for measuring the difference in absorption between the sample and the empty or reference. solvent and pH are important factors in the solubility of anthocyanins. This affects the quaternary structure of anthocyanins in the absorption spectrum [20].

2.3.3. Press Pneumatic Extractor for Pilot Scale and its Potential for SME Scale

Increasing the scale of research results from laboratory scale to pilot scale in the Rice bran oil extraction process with good performance can be carried out using a combination of maceration technology with organic solvents and a pneumatic press. The pneumatic press tool has a capacity of up to 5 kg (Mix of Solvent and Macerated Rice Bran). So that with the increasing capacity of raw material for rice bran and solvent (1: 7 v/v), it is hoped that the yield will also be greater and the product characteristics will also be good, because there is no heating.

3. RESULTS AND DISCUSSIONS

3.3.1. Effect of Press Pressure on Rice Bran Oil Yield

The extraction process is carried out with a pneumatic press machine. The weight of each sample used was 200 g with pressure variations of 3, 4, 5, 6, and 7 bar. For stabilization time of 10 minutes, as shown in Table 1.

Table 1. Data on Pressure Variation and RBO Yield (%)

Pressure (Bar)	Filtrate Color	Rice Bran Oil Yield (%)
3	Bright Yellow	5
4	Bright Yellow	5.24
5	Bright Yellow	5.5
6	Bright Yellow	6
7	Bright Yellow	6.45

3.2. Analysis of Anthocyanin Content in Rice Bran Extract from Pressure Variations

The anthocyanin content test was carried out using the Spectrophotometric method. The results of the anthocyanin content test are shown in Table 2.

Table 2. Data on Pressure Variation and Anthocyanin Content

No	Pressure (Bar)	Simplo (Mg/Kg)	Duplo (Mg/Kg)
1	3	6.18	6.01
2	4	0.83	0.75
3	5	0.83	0.92
4	6	0.58	0.58
5	7	3.76	3.76

3.3. Effect of Stabilization Time on Rice Bran Oil Yield

The stabilization process carried out in this study was by roasting rice bran using bunsen. The weight of each sample used was 200 grams with variations in stabilization time of 8, 11, 14, 17 and 20 minutes. Then the extraction process was carried out with a pneumatic press machine at a constant pressure of 7 bar, as shown in Table 3

Table 3 Data on Variation of Stabilization Time and RBO Yield (%)

Stabilization Time (Minute)	Filtrate Color	Rice Bran Weight (gram)	RBO weight (gram)	% RBO
8	Bright Yellow	200	9.42	4.71
11	Bright Yellow	200	13.4	6.7
14	Dark Yellow	200	14.07	7.035
17	Dark Yellow	200	13.26	6.63
20	Reddish yellow	200	12.42	6.21

3.4. Analysis of Anthocyanin content in Rice Bran Extract from Stabilization Time Variations

Anthocyanin content test was carried out using the spectrophotometric method. Spectrophotometry is an analytical method based on measuring the absorption of monochromatic light by a colored solution column at a specific wavelength using a prism monochromator and a hollow photon tube [11]. The content of the Anthocyanin are shown in Table 4.

Table 4. Data on Variation of Stabilization Time and Anthocyanin Content

No.	Stabilization Time (Minute)		Simplo (mg/kg)	Duplo (mg/kg)
1	8		0.25	0.25
2	11		8.85	8.68
3	14		13.36	13.86
4	17		1.75	1.84
5	20		35.99	36.9

3.5. Analysis of the Effect of Press Pressure on Rice Bran Oil Yield

Table 1 shows that the filtrate results from the filtering have the same color due to the stabilization time carried out for 10 minutes. In addition, the solution of the filtrate is bright yellow. This is because rice bran's lipase and protein enzymes have not been destroyed.

The size of the percentage yield of rice bran oil can be seen clearly after being channeled on the graph shown in **Figure 1** At the beginning of the 3, 4, and 5 bar pressures, an increase in the yield of rice bran oil (% RBO) and after passing through the bar. There was a significant increase in the result of rice bran oil. This is because the percent yield of rice bran oil (% RBO) is influenced by pressure. If the pressure is high, the percent yield of rice bran oil is higher (% RBO).Based on Figure 1. The effect of pressure on the yield of rice bran oil (% RBO) obtained a polynomial regression equation, namely

$$y = 0.0471x^2 + 0.0831x + 4.87 \qquad (2)$$

It is known that the coefficient of determination (R-Squared) on the graph is $R^2 = 0.9969$. Because the interaction correlation coefficient between press pressure and rice bran oil yield is 0.9969, which means that the relationship between the two variables is very close and has a connection [14]

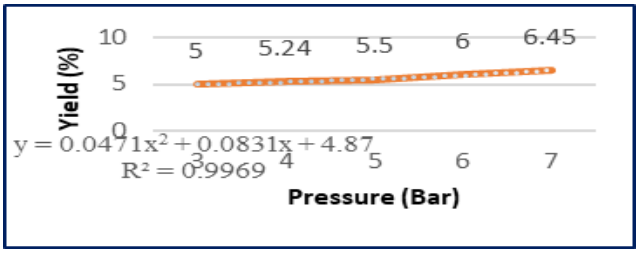

Figure 1. Rice Bran Extraction Press Pressure against RBO Yield (%)

3.6. Analysis of the Effect of Press Pressure on Anthocyanin Levels in Rice Bran Oil

The results of the Anthocyanin content can be seen clearly after being made on the block diagram shown in Figure 2, Figure 3, and Figure 4. In contrast to the yield of rice bran oil, at the 3rd bar pressure, the anthocyanin content was the highest, reaching 6.18 Mg/Kg for simplo and 6.01 Mg/Kg for Duplo. Then at the pressure 4 bar, there was a drastic decrease in the anthocyanin content, which was only 0.83 Mg/Kg for simplo and 0.75 Mg/Kg for Duplo.

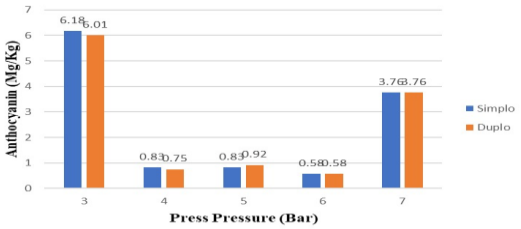

Figure 2. Results of Rice Bran Press Pressure on Anthocyanin Content

Then the anthocyanin content at 5 bar pressure increased in Duplo by 0.92 Mg/Kg, while in simplo it did not increase, which was 0.83 Mg/Kg. Furthermore, at the 6th bar pressure, there was a decrease in the anthocyanin content, which was 0.58 Mg/Kg for simplo and 0.58 Mg/Kg for Duplo. Finally, at 7 bar pressure, there was a significant increase in anthocyanin content, which was 3.76 Mg/Kg for simplo and 3.76 Mg/Kg for Duplo.

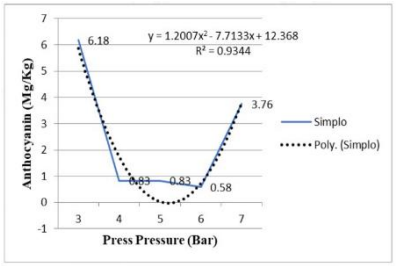

Figure 3. Rice Bran Press Pressure on Anthocyanin Content (Simplo)

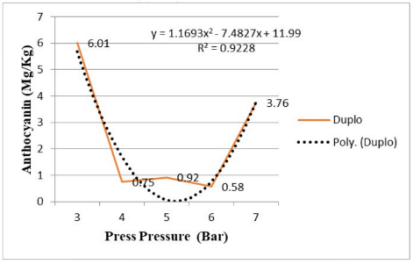

Figure 4. Rice Bran Press Pressure on Anthocyanin Content (Duplo)

The drastic decrease in the 4 bar pressure and a significant increase in 7 bar pressure can be caused by the amount of anthocyanin that has shifted and degraded at 4 bar pressure. This causes this compound to undergo hydrolysis in glycosidic bonds easily. The aglycone ring opens, forming various labile aglycones, colorless carbinol, and chalcone groups [21]. Then a significant increase in 7 bar pressure can be caused by the temperature in the stabilization/roasting process is not too high so that the lipase and protein enzymes are not completely degraded.

Based on Figure 3 and Figure 4, the effect of Press Pneumatic Pressure on the results of anthocyanin content obtained a polynomial regression equation, namely y = 1.2007x2 - 7.7133x + 12.368 for Simplo and y = 1.1693x2 - 7.4827x + 11.99 for Duplo. The coefficient of determination (R Square) on the two graphs is $R^2 = 0.9344$ for Simplo

and $R^2 = 0.9228$ for Duplo. Because the average correlation coefficient of the interaction of the two graphs above between pressing pressure and anthocyanin content is $R^2 = 0.9286$, the relationship between the two variables is

closely relate[22]. This analysis revealed that the optimal anthocyanin content was at a press pressure of 3 bar, namely 6.18 mg/kg for Simplo and 6.01 mg/kg for Duplo.

3.7. Analysis of the Effect of Stabilization Time on the Yield of Rice Bran Oil

The process of stabilizing rice bran prior to oil extraction is carried out with the aim of making it easier for the oil to come out of the enzymes, increasing the dilution of the oil, evaporating the water to a certain water content, turning off the activity of certain enzymes and microorganisms, is a method of preliminary sterilization, and agglomerates some proteins making it easier further separation [23][24]. RBO stabilization can be done without heating with a lipase yield of up to 50%[25].The stabilization process carried out in this study, namely by roasting rice bran using bunsen. The weight of each sample used was 200 grams with variations in stabilization time of 8, 11, 14, 17 and 20 minutes. Then the extraction process was carried out with a pneumatic press machine at a constant pressure of 7 bar. Base on Table 4.1 can be seen that the filtrate results from screening have different colors according to the length of time the stabilization is carried out. At the stabilization time at 8 and 11 minutes the solution produced a bright yellow filtrate, this was because the lipase enzymes and proteins in rice bran had not been completely destroyed [21]. Then at the stabilization time of 14 and 17 minutes the results of the filtrate are dark yellow. This can be influenced because the lipase enzymes and proteins in rice bran have begun to be completely destroyed. Furthermore, in 20 minutes there was a significant change in the color of the solution resulting in a reddish yellow color. This can be influenced by the destruction of lipase enzymes, proteins and several other compounds contained in the rice bran, causing a red color in the filtrate solution [21]. This is caused by the long stabilization time and temperature that continues to increase.

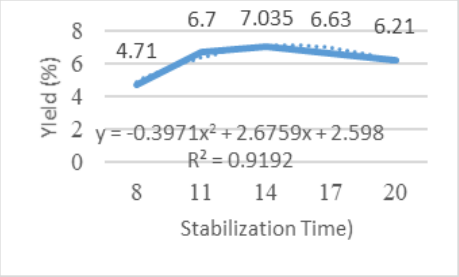

Figure 5. Graph of Rice Bran Stabilization Time against % RB

The size of the percentage yield of rice bran oil (Rice Bran Oil) can be seen clearly after plotting it on the graph shown in Figure 5. At the beginning of the stabilization time of 8, 11, and 14 minutes, there was a significant increase in the yield of rice bran oil (%RBO) and after 14 minutes, there was a decrease in the yield of rice bran oil. This is because rice bran contains the lipase enzyme, so to destroy the lipase enzyme it only takes a few minutes at a temperature of 100-120oC [21], so that if the heating is carried out longer, it will make the components contained in the bran rice becomes damaged and affects the yield of rice bran oil produced. The yield percentage of RBO in this study was lower than the yield percentage of RBO reported by Nasir et al. (2009) with N-Hexane and Ethanol at a stabilization time of 15 minutes at 110oC, which is 18.34%. Based on Figure 5, the effect of stabilization time on the yield of rice bran oil (%RBO) is a polynomial regression equation, namely y = -0.3971x2 + 2.6759x + 2.598. It is known that the coefficient of determination (R Square) on the graph is R2 = 0.9192. This results are the correlation between the dependent variable and the independent variable. Because the correlation coefficient of interaction between stabilization time and yield of rice bran oil is 0.9192, which means that the relationship between the two

variables is very close and related [14]. The results of this study revealed that the optimal stabilization time of rice bran was 14 minutes with a pneumatic press pressure of 7 bar.

3.8. Analysis of Anthocyanin Content in Rice Bran Extract

Analyzing of the anthocyanin content in this study, namely by using the spectrophotometric method[26]. This test was carried out using spectrophotometry with the duplo method to determine the content of anthocyanins in rice bran extract. The results of the analysis of anthocyanin content using the spectrophotometric method can be seen in Table 2.

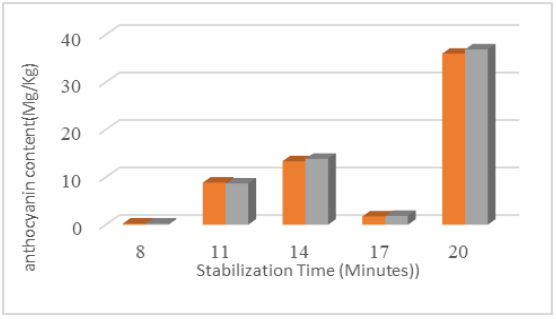

Figure 6 . Time Block Diagram of Rice Bran Stabilization on Anthocyanin Content

The results of the anthocyanin content can be seen clearly after making it on the bar diagram shown in Figure 6. Just like the yield of rice bran oil, at the beginning of the stabilization time of 8, 11, and 14 minutes there was a significant increase in the yield of anthocyanin content, which reached a yield of anthocyanin content of 13.36 Mg/Kg for simplo and 13.86 Mg/Kg for duplo. Then in the 17 minute there was a quite drastic decrease in the anthocyanin content, which was only 1.75 Mg/Kg for simplo and 1.84 Mg/Kg for duplo. The amount of anthocyanin content at the 17 minute stabilization time was even smaller than the amount of anthocyanin content at 11 minutes stabilization time of 8.85 Mg/Kg for simplo and 8.86 Mg/Kg for duplo. Furthermore, at the 20 minute there was a very significant increase in the anthocyanin content, even the amount of anthocyanin content at the 20 minutes was the largest and optimal, namely 35.99 Mg/Kg for simplo and 36.9 Mg/Kg for duplo. The drastic decrease in 17 minutes and a very significant increase in the 20 minutes could be due to the amount of anthocyanin content which had been damaged/degraded a lot in 17 minutes due to exposure to too high a temperature during the roasting process. Then the occurrence of a very significant increase in 20 minutes could be due to the temperature used in the stabilization/roasting process is not too high and tends to be stable. So that the lipase enzymes and proteins are degraded, but not to damage the anthocyanins contained in the rice bran, So that the results of the Anthocyanin content at 20 minutes stabilization time increased.

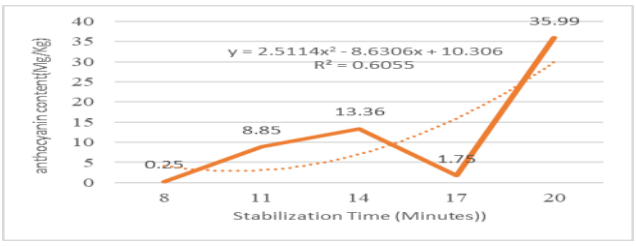

Figure 7. Graph of Rice Bran Stabilization Time on Anthocyanin Content (Simplo)

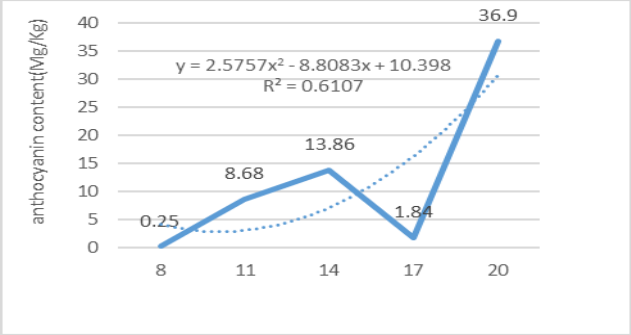

Figure 8. Graph of Rice Bran Stabilization Time on Anthocyanin Content (Duplo)

Based on **Figure 7** and **Figure 8**, the effect of stabilization time on the results of the anthocyanin content. The polynomial regression equation is obtained, namely Y = 2.5114X2 -8.6306X+10.306 for simplo and Y = 2.5757 X2-8.8083X+10,398 for duplo. It is known that the coefficient of determination (*R square*) on both graphs is R2 =0.6055 for simplo and R2 = 0.6107 for duplo. There are a correlation between anthocyanin content and stabilization time. Because the average correlation coefficient of the interaction of the two graphs above betwee the stabilization time and the anthocyanin content is R2=0.6081, which means that the relationship between the two variables is less close and less related. The total anthocyanin content in this study were lower than the total anthocyanin content of brown rice bran reported by [2] with the maceration method amd ethanol solvent which is equal to 106.90 mg/100g of material. The results of this analysis reveal that the optimal anthocyanin content is at a stabilization time of 20 minutes, namely 35.99 mg/kg for simplo and 36.9 mg/kg for duplo with a pneumatic press pressure used of 7 bar.

2.3.3. Press Pneumatic Extractor for Pilot scale and its Potential for SME Scale

Increasing the scale of research results from laboratory scale to pilot scale in the Rice bran oil extraction process with good performance can be carried out using a combination of maceration technology with organic solvents and a pneumatic press. The pneumatic press tool has a capacity of up to 5 kg (Mix of Solvent and Macerated Rice Bran). So with the increasing capacity of rice bran raw materials and solvent (1: 7 v/v), it is hoped that the yield will also be greater and the product characteristics will also be good, because there is no heating. The capacity of this press machine is 5 kg, so by using the ratio of rice bran: solvent (1: 7), if the maximum raw material that can be processed is 625 gr and the solvent is 4375 gr, a yield of 40.3125 gr will be obtained. This value indicates the potential use of a pneumatic press machine as a pilot-scale extractor for MSME needs. When compared to using an ultrasonicator with a maximum capacity, the capacity of rice bran is quite small [27,28]

CONCLUSIONS

The conclusion of this research are as follow:

a. The pneumatic press extraction method can produce high yields of extract Rice bran oil using N-Hexane solvent with a ratio of 1:7 (v/v). Therefore, the pneumatic press extraction method is very suitable for use on a large scale / industrial scale at 3 bar and stabilization time 20 menit. This is because 200 grams of rice bran can produce an RBO volume of 14.8 ml and anthocyanin produced an average of 36.45 mg/kg.

b. The optimum pressure required for the extraction process of rice bran by pneumatic press machine is 7 bar with an optimal yield of 6.45%. The optimum time required for the bran stabilization process is 14 minutes with an optimal yield of 7.035%.

c. The high pressure during the pneumatic press extraction process has no significant effect on the results of Anthocyanin content. The optimum Anthocyanin content on 6.18 mg/kg at 3 bar. The optimum Anthocyanin content at 20 minutes stabilization time is 36.9 mg/kg.

d. The capacity of this press machine is 5 kg, so by using the ratio of rice bran: solvent (1: 7), if the maximum raw material that can be processed is 625 gr and 4375 gr solvent, a yield of 40.3125 gr will be obtained. This value shows the potential for using a pneumatic press machine as a pilot scale extractor for SME needs

ACKNOWLEDGEMENT

We would like to express gratitude to Ministry of Research, Technology, and Higher Education Republic of Indonesia for financial support from the PTUPT Grant 2022-2023 contract no 073/E5/PG.02.00/PL/2023, LLDIKTI III, Chemical Engineering Department and Research and Community Service Institute (LPPM) Universitas Muhammadiyah Jakarta for the facility supports of this work throughout this research.

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DOI: https://doi.org/10.15379/ijmst.v10i2.3194