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The Ultrasound-Assisted Extraction of Rice Bran Oil with n-Hexane as a Solvent

The Ultrasound-Assisted Extraction of Rice Bran Oil with n-Hexane as a Solvent

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Abstract. Rice bran oil (RBO) is one of edible oil which widely used in chemical, pharmaceutical, and food industries due to its unique properties and high medicinal value. RBO obtained by ultrasound-assisted extraction using n-hexane as solvent. This present study aims to determine the ideal bran to solvent ratio to obtain the highest extraction yield using optimal temperature. Rice bran which 90% passable through a sieve with 700 μm opening, was used for the extraction process. The extraction process was done at various temperature (40, 50, 60°C), and various bran to solvent ratio (1:5, 1:10, 1:15 w/v) for 2 hours at 40 kW. The highest yield ultrasound-assisted extraction was 20.35% with ideal bran to solvent ratio 1:5 w/v using 60°C. The RBO yield increased with increasing bran to solvent ratio and temperature at the isobaric condition.

Keywords: ultrasound-assisted extraction; solvent extraction; rice bran oil; n-hexane

1. Introduction

Rice is the most important cereal crop and a staple food in Asia. There are around 18000 varieties accounting for about 25% of the world's food grain production [1]. According to BPS data, in 2015 rice production reached 75.4 million tons, around 6 million tons of by-products for bran [2]. The number of by-products that have been obtained has not been used properly, only used for animal feed.

Rice bran oil is considered superior among the other vegetable oils due to its balanced fatty acid profile and presence of natural antioxidants such as tocopherols, tocotrienols, and γ-oryzanol [3]. γ-oryzanol is important component peculiar to rice bran oil since it has the abilities to decrease the cholesterol, carcinogenic and oxidation defect, also to attenuate allergic inflammation [4].

The content of rice bran oil depending on the rice variety and the length of rice bran storage. Rice bran has an oil content of 12-22%, protein 11-17%, fiber 6-14%, moisture 10-15%, ash 8-17%, minerals, vitamins, and phenolic components. Vitamins in bran include vitamin E, thiamin, niacin, and minerals including aluminum, calcium, chlorine, iron, magnesium, manganese, phosphorus, potassium, sodium and zinc [1,5].

Rice bran oil can be extracted from rice bran by solvent extraction or in the solvent-free process by using ohmic heating or supercritical fluid extraction technology [6]. Solvent extraction of oil from seeds is a diffusional operation that involves the transfer of a solute from a complex, porous plant-tissue matrix, to the solvent. The conventional oil extraction process, the most commonly employed solvent is a mixture of n-hexane. The extraction method is carried out to get the antioxidant content in bran oil [7,8,9]. In the previous study, the extraction using the Soxhlet methods produced bran oil as much as 24% [4].

Rice bran oil has been widely used in the world of health which has a fairly large antioxidant compared to other vegetable oils. Several studies have examined the extraction process of bran oil. The bran oil extraction process using an ultrasonic-assisted device, is one option to get yield quickly [10]. But based on literature, it's hard to find the study about the maximum yield of rice bran oil using ultrasonic-assisted extraction. This present study aims to determine the ideal bran to solvent ratio to obtain the highest extraction yield using optimal temperature.

2. Materials and Methods

2.1. Materials

Rice bran as the raw materials for this research was obtained from a rice mill in Semarang, Indonesia. The bran was passed through a 30-mesh sieve (700 μm aperture size) to remove paddy kernels, broken grains, hull fragments, and foreign materials. After sieving, the rice bran was stored in the plastic bag at 5°C. N-Hexane with purity 95% as the organic solvent materials were obtained from Sigma-Aldrich, Singapore.

2.2. Methods

This research consisted of several steps that involved oil production using ultrasound-assisted extraction, yield and color analysis.

2.2.1. Oil Production. The oil production process using Ultrasonic Bath Cleaner, SS-6820C model with 2 liter capacity, 40 kHz frequency and 80 / 100W power. The method used in the extraction process refers to the method carried out by previous research [11]. The extraction process was done at various temperature (40, 50, 60°C), and various bran to solvent ratio (1:5, 1:10, 1:15 w/v) for 2 hours. The extract with the solvent was separated by a rotary evaporator which had been filtered using filter paper.

2.2.2. Color analysis. The color test in rice bran oil were observed using a Chroma Meter (CR-300, Minolta Co., Ltd., Osaka, Japan). The observation of color test was produce code that identified as Hunter L* (brightness), a* (redness and greenness) and b* (yellowness and blueness) value. The L*, a* and b* was then calculated as the total color difference value (ΔE) (Eq. 1) and color combination of L*×a*×b* [12].

$$\Delta E = \sqrt{\left(L^*_{reference} - L^*_{sample}\right)^2 + \left(a^*_{reference} - a^*_{sample}\right)^2 + \left(b^*_{reference} - b^*_{sample}\right)^2} \quad (1)$$

3. Result and Discussion

3.1. The effect of temperature on rice bran oil yield

Ultrasonic waves have the ability to the acoustic cavitation phenomena. These phenomena refer to bubble formation that occurrence of cell swelling and dissolution of components caused by enlargement of cell wall pores [13]. The yield of rice bran oil value at various temperature was observed. The different temperature resulted in different value of yield (Figure 1). The result in, the yield of rice bran oil increased with the increase in temperature. Increasing temperature to 60°C will increase the yield of rice bran oil up to 20%.

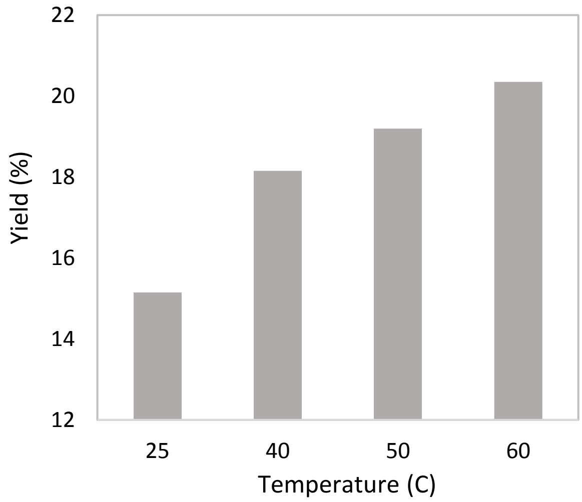

Figure 1. The yield of rice bran oil at various temperature on 1:5 ratio

The temperature affected the secreting oil out from the rice bran also the viscosity, surface tension and solubility of the solvent. The increasing temperature will reduce viscosity and surface tension of solvent that cause more solvent vapor to fill the cavitation bubble [14]. The diffusivity of oil and the solubility of solvent nearing the vaporizes point increases [15]. The kinetic energy of solvent molecules increases and their ability to dissolve the solute is enhanced, thus increasing the yield of rice bran oil [16].

3.2. The effect of ratio on rice bran oil yield

The solvent amounts are a critical factor in the extraction process. The yield of rice bran oil on the different ratio of rice bran: solvent was observed at temperature 60°C (Figure 2).

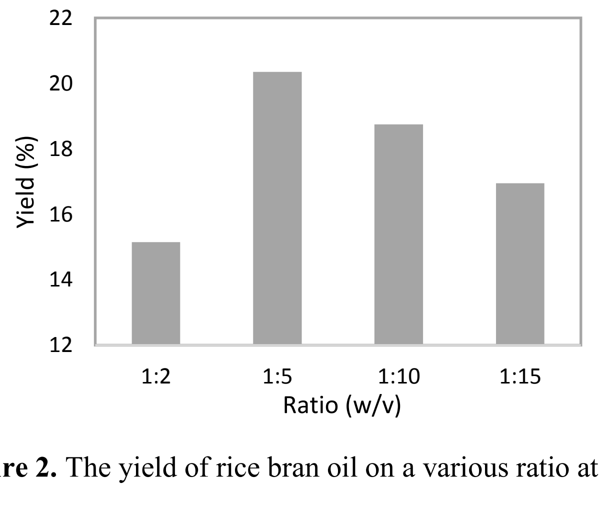

Figure 2. The yield of rice bran oil on a various ratio at 60°C

The result showed when the ratio of rice bran: solvent is 1:2 (w/v) the yield is 15%. Further, as the ratio increased to 1:5 (w/v), the yield also increased to 20%, however increasing the ratio above 1:5 (w/v) resulted in the yield decreased. The increased yield of rice bran oil from ratio 1:2 to 1:5 (w/v) causes from the higher interfacial area between two phases and concentration gradient, the agitation between the rice bran and solvent more effective [16]. The decreasing yield of rice bran oil from ratio 1:5 to 1:15 (w/v) causes highly viscous suspension is formed and maintain the mixture of homogeneity [17].

3.3. The effect of temperature and ratio on rice bran oil color

The effect of temperature and ratio on rice bran oil color was observed (Figure 3 and Figure 4). The ΔE (total color different value) increased along with increasing temperature and rice bran: solvent ratio. The brightness (L*) and yellowness (b*) value decreased while the redness (a*) value increased with the increasing temperature. In the condition increasing rice bran: solvent ratio, the brightness (L*) value increasing, while the redness (a*) and yellowness (b*) decreased.

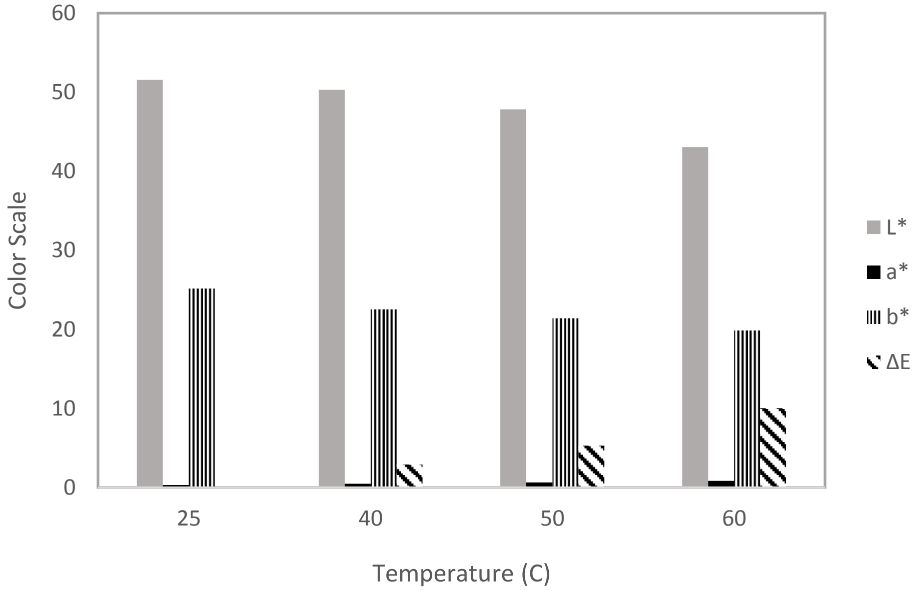

Figure 3. The color scale of rice bran oil at a various temperature on ratio 1:5

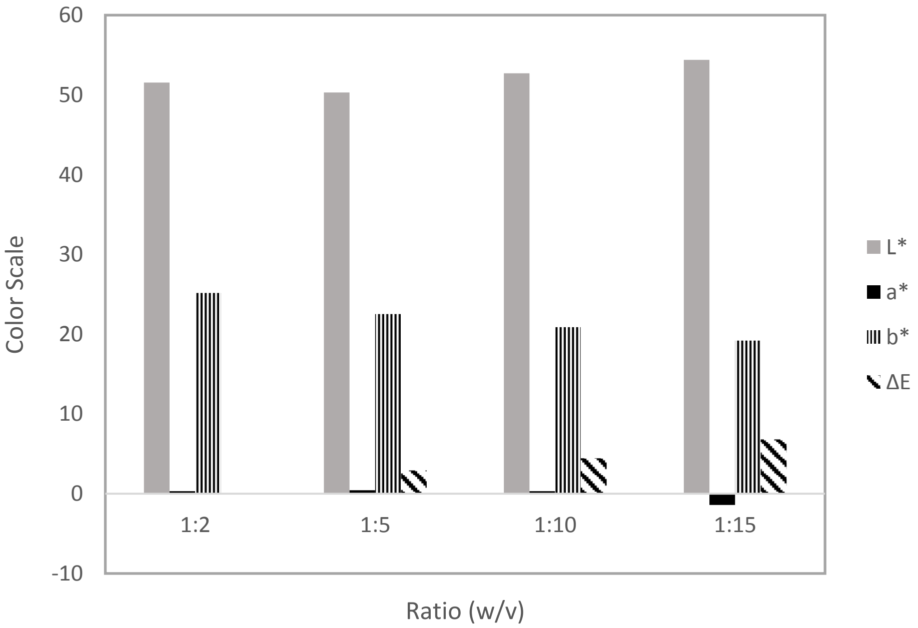

Figure 4. The color scale of rice bran oil on a various ratio at 40ºC

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Depending on the rice bran, the rice bran oil color is dark greenish brown to light yellow [18]. Two main pigments in rice bran oil are β-carotene and chlorophyll, but there are Maillard browning products. The decreasing in brightness (L*) and yellowness (b*) value with the increasing temperature caused by the Maillard browning products [19]. The increases in brightness (L*) value and decreasing yellowness (b*) value with the increasing rice bran: solvent ratio can be explained by increased moisture content that indicated solvent diffusion faster at a higher volume of solvent to leaching the rice bran [20].

4. Conclusion

The yield and color from rice bran oil using Ultrasound-Assisted extraction affected by temperature and rice bran: solvent ratio. The increasing temperature will increase the yield of rice bran oil. The best rice bran: solvent ratio is 1:5 to get the most yield of rice bran oil. The higher extraction temperature, reduce the brightness and increase redness and yellowness. The higher rice bran: solvent ratio increases the brightness of rice bran oil.

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