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FULL PAPER

The effect of catfish oil (*Pangasius* sp.) addition on physical and chemical characteristics of rice bran oil mayonnaise

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Abstract

Rice bran oil (RBO) and catfish oil (CFO) have high unsaturated fatty acids that are good for health. Mayonnaise products are made mostly from oil. Adding catfish oil and rice bran oil to the mayonnaise will add nutritional value to the product. This study aimed to determine the effect ratio of CFO:RBO on the physical, chemical, and sensory characteristics of mayonnaise. This research used a completely randomized design with one factor, that is ratio of RBO:CFO (74:0, 66.6:7.4, 59.2:14.8, 51.8:22.2 and 44.4:29.6) (% w/w). Data were analyzed by one-way analysis of variance method and continued by Duncan's multiple range tests (α=0.05). The research showed that the ratio of RBO:CFO significantly affected chemical and sensory characteristics but not physical characteristics. Mayonnaise in the % ratio of RBO:CFO = 59.2%:14.8% was the best formula. The selected mayonnaise has foaming capacity, foaming stability, total phenol, moisture, ash, protein, fat, and calorie content of 6.127%, 98.844%, 0.863%, 16.089%, 0.441%, 0.718%, 90% and 718.92 kcal/100 g, respectively. Panelists indicate their level of preference for the color, aroma, texture, and overall mayonnaise at a preference value between 3.067-3.867.

1. Introduction

Mayonnaise is an emulsion system oil-based food product generally made from vegetable oils, emulsifiers, and other condiments. Mayonnaise is a semi-solid emulsion that, in its manufacture, consists of a mixture of vinegar, vegetable oil, and egg yolk, which acts as an emulsifier. In addition, the manufacture of mayonnaise also requires the addition of salt and sugar. The principle of making mayonnaise is to add and mix until homogeneous between vegetable oil, sugar, salt, mustard, vinegar, and egg yolk as an emulsifier (Lioe *et al*., 2018; Aznury *et al*., 2022; El-Waseif *et al*., 2022). Products derived from egg-based emulsions other than mayonnaise, one of which is the salad dressing. Mayonnaise and salad dressing are types of an oil-in-water emulsions. However, the amount of vegetable oil in salad dressing is only about 30%, while the concentration of vegetable oil in mayonnaise is more (Abd Rashed *et al*., 2017; Hill *et al*., 2020).

Rice bran oil is one of the vegetable oils that can be used to make mayonnaise. The nutrients in rice bran are carbohydrates (42-45%), fat (23-27%), protein (12-14%), crude fiber (2-10%), and B vitamins, especially vitamin B1 (thiamin). Rice bran has excellent nutritional value, which includes fat content, amino acid lysine, fiber, and protein which are very beneficial for the body (Satter *et al*., 2014; Chakraborty *et al*., 2018). Indonesia is the third largest rice-producing country after China and India. In 2018, it was known that Indonesia produced about 56 million tons of rice. Rice processing produces by-products in the form of rice bran. Currently, rice bran in Indonesia is only used by the community for animal feed. It is due to a lack of knowledge about rice bran's nutritional value, which is beneficial for humans (Yunardi *et al*., 2020; Arsani, 2020; Sujarwanta *et al*., 2021).

The high-fat content in rice bran has the potential to be extracted and produce rice bran oil. Rice bran oil contains unsaturated fatty acids, with the main content of oleic acid at 54.1% and linoleic acid at 22.1%. In

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addition, it also contains saturated fatty acids, especially palmitic acid (16.2%) and myristic acid (1.9%). Rice bran oil contains a phytonutrient that works as an antioxidants, vitamin E, γ-orthzanol, phytosterols, and squalene. Based on the content, rice bran oil is helpful for health, primarily related to preventing cholesterol-related diseases (Ali and Devarajan, 2017; Mingyai *et al*., 2017).

Rice bran oil mayonnaise can be added with catfish oil which is high in unsaturated fat. Catfish (*Pangasius* sp.) is very easy to breed in Indonesia. Catfish is one of the targets of the Indonesian government as the main freshwater fish commodity in aquaculture besides tilapia and carp (Henriksson *et al*., 2019). Catfish have a high nutritional content, especially fat, which is 8.1%. Catfish fat contains monounsaturated fatty acids, especially oleic acid (33.1%), palmitoleic acid (3.5%), and elaidate (2.5%). In addition, it also contains polyunsaturated fatty acids, such as linoleic (12%), arachidonic (1.9%), EPA, and DHA. The content of unsaturated fatty acids in catfish is also beneficial for health, especially those related to cardiovascular diseases (Hashim *et al*., 2015; Abdel-Mobdy *et al*., 2021).

In the manufacture of mayonnaise, oil is the main component compared to other ingredients. Adding catfish oil to manufacture mayonnaise increases nutritional value, such as omega-3. However, Amri *et al*. (2021) reported that catfish oil has a fishy smell. It will affect the smell of the mayonnaise products produced. Therefore, it is necessary to have the proper formulation between catfish oil and rice bran oil used. The purpose of this study was to determine the effect of variations in the concentration of catfish oil (*Pangasius* sp.) and rice bran oil on physical characteristics (foaming capacity and foaming stability), chemical characteristics (phenol content, moisture content, ash content, protein content, fat content, calorie content) and sensory characteristics in making mayonnaise and knowing the best mayonnaise formulation.

2. Materials and methods

2.1 Materials

This study used raw materials such as fresh catfish that are more than 45 cm in length. Catfish were obtained from the fish distributor in Pajang, Central Java, Indonesia. The rice bran oil was obtained from Oryza Grace Brand, produced by Kasisuri Co. Ltd, Thailand, and purchased from PT. Indoglobal Distribusi Nusantara, Karanganyar, Central Java, Indonesia. Eggs, sugar, vinegar, salt, and citron can be found at Jongke Pajang Traditional Market. All chemicals were of analytical grade from Merck.

2.2 Catfish oil extraction

Catfish oil extraction by dry rendering refers to method described by Lestari *et al*. (2020), with some modification. This procedure begins with fresh catfish being cleaned and separated from the viscera. A cleaned catfish is then cut into small pieces and heated using an oven at 90°C for 2 mins. The oil and liquid from oven heating were separated by a filter cloth and put in an Erlenmeyer flask. Then, manually press the heated catfish, and the yield containing crude catfish oil and other residue was collected in the earlier Erlenmeyer flask.

2.3 Refining of crude catfish oil

The refining procedure conducted refers to method described by Shabanikakroodi *et al*. (2015). This procedure begins with crude catfish oil being centrifugated for 10 mins at 1000 rpm. The upper layer was heated at 65^{o}C and 250 rpm for 1 min. Then add 3% citric acid, which is equivalent to 3% from the sample weight. The pH is then checked to ensure the pH value is below 7. The mixture was then held at room temperature for 5 mins. After that, 9.5% NaOH was added and stirred at 65^{o}C and 250 rpm for 20 mins. The pH is then checked to ensure the pH value is at the neutral point. The mixture was then held at room temperature for 5 mins. 7% active carbon was added (w/w) and stirred at 250 rpm and 65^{o}C for 20 mins. The mixture was held at room temperature for 5 mins and then centrifugated at 1000 rpm for 10 mins. The top layer, refined fish oil, is used for further procedures.

2.4 Mayonnaise production

The production of mayonnaise refers to the method described by Yesiltas *et al*. (2021) with modifications. The process begins by beating the egg yolks at high speed for 5 minutes. Followed by the addition of sugar and salt, then mixed again at high speed for 2 minutes. Mustard was added and mix again with a mixer at high speed for 1 minute. After being homogeneous, the oil was added little by little while mixed at high speed for 7 minutes. Catfish oil and rice bran oil were gradually added up to 74% with various formulations (% w/w RBO (Rice Bran Oil) : FO (Fish Oil)) {(74% : 0%), (66.6% : 7.4%), (59.2% : 14.8%), (51.8% : 22.2%), and (44.4% : 29.6%)}. At the end of each formulation, vinegar was added while stirring at high speed for 1 minute until homogeneous.

2.5 Sample analysis

Analysis of chemical properties included total phenolic content by the Folin-Ciocalteu method (Muntana and Prasong, 2010), proximate analysis

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(moisture content using the Thermogravimetric method, ash content using the dry ashing method, fat content using the Soxhlet extraction method, protein content using the micro-Kjeldahl method), total calories using the Bomb Calorimeter method (Mulyaningsih and Rosida, 2002). The physical properties were analyzed for foaming capacity and stability (Mune and Sogi, 2016). Sensory properties were analyzed using preference test scoring (Hari *et al*., 2021).

2.6 Statistical analysis

This research used a completely randomized design (CRD) with one factor: catfish oil and rice bran oil percentage ratio. Data were analyzed using IBM SPSS Statistic version 23 by the one-way analysis of variance (ANOVA) method and continued by Duncan's multiple range test (DMRT) ($\alpha = 0.05$) if there is a significant difference result.

3. Results and discussion

3.1 Foaming capacity and foaming stability

The principle of foaming capacity testing is to provide a mixing treatment (hand mixer) to trigger the capture of air in the sample so that it can form foam. In contrast, the foaming stability test measures the decrease in foam volume according to the resulting time function. The speed of air absorption determines the foam formation in the liquid phase during the whipping process. Proteins are mainly from egg yolk, which acts as an emulsifier that is hydrophilic and hydrophobic. The hydrophilic group will bind water, while the hydrophobic group will bind air so that it will form bubbles (foam) during the whipping process. The foam will be more stable if the amount of air trapped inside the foam is between 30-70%. However, whipping too high a speed will produce smaller and more unstable foam (Lomakina and Míková, 2011; Hou and Wang, 2017).

The results showed that variations in the concentration of rice bran oil and catfish oil had no significant effect on the foaming capacity and stability of the resulting mayonnaise foam (Table 1). The foaming capacity of mayonnaise ranged from 5.637-6.373%. The mayonnaise content foam stability ranged from 98.141-99.314%. The results in this study are higher than the findings of Fauziah *et al*. (2016), who reported that adding egg yolk to Mayonaise produces a foaming capacity of 4% and foaming stability of 94.55%. The difference in foam capacity and stability is influenced by the effectiveness of the emulsifier added (Hari *et al*., 2021).

Table 1. Foaming capacity and foaming stability of rice bran oil mayonnaise with the addition of catfish oil.

Treatment	Foaming capacity (%)	Foaming stability (%)
F1	5.637±0.490[a]	98.141±0.767[a]
F2	5.637±0.490[a]	98.619±1.187[a]
F3	6.127±0.490[a]	98.844±0.887[a]
F4	6.373±0.566[a]	99.071±0.756[a]
F5	6.373±0.566[a]	99.314±1.570[a]

Values are presented as mean±SD. Values with different superscripts within the same column are statistically significantly different ($p<0.05$).

3.2 Phenolic content

Table 2 shows that the amount of rice bran oil and catfish oil significantly affects the phenol content of mayonnaise. The results of the analysis of phenol levels ranged from 0.748-1.020%. The water content of mayonnaise was only significantly different in F1 and F5. The highest phenol content is F1, where there is no addition of catfish oil, while the lowest is F5 which is mayonnaise with the highest concentration of catfish oil addition. The higher the rice bran oil concentration, the higher the phenol value produced. Rice bran oil is known to contain a lot of phenols and flavonoids. The most abundant phenolic compounds in rice are oryzanol and its derivatives and tocotrienols. The rice bran contains several phenolic compounds and is rich in dietary fiber, minerals, and vitamins (Issara and Rawdkuen, 2016; Mingyai *et al*., 2017).

3.3 Proximate

The results of proximate analysis (water, ash, protein and fat) are shown in Table 2. The water content of mayonnaise ranged from 15.606%-16.603%. According to SNI01-4473-1998, the water content in mayonnaise is 30% (Badan Standar Nasional, 1998). The results obtained in this study indicate that the water content in F5 mayonaise is significantly different from F1. This result is suspected of being influenced by the water content in catfish oil. Lestari *et al*. (2020) reported that catfish oil extracted by dry rendering contains water between 0.08-4.02%. Furthermore, Anandganesh *et al*. (2016) reported that the process of refining fish oil was only able to reduce the water content by 54.29%, so after the refining process, fish oil still contained water. The results in this study are lower than commercial mayonnaise in Malaysia, which contains a moisture content of 28.71% (Abd Rashed *et al*., 2017).

The mayonnaise ash content was 0.423%-0.465%. The highest ash content is found in mayonnaise F1, which is mayonnaise without adding catfish oil. Rice bran oil contains the minerals Fe, Si, and P at 17 mg/L, 13 mg/L, and 955 mg/L, respectively (Mas'ud *et al*., 2017). In contrast, fish oil contains lower minerals ranging from 4.2-43.9 mg/L (Arena *et al*., 2021). Based

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Table 2. Chemical characteristics of rice bran oil mayonnaise with the addition of catfish oil.

Treatment	Phenol (%)	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Calorie (kcal/100 g)
F1	1.020±0.010^{c}	15.606±0.103^{a}	0.465±0.025^{b}	0.680±0.0007^{a}	85.000±4.082^{a}	756.01±88.153^{c}
F2	0.893±0.046^{b}	15.972±0.318^{ab}	0.444±0.029^{ab}	0.699±0.010^{a}	88.750±6.292^{a}	727.36±257.721^{bc}
F3	0.863±0.026^{b}	16.089±0.656^{ab}	0.441±0.016^{a}	0.718±0.024^{b}	90.000±7.071^{a}	718.92±306.977^{ab}
F4	0.768±0.009^{a}	16.479±0.678^{ab}	0.428±0.036^{ab}	0.745±0.020^{c}	90.000±0.000^{a}	699.92±156.764^{ab}
F5	0.748±0.007^{a}	16.603±0.787^{b}	0.423±0.011^{a}	0.792±0.007^{d}	90.000±4.082^{a}	689.18±55.833^{a}

Values are presented as mean±SD. Values with different superscripts within the same column are statistically significantly different ($p<0.05$).

on this, the higher the addition of catfish oil, the lower the ash content of mayonnaise. Sarungallo *et al*. (2021), reported that the highest ash content of mayonnaise with the addition of palm oil is 4.50%. It shows that the mineral content in vegetable oil is higher than in fish oil.

The analysis of mayonnaise protein levels ranged from 0.680% to -0.792%. The highest protein content is found in mayonnaise F5, which is mayonnaise with the addition of the highest catfish oil. In addition to being sourced from added egg yolk, protein in mayonnaise is also influenced by the protein content of catfish oil. Sarungallo *et al*. (2021) reported that the protein content in the oil is in the form of lipoproteins that are followed during the extraction process. The degumming process in oil refining does not remove protein content. Salman *et al*. (2021) reported that the protein content in catfish meat ranges from 14.75-16.6%. The high protein content in catfish is thought to be from the lipoprotein in fish oil during the extraction process, so the higher the addition of catfish oil the higher the protein content in mayonnaise.

The fat content analysis of mayonnaise ranged from 85.0% to 90.0% and was not significantly different for all mayonnaise tested. According to SNI 01-4473-1998, the fat content in mayonnaise was at least 60%. The analysis of the calorie content of mayonnaise ranged from 689.18 kcal/100 g to 756.01 kcal/100 g. The results in this study indicate that all the calories of mayonnaise produced have met the SNI.

3.4 Sensory characteristics

The sensory characteristics of mayonnaise are shown in Table 3. The panelists' assessment of the color of mayonnaise ranged from 3.400-3.867, with the analysis results are not significantly different for all mayonnaises tested. This value means that the panelist accepts mayonnaise on the color parameter at a neutral level. The color produced from rice bran oil mayonnaise with the addition of catfish oil is bright yellow (Figure 1). The formation of the mayonaise color is caused by the materials used, such as the rice bran oil, fish oil, egg yolk, and mustard which are all yellow. The results in this study concurred with El-Waseif *et al*. (2022), where mayonnaise with the addition of flaxseed oil enriched with omega-three fatty acids fish oil produces a mayonaise color that is not significantly different.

Figure 1. Image of rice bran oil mayonnaise with the addition of catfish oil.

In the aroma parameters, panelists received mayonnaise with a value ranging from 2.900-3.167 which was not significantly different in all mayonnaises. This range of values means the panelist receives mayonnaise at a neutral level. With the addition of catfish oil, rice bran oil mayonnaise has a fishy smell. Catfish oil has a fishy aroma (Lestari *et al*., 2020). The fishy smell of catfish is caused by the compound trimethylthiamine (TMA). The fishy smell is caused by the addition of catfish and can be overcome by the flow of hot steam (Mohammadi *et al*., 2021). In this study, it

Table 3. Sensory of rice bran oil mayonnaise with the addition of catfish oil.

Treatment	Color	Aroma	Taste	Texture	Overall
F1	3.567±0.817^{a}	3.033±0.928^{a}	3.133±0.973^{b}	3.733±0.785^{b}	3.400±0.855^{b}
F2	3.567±0.858^{a}	3.167±0.834^{a}	3.300±0.877^{b}	3.067±1.015^{a}	3.367±0.765^{b}
F3	3.867±0.681^{a}	3.067±0.907^{a}	3.167±1.117^{b}	3.133±1.074^{a}	3.200±0.997^{ab}
F4	3.400±0.814^{a}	3.100±0.712^{a}	2.967±0.890^{ab}	2.933±0.980^{a}	3.167±0.648^{ab}
F5	3.400±0.932^{a}	2.900±0.960^{a}	2.533±1.008^{a}	2.700±1.055^{a}	2.767±0.935^{a}

Values are presented as mean±SD. Values with different superscripts within the same column are statistically significantly different ($p<0.05$).

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is known that the fishy aroma of catfish oil can be covered by rice bran fish oil, so mayonnaise with the addition of catfish oil is not significantly different from mayonnaise without the addition of catfish oil.

Panelists' preferences for the taste of mayonnaise ranged from 2.533-3.300. This value means that the panelist accepts mayonnaise on the color parameter at a neutral level. Mayonnaise has a distinctive taste, such as sweet, salty, and slightly sour (Lioe *et al*., 2018). Mayonaise's with the highest catfish oil addition resulted in the lowest panelist acceptance value. It was influenced by the fishy taste and smell of catfish oil. These two parameters cannot be separated where aroma and taste shape food flavor (Miedviedieva, 2016; Hastarini *et al*., 2021). The results of this study were in agreement with Kartikasari *et al*. (2019), who added an egg yolk to mayonnaise, resulting in the acceptance of panelists at a neutral level.

The panelists received mayonaise on texture parameters with values ranging from 2.700-3.733. This value means that the panelist accepts mayonnaise on the color parameter at a neutral level. However, the results of this analysis are not significantly different for all mayonnaise tested. In general, mayonnaise has a thick, paste-like texture and is creamy, where consumers assess the texture of mayonnaise-based on its ease of breakdown in the mouth (Olsson *et al*., 2018). However, the mayonnaise with rice bran oil with catfish oil has a slightly denser texture. The results in this study concurred with El-Waseif *et al*. (2022), who reported that mayonnaise with the addition of flaxseed oil enriched with omega-three fatty acids fish oil produces a mayonaise color that is not significantly different. The highest overall value was given to panelists on Mayonaise F1 and F2, where panelists received a neutral level.

4. Conclusion

Variations ratio of rice bran oil and catfish oil significantly affect the chemical (phenolic content, water, ash, protein, calorie) characteristics, but not the physical characteristics of mayonnaise (foaming capacity and stability of the resulting mayonnaise foam). Mayonaise's with the highest catfish oil addition resulted in the lowest panelist acceptance value. It was influenced by the fishy taste and smell of catfish oil. Mayonnaise in the % ratio of RBO:CFO=59.2%:14.8% was the best formula.

Conflict of interest

The authors declare no conflict of interest.

References

Abd Rashed, A., Md Noh, M.F., Mustafa Khalid, N., Ab Rahman, N., Tasirin, A., Wan Omar, W.S., Mohd Nawi, M.N., Jamilan, M.A. and Selamat, R. (2017). The Nutritional Composition of Mayonnaise and Salad Dressing in the Malaysian Market. *Sains Malaysiana*, 46(1), 139–147. https://doi.org/10.17576/jsm-2017-4601-18

Abdel-Mobdy, H.E., Abdel-Aal, H.A., Souzan, S.L. and Nassar, A.G. (2021). Nutritional Value of African Catfish (*Clarias gariepinus*) Meat. *Asian Journal of Applied Chemistry Research*, 8(2), 31–39. https://doi.org/10.9734/ajacr/2021/v8i230190

Ali, A. and Devarajan, S. (2017). Nutritional and Health Benefits of Rice Bran Oil. In Manickavasagan, A. Santhakumar, C. and N. Venkatachalapathy, N. (Eds.), Brown Rice, p. 135–158. Cham, Netherlands: Springer International Publishing. https://doi.org/10.1007/978-3-319-59011-0_9

Amri, U., Diharmi, A. and Sukmiwati, M. (2021). Characteristics of catfish oil, red palm oil and shark liver oil as functional foods. *Depik*, 10(2), 151–160. https://doi.org/10.13170/depik.10.2.19131

Anandganesh, E., Nazar, A.R., Marichamy, G., Gowtham, K. and Shanker, S. (2016). Extraction, Purification, Composition and Quality Deterioration of Fish Body Oil Extracted From *Sardinella fimbriata* by Traditional Method. *International Journal of Innovative Research in Medical Science*, 1(7), 232-241.

Arena, A., Zoccali, M., Trozzi, A., Tranchida, P.Q. and Mondello, L. (2021). Occurrence of Mineral Oil Hydrocarbons in Omega-3 Fatty Acid Dietary Supplements. *Foods*, 10(10), 2424. https://doi.org/10.3390/foods10102424

Arsani, A.M. (2020). The Future of Indonesia and Global Agriculture: Rice Consumption and Agricultural Modernization. *Jurnal Litbang Sukowati: Media Penelitian Dan Pengembangan*, 4(1), 57-64. https://doi.org/10.32630/sukowati.v4i1.132

Aznury, M., Zikri, A., Ningsih, A.S., Chodijah, S., Ghoni, M.A.A., Zhafira, R.Y. and Rachmadona, N. (2022). Utilization of Palm Kernel Oil (PKO) as Vegetable Oil in Making Mayonnaise with the Addition of Virgin Coconut Oil (VCO) and Palm Cooking Oil (PCO). 5th FIRST T1 T2 2021. Netherlands: Amsterdam. https://doi.org/10.2991/ahe.k.220205.025

Badan Standar Nasional. (1998). Mutu Mayonnaise (SNI 01-4473-1998). Jakarta, Indonesia: Badan Standar Nasional [In Bahasa Indonesia].

Chakraborty, M., Budhwar, S., Pooja and Vinod. (2018). Nutritional and therapeutic value of rice bran.

International Journal of Green and Herbal Chemistry, 7(3), 451-461 https://doi.org/10.24214/ijghc/gc/7/3/45161

El-Waseif, M., Saed, B., Fahmy, H., Sabry, A., Shaaban, H., Abdelgawad, M., Amin, A. and Farouk, A. (2022). Mayonnaise Enriched with Flaxseed Oil: Omega-3 Fatty Acids Content, Sensory Quality and Stability during the Storage. *Foods*, 11(15), 2288. https://doi.org/10.3390/foods11152288

Fauziah, C.I., Zaibunnisa, A.H., Osman, H. and Wan Aida, W.M. (2016). Physicochemical analysis of cholesterol-reduced egg yolk powder and its application in mayonnaise. *International Food Research Journal*, 23(2), 578–582.

Hari, P.D., Novelina, Dina, M. and Afifah, D. (2021). The Study of Avocado Mayonnaise with Addition of Dadih as Emulsifier. *IOP Conference Series: Earth and Environmental Science*, 757(1), 012059. https://doi.org/10.1088/1755-1315/757/1/012059

Hashim, R.B., Jamil, E.F., Zulkipli, F.H. and Daud, J.M. (2015). Fatty Acid Compositions of Silver Catfish, *Pangasius* sp. Farmed in Several Rivers of Pahang, Malaysia. *Journal of Oleo Science*, 64(2), 205–209. https://doi.org/10.5650/jos.ess14191

Hastarini, E., Nabilla, M., Permadi, A., Adi, C.P. and Nurbayasari, R. (2021). Characteristic of margarine with ingredient mixed of catfish (*Pangasius* sp.) oil and vegetable oil. *IOP Conference Series: Earth and Environmental Science*, 919(1), 012043. https://doi.org/10.1088/1755-1315/919/1/012043

Henriksson, P.J.G., Banks, L.K., Suri, S.K., Pratiwi, T.Y., Fatan, N.A. and Troell, M. (2019). Indonesian aquaculture futures—Identifying interventions for reducing environmental impacts. *Environmental Research Letters*, 14(12), 124062. https://doi.org/10.1088/1748-9326/ab4b79

Hill, S.E., Krishnamurthy, R.G., Hossain, A. and Shahidi, F. (2020). Cooking Oils, Salad Oils, and Dressings. In Shahidi, F. (Ed.), Bailey's Industrial Oil and Fat Products. 1st ed., p. 1–33. Wiley Online Library. https://doi.org/10.1002/047167849X.bio058.pub2

Hou, Q. and Wang, X. (2017). The effect of PVA foaming characteristics on foam forming. *Cellulose*, 24(11), 4939–4948. https://doi.org/10.1007/s10570-017-1452-1

Issara, U. and Rawdkuen, S. (2016). Rice bran: A potential of main ingredient in healthy beverage. *International Food Research Journal*, 23(6), 2306–2318.

Kartikasari, L.R., Hertanto, B.S. and Nuhriawangsa, A.M.P. (2019). Evaluasi Kualitas Organoleptik Mayonnaise Berbahan Dasar Kuning Telur yang Mendapatkan Suplementasi Tepung Purslane (*Portulaca oleracea*). *Jurnal Ilmu Produksi dan Teknologi Hasil Peternakan*, 7(2), 81–87. https://doi.org/10.29244/jipthp.7.2.81-87 [In Bahasa Indonesia]

Lestari, D.U., Sumardianto, S. and Purnamayati, L. (2020). The Characteristics of Striped Catfish Oil (*Pangasius hypophthalmus*) Extracted by Dry Rendering Method at Different Temperatures. *Caraka Tani: Journal of Sustainable Agriculture*, 35 (1), 66-77. https://doi.org/10.20961/carakatani.v35i1.31604

Lioe, H.N., Andarwulan, N. and Rahmawati, D. (2018). Karakteristik Fisikokimia dan Sensori Mayonnaise pada Berbagai Komposisi Asam Lemak dari Penggunaan Minyak Nabati Berbeda. *Jurnal Mutu Pangan*, 5(1), 1-9. [In Bahasa Indonesia]

Lomakina, K. and Míková, K. (2011). A study of the factors affecting the foaming properties of egg white; a review. *Czech Journal of Food Sciences*, 24(3), 110–118. https://doi.org/10.17221/3305-CJFS

Mas'ud, F., Mahendradatta, M., Laga, A. and Zainal, Z. (2017). Component, Fatty Acid And Mineral Composition Of Rice Bran Oil Extracted By Multistage With Hexane And Ethanol. *International Journal of Scientific and Technology Research*, 6 (11), 63-69.

Miedviedieva, N. (2016). Mayonnaise quality expertise. *Ukrainian Journal of Food Science*, 4(2), 299-308. https://doi.org/10.24263/2310-1008-2016-4-2-11

Mingyai, S., Kettawan, A., Srikaeo, K. and Singanusong, R. (2017). Physicochemical and Antioxidant Properties of Rice Bran Oils Produced from Colored Rice Using Different Extraction Methods. *Journal of Oleo Science*, 66(6), 565–572. https://doi.org/10.5650/jos.ess17014

Mohammadi, M., Alizadeh, A.M. and Meybodi, M.N. (2021). Off-Flavors in Fish: A Review of Potential Development Mechanisms, Identification and Prevention Methods. *Journal of Human, Environment, and Health Promotion*, 7(3), 120–128. https://doi.org/10.52547/jhehp.7.3.120

Mulyaningsih, Y. and Rosida, J. (2002). Membandingkan Hasil Analisis Energi Total Menggunakan Bom Kalorimeter Dengan Hasil Analisis Proximat. *Temu Teknis Fungsional Non Peneliti,* 2002, 93–97. [In Bahasa Indonesia]

Mune, M.A.M. and Sogi, D.S. (2016). Emulsifying and Foaming Properties of Protein Concentrates Prepared from Cowpea and Bambara Bean Using Different Drying Methods. *International Journal of Food Properties*, 19(2), 371–384. https://doi.org/10.1080/10942912.2015.1023399

Muntana, N. and Prasong, S. (2010). Study on Total Phenolic Contents and their Antioxidant Activities of Thai White, Red and Black Rice Bran Extracts. *Pakistan Journal of Biological Sciences*, 13(4), 170–174. https://doi.org/10.3923/pjbs.2010.170.174

Olsson, V., Håkansson, A., Purhagen, J. and Wendin, K. (2018). The Effect of Emulsion Intensity on Selected Sensory and Instrumental Texture Properties of Full-Fat Mayonnaise. *Foods*, 7(1), 9. https://doi.org/10.3390/foods7010009

Salman, Md., Suraiya, S., Das, P., Islam, Md. A. and Haq, M. (2021). Variation in the Proximate Composition, Amino Acids Content and Fatty Acids of Thai Pangus *(Pangasianodon hypophthalmus*) Fish Depending on Size. *Asian Food Science Journal*, 20(6), 35–49. https://doi.org/10.9734/afsj/2021/v20i630307

Sarungallo, Z.L., Santoso, B., Roreng, M.K., Yantewo, E.P. and Epriliati, I. (2021). Karakteristik Fisiko-kimia, Organoleptik, dan Kandungan Gizi Mayones Minyak Buah Merah (*Pandanus conoideus*). *agriTECH*, 41(4), 316-326. https://doi.org/10.22146/agritech.55328 [In Bahasa Indonesia]

Satter, M.A., Ara, H., Jabin, S., Abedin, N., Azad, A., Hossain, A. and Ara, U. (2014). Nutritional Composition and Stabilization of Local Variety Rice Bran BRRI-28, International Journal of Scientific and Technology Research, 3(5), 306-313.

Shabanikakroodi, S., Christianus, A., Tan, C.P., Che Man, Y.B. and Ehteshami, F. (2015). Refined Oil Production from Patin Catfish (*Pangasianodon hypophthalmus*) by-products. *Iranian Journal of Fisheries Sciences*, 14(2) 457-466.

Sujarwanta, R.O., Beya, M.M., Utami, D., Jamhari, J., Suryanto, E., Agus, A., Smyth, H.E. and Hoffman, L.C. (2021). Rice Bran Makes a Healthy and Tasty Traditional Indonesian Goat Meatball, 'Bakso.' *Foods*, 10(8), 1940. https://doi.org/10.3390/foods10081940

Yesiltas, B., García-Moreno, P.J., Sørensen, A.-D.M., Soria Caindec, A.M., Hyldig, G., Anankanbil, S., Guo, Z. and Jacobsen, C. (2021). Enrichment of Mayonnaise with a High Fat Fsh Oil-in-Water Emulsion Stabilized with Modified DATEM C14 Enhances Oxidative Stability. *Food Chemistry*, 341, 128141. https://doi.org/10.1016/j.foodchem.2020.128141

Yunardi, Y., Meilina, H., Fathanah, U., Mahadina, R., Rinaldi, A. and Jauharlina, J. (2020). Potential of Edible Oil Production from Rice Bran in Indonesia: A Review. *IOP Conference Series: Materials Science and Engineering*, 845(1), 012030. https://doi.org/10.1088/1757-899X/845/1/012030

https://doi.org/10.26656/fr.2017.7(S3).3