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Characterization of Reduced Fat Mayonnaise with Variations of Oil and Porang Flour (*Amorphophallus muelleri Bl.*) Concentration

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Abstract

Commercial mayonnaise currently available is full fat mayonnaise with high oil content (70-80%) which can be harmful to health when consumed in the long time. Reduced fat mayonnaise (RFM) as an alternative mayonnaise, which reduces the oil content causes the emulsion changes so a stabilizer is needed. The stabilizer that can be used is porang flour which rich in glucomannan. This study aimed to determine the physicochemical and sensory of RFM with variations in oil (M) (40%, 50%, and 60%) and porang flour concentration (P) (0.1%, 0.2%, and 0.3%). This study used a Completely Randomized Design. Physicochemical parameters include water content, ash content, fat content, protein content, pH, viscosity, emulsion stability, color and emulsion droplets. The result showed that RFM has water content content 26,14 - 44,25%, ash content 0,52% - 0,60%, fat content 37,61% - 64,11%, protein content 3,35% - 3,76%, pH 4,07 - 4,17, viscosity 639,90 cP - 9250,00 cP, emulsion stability 99,98% - 100%, and color L* 83,92 - 85,72, a* 2,67 - 5,92, b* 20,28 - 29,25, and chroma 20,75 - 29,48. M2P3 was the selected formulation with higher acceptance for parameters such as color, aroma, texture, taste, and overall compared to the control mayonnaise.

Keywords: emulsion, oil content, porang flour, reduced fat mayonnaise

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1. Introduction

Mayonnaise is a type of food in the form of an oil-in-water (o/w) emulsion which is semi-solid form (Sarungallo et al., 2021). Mayonnaise is commonly made from vegetable oil as a dispersed medium, emulsifier (egg yolk), acid component, and flavoring ingredients (sugar, salt, mustard) (Prasetya & Evanuraini., 2019). Mayonnaise currently available is full fat mayonnaise with an oil content of 70-80% (Sunjaya, 2019). The high fat content has dangerous effects on consumers, such as increasing the risk of cholesterol, heart disease, obesity, and several types of cancer if over-consumed and long term (Marchelina et al., 2020). Reduced fat mayonnaise can be an alternative way that can be replaced with a fat content ranging from 40-60%.

The principle of processing reduced fat mayonnaise aims to reduce the dispersed phase of oil, and increase the dispersing phase of water (Evanuarini et al., 2016). The problem that occurs with reduced fat mayonnaise products is that the water content is quite high, the increase in the water phase causes the emulsion in the mayonnaise to be unstable (Erlangga, 2018). If left untreated, the both phases will tend to separate and cause damage to the emulsion, so a stabilizer needs to be added to maintain stability.

Several types of stabilizers that are often used in reduced fat mayonnaise research are gum arabic (Rahmayanti, 2018), CMC, maltodextrin, and xanthan gum (Prabawati et al., 2020). Moreover, there are local foods that can be used as stabilizers, one of which is porang tubers. According to (Perwira et al., 2020), the use of porang tubers in flour form can be used as an alternative. Its flour can be used as a stabilizer because it contains glucomannan. According to (Prasetya et al., 2015) the glucomannan content in yellow porang tuber flour (*Amorphophallus muelleri Blume*) is 64.98%.

Research conducted by (Evanuarini et al., 2015) showed that the concentration of porang flour 0.3% was the best results. This is because the use of porang flour at the highest level has a more stable emulsion droplet structure because the fat

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globules are small, uniform and tightly packed so that the fat globules will move slowly. In addition, the influence on viscosity is that the higher the concentration of porang flour, the higher the viscosity of mayonnaise. This research aims to determine the physicochemical and sensory of RFM with variations in oil and porang flour concentration.

2. Method

2.1. Tools and Materials

The tools used in creation of RFM were a portable hand mixer (Qcooker Xiaomi Mijia Cd-hb01) and a container. Product analysis tools include *rotational viscometer* model QC 300 (Anton Paar-Visco), analytical balance model H7K (Excellent), oven model UN55 (Memmert), hunterlab *chromatometer* (ColorFlex EZ), and microscope Olympus CX33 binoculars. The ingredients used palm oil (Sunco), egg yolk, water (Aqua), porang flour (El Masta), vinegar (DIXI), sugar (Rose Brand), salt (Dolpin), pepper (Ladaku), and mustard powder (Jay's), while material chemical used includes H_2SO_4 , selenium, H_3BO_3 , NaOH, indicator PP (phenolphthalein), *bromcresol green* indicator, *methyl red indicator*, HCl, hexane, paper filter, and distilled water.

2.2. Stages of Making Reduced Fat Mayonnaise

The process of making RFM is based on (Piceslia et al., 2023) and (Umma, 2018) with a little modification. Product formula can seen in Table 1. Ingredients such as sugar, salt, pepper, mustard, and egg yolks which have previously been pasteurized at 57°C for 15 minutes in a water bath, were mixed using a hand mixer at a speed of 12000 rpm for 1 minute until homogeneous. The next step was added with oil and acid vinegar little by little in a way alternated and homogenized with *hand mixer*. RFM used 40%, 50%, and 60% (w/w) of palm oil concentration. The final step was adding the porang flour solution, then mixing at the same speed until an emulsion was formed. FFM made with the same method however use 70% of oil concentration. RFM and FFM saved in plastic cup container and stored at temperature refrigeration until analysis.

Table 1. RFM formula

Formulas	Material								
	PO	**PF**	**Egg**	**Vinegar**	**Mustard**	**Salt**	**Sugar**	**Pepper**	**Water**
FFM	70	0	25	2.5	0.25	0.5	0.5	0.25	1
M1P1	40	0.1	25	2.5	0.25	0.5	0.5	0.25	30.9
M1P2	40	0.2	25	2.5	0.25	0.5	0.5	0.25	30.8
M1P3	40	0.3	25	2.5	0.25	0.5	0.5	0.25	30.7
M2P1	50	0.1	25	2.5	0.25	0.5	0.5	0.25	20.9
M2P2	50	0.2	25	2.5	0.25	0.5	0.5	0.25	20.8
M2P3	50	0.3	25	2.5	0.25	0.5	0.5	0.25	20.7
M3P1	60	0.1	25	2.5	0.25	0.5	0.5	0.25	10.9
M3P2	60	0.2	25	2.5	0.25	0.5	0.5	0.25	10.8
M3P3	60	0.3	25	2.5	0.25	0.5	0.5	0.25	10.7

Note: FFM (*Full Fat Mayonnaise*), PO (Palm Oil), PF (Porang Flour)

2.3. Analysis Method

Chemical analysis includes water content and pH (AOAC, 2005), fat content. (BSN, 1992) Physical analysis includes viscosity (Setiawan, 2020), stability emulsion (Yusra et al., 2021), emulsion droplets (Prasetya & Evanuraini., 2019). As well as organoleptic analysis (BSN, 2006)

2.4. Statistical Analysis

Data analyzed in a way statistics with use analysis fingerprint variety (ANOVA) with level significance 5%. If it shows influence real so further tests were carried out with using DMRT (Duncan Multiple Range Test) at a level of 5%.

3. Result and Discussion

3.1. Chemical Analysis

3.1.1. Water Content

Table 2. Results of water content analysis in reduced fat mayonnaise (%)

Oil Concentration (%)	Porang Flour Concentration (%)			Average (%)
	0,1 (P1)	0,2 (P2)	0,3 (P3)	
40 (M1)	$44,25 \pm 0,71^{e}$	$46,90 \pm 2,22^{e}$	$46,42 \pm 0,13^{e}$	$45,86^{W}$
50 (M2)	$38,95 \pm 1,90^{d}$	$34,57 \pm 1,99^{c}$	$31,01 \pm 0,31^{b}$	$34,84^{V}$
60 (M3)	$29,99 \pm 0,62^{b}$	$26,14 \pm 0,00^{a}$	$28,68 \pm 0,59^{ab}$	$28,27^{U}$
Average (%)	$37,73^{Y}$	$35,87^{X}$	$35,37^{X}$	36,32

Note: Numbers followed by the same upper/lower case letters in the same column and row indicate that they are not significantly different in the 5% level of the DMRT test. Lowercase letters indicate interactions of the both factors.

The concentration of oil and porang flour has a significant effect on water content. The average of water content of RFM is 26.14% - 44.25%. As the concentration of oil and porang flour increases, the average water content will be lower it is thought caused by an increase in oil concentration which results in a reduction in the proportion of water in the RFM formula's. In line with (Amin et al., 2014) who stated that making emulsion products with low fat content could be done by reducing the dispersed phase of oil, and increasing the dispersing phase of water, so that a small oil concentration will produce RFM with a high water content.

The water content value also decreased as the concentration of porang flour increased. According to (Perwira et al., 2020) one of the properties of glucomannan is that it is a substance that can bind water well. The water contained in the product is bound by the stabilizer so that it becomes bound water which is difficult to free. Furthermore, as the addition of the stabilizer increases, the water content decreases because the addition of the stabilizer will increase the solids in the product (Nofrida et al., 2018). The water content value produced in RFM is higher when compared to the FFM value, by 21.93%. This is due to the use of oil in the FFM with a high concentration of 70% and without the addition of porang flour as well as the use of a very small amount of water.

3.1.2. Fat Content

Table 3. Results of fat content analysis in reduced fat mayonnaise (%)

Oil Concentration (%)	Porang Flour Concentration (%)			Average (%)
	0,1 (P1)	0,2 (P2)	0,3 (P3)	
40 (M1)	$37,61 \pm 0,06^{a}$	$45,68 \pm 0,07^{c}$	$43,62 \pm 0,23^{b}$	$42,30^{U}$
50 (M2)	$53,80 \pm 0,25^{d}$	$58,72 \pm 0,06^{f}$	$57,38 \pm 0,10^{e}$	$56,63^{V}$
60 (M3)	$61,69 \pm 0,11^{g}$	$64,11 \pm 0,02^{i}$	$62,28 \pm 0,01^{h}$	$62,70^{W}$
Average (%)	$51,03^{X}$	$56,17^{Z}$	$54,43^{Y}$	53,88

Note: Numbers followed by the same upper/lower case letters in the same column and row indicate that they are not significantly different in the 5% level of the DMRT test. Lowercase letters indicate interactions of the both factors.

The concentration of oil and porang flour has a significant effect on fat content. The average of fat content of RFM is 37.61% - 64.11%. The higher concentration of oil and porang flour, the higher the average fat content. At the highest concentration of porang flour, the fat content in RFM has decreased. Palm oil is one of the many vegetable oils used as the main ingredient in making mayonnaise, which is fat in liquid form, making the increase oil concentration will also increase the fat content (Li et al., 2016). The increase in fat content at a porang flour concentration of 0,2% suggests that porang flour has a low fat content. According to (Pasaribu, 2019), porang flour has a fat content of 1,45%. The decreasing fat content value at a porang flour concentration of 0,3% is because the fat content in RFM is tied to the highest concentration of porang flour at the time of testing, which causes the unstable fat content. In the research of Cato et al. (2015), the fat in the chicken nugget samples during the fat content test was not all dissolved during the fat dissolution process, the fat which was bound by empty chains in the chemical composition of porang flour was not easy to dissolve, resulting in rising and falling levels. Fat is closely related to porang flour as a natural stabilizer in emulsion products. The fat content value produced in RFM is lower than the FFM value of 72,48%. This is because the type of mayonnaise made in the study was RFM, different from FFM.

3.1.3. pH

Table 4. Results of pH analysis on reduced fat mayonnaise

Oil Concentration (%)	Porang Flour Concentration (%)			Average (%)
	0,1% (P1)	0,2% (P2)	0,3% (P3)	
40% (M1)	$4,17 \pm 0,03^{c}$	$4,16 \pm 0,03^{bc}$	$4,12 \pm 0,01^{abc}$	$4,15^{V}$
50% (M2)	$4,12 \pm 0,01^{abc}$	$4,11 \pm 0,01^{ab}$	$4,15 \pm 0,02^{bc}$	$4,13^{UV}$
60% (M3)	$4,15 \pm 0,02^{bc}$	$4,12 \pm 0,00^{abc}$	$4,07 \pm 0,01^{a}$	$4,11^{U}$
Average (%)	4,15	4,13	4,11	4,13

Note: Numbers followed by the same upper/lower case letters in the same column and row indicate that they are not significantly different in the 5% level of the DMRT test. Lowercase letters indicate interactions of the both factors.

The oil concentration has a significant effect on the pH value of RFM, while the concentration of porang flour has no significant effect on the pH of RFM. The average pH value of RFM is 4.07 - 4.17. As the oil concentration increases, the average pH value experiences a relatively stable decrease. Increasing the concentration of porang flour had no significant influence on the pH value of RFM. Basically, the oil concentration does not directly affect the pH value of the product. According to (Ketaren, 1985), vegetable oils have a pH that tends to be neutral, so they do not affect the pH of mayonnaise. The decrease in pH value along with increasing oil concentration is thought to be caused by the water content in the material. When the oil concentration increases, the water concentration in the formulation becomes less, which causes the amount of acidic liquid (vinegar solution) to be greater than the amount of water so that the pH value decreases. The pH value produced by RFM is higher when compared to the FFM value by 4,01. The low pH value in the FFM is due to the use of a high concentration of oil so that water used is less, causing the dominant mayonnaise to be more acidic, making it has a lower pH than the other treatment samples.

3.2. Physical Analysis

Table 5. Analysis results viscosity (cP) and stability emulsion (%) on RFM

Sample	Viscosity (cP)	Stability Emulsion (%)
M1P1	639.90 ± 56.57^{a}	99.98 ± 0.00
M1P2	844.90 ± 35.36^{a}	99.98 ± 0.00
M1P3	920.18 ± 13.75^{a}	99.99 ± 0.00
M2P1	1389.50 ± 272.94^{b}	99.99 ± 0.00
M2P2	2205.00 ± 148.49^{c}	99.99 ± 0.00
M2P3	3975.00 ± 21.21^{d}	99.99 ± 0.00
M3P1	5346.50 ± 243.95^{e}	100.00 ± 0.00
M3P2	6737.50 ± 102.53^{f}	100.00 ± 0.00
M3P3	9250.00 ± 339.41^{g}	100.00 ± 0.00

Note: Numbers followed by the same letters in the same column indicate that they are not significantly different in the 5% level of the DMRT test.

3.2.1. Viscosity

The concentration of oil and porang flour has a significant effect on viscosity. The average viscosity of RFM is 639.90 cP - 9250.00 cP. The increase in viscosity value along with the increase in oil concentration is due to the fact that less water is used in making RFM so that the emulsion formed will be thicker. In line with Evanuarini et al. (2016), who stated that the amount of use of the oil phase and water phase affects the viscosity of RFM. There is an increase in viscosity along with an increase in the concentration of porang flour because it contains high levels of glucomannan by 54,49% - 83,96% (Perwira et al., 2020) and (Pasaribu, 2019) which has the ability to absorb water well. (Deliana et al., 2014) suggested that glucomannan is a hydrocolloid polysaccharide consisting of D-glucose and D-mannose residues linked together in β-1,4 glycosidic and β-1,6 glycosidic bonds. The hydroxyl group in glucomannan will interact with water via hydrogen bonds (Silva et al., 2013). These hydrogen bonds allow glucomannan to interact with water strongly so that it forms a colloid in gel form, which can increase the viscosity of the product. The viscosity produced in RFM is lower than the FFM value of 12592.50 cP. This is because FFM is made with a high oil concentration of 70%. The higher the concentration of oil and porang flour used, the higher the viscosity produced.

3.2.2. Emulsion Stability

The concentration of oil and porang flour has a significant effect on emulsion stability. The average emulsion stability of RFM is 99.98% - 100.00%. The increase in emulsion stability value along with increasing oil concentration is because the higher the concentration of oil added, the viscosity of the emulsion also increases so that the resulting emulsion is more stable. (Dokic et al., 2012) Who stated that the higher the concentration of the dispersed phase (oil) in the emulsion system, the slower the cream separation occurs. The use of porang flour in RFM affects the stability of the emulsion and makes the mayonnaise more stable. In research conducted by (Evanuarini et al., 2015), porang flour is a local hydrocolloid product that can increase the stability of the emulsion in mayonnaise. The glucomannan contained in porang flour can stabilize the emulsion by increasing the viscosity in the dispersing phase. The stability value of the emulsion produced in RFM is in accordance with FFM value by 100,00%. The emulsion results in RFM are stable because there is only a slight phase separation in the formulations that have the lowest emulsion stability values, namely M1P1 and M1P2, whereas there is no separation between phases in the other formulations.

3.2.3. Emulsion Droplets

Microscopic observation of mayonnaise emulsion droplets with an Olympus CX33 microscope with 1000x magnification. Differences in the concentration of oil and porang flour will produce different emulsion droplets. Photos of control mayonnaise emulsion droplets and reduced fat mayonnaise can be seen in Figure 1.

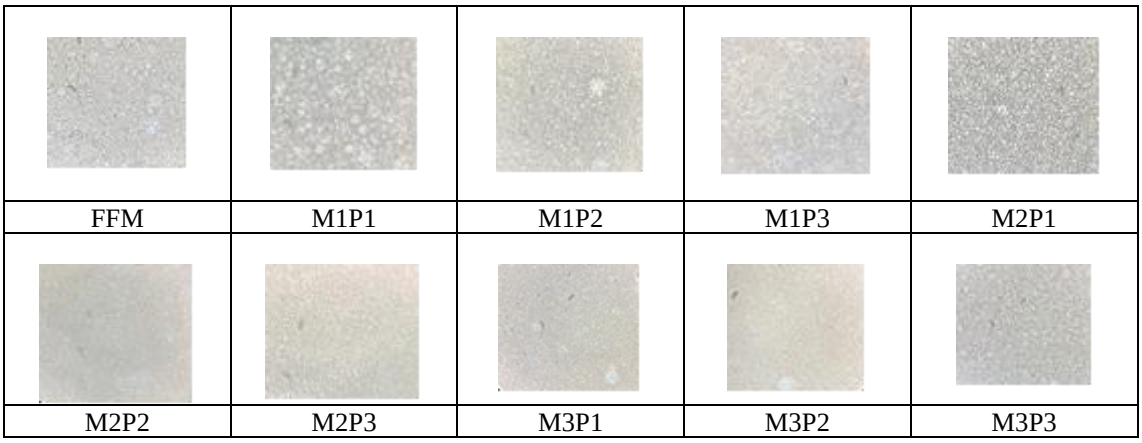

Figure 1. Emulsion droplets of FFM and RFM with different concentrations of oil and porang flour (1000x magnification)

The concentration of oil and porang flour affects the globule size. This appears to be large and tends to be non-uniform when using low concentrations of oil and porang flour due to the increase in the water phase in the emulsion system. This is in line with research by Prasetya & Evanuraini. (2019), which states that increasing the water phase makes the globule size large and there is a lot of space between droplets. This causes the droplets to move irregularly because of the empty space. In treatments with high concentrations of oil and porang flour, the size of the globules produced is small, dense and uniform, especially in the control treatment, which used an oil concentration of 70%.

According to (Umma, 2018), a higher oil concentration will make the globule size smaller, while using a low oil concentration will make the globule size larger and less uniform. Moreover, according to (Anwar et al., 2016), the use of porang flour containing glucoman can increase the viscosity of the solution and make the resulting oil droplets unable to merge quickly with other droplets because of their limited movement, making the emulsion more stable.

3.2.4. Selected Samples

The selected formula for the parameters considered in determining the selected sample includes water content, fat content, emulsion stability, viscosity and pH. The selected samples are 50% oil formulation and 0,3% porang flour (M2P3). The selected samples will be further tested, namely hedonic organoleptic sensory analysis to measure the level of liking for the FFM with RFM treatment of the selected samples, then a t test (T-Test) was carried out on the two samples to determine whether there are differences or not.

3.3. Sensory Analysis

The sensory analysis in this study was the hedonic rating test. This was carried out to determine the level of panelists' liking for a product. In this study, the level of preference for FFM was measured using the RFM treatment of selected sample namely M2P3. The results of the hedonic rating test can be seen in Figure 2.

Color is the main parameter to determine the level of consumer interest visually (Umar et al., 2019). The assessment scores for FFM and RFM for selected samples were respectively 4,66 (neutral-somewhat like) and 5,34 (somewhat like). This shows that the panelists preferred the color of the selected RFM, which was yellowish white compared to the FFM, which was dark yellow. In accordance with the (O'Brien, 2003), they stated that mayonnaise generally has a white to yellowish color. The yellow color produced in this study is thought to be due to the carotene content, which influences the concentration of the oil used. FFM used 70% oil, the high concentration of oil used made the mayonnaise color increasingly yellow.

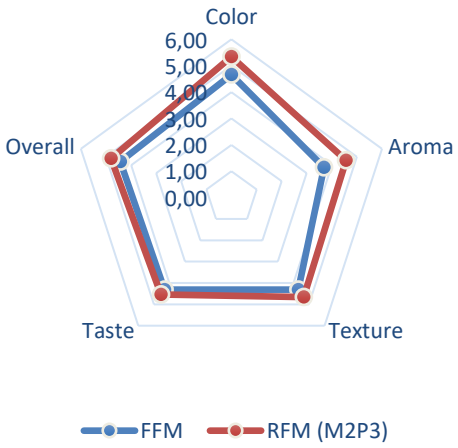

Figure 2. Hedonic Rating Test Results

The aroma of a food ingredient will influence the level of consumer preference (Umma, 2018). The assessment scores for FFM and RFM for selected samples are respectively 3,69 (somewhat dislike-neutral) and 4,57 (neutral-somewhat like). This shows that the panelists preferred the aroma of the selected sample of RFM compared to the FFM. Panelists indicated that FFM had a quite strong sour and oily aroma. This is thought to be because the FFM uses less water than the selected RFM samples so that the vinegar acid is less soluble in water, which causes the sour aroma to be more pungent. Additionally, according to Umma (2018), using different oil concentrations can also have an influence on the aroma, flavor, and texture of mayonnaise.

Texture is a sense associated with touch. Texture can also be considered as important as smell, taste and aroma because it influences the image of food (Yue, 2020). The assessment scores for the FFM and RFM for the selected samples are 4,31 (neutral-somewhat like) and 4,66 (neutral-somewhat like) respectively. FFM and RFM has a thick and quite thick texture. This is in accordance with research (Wahyuni & Sulistyani, 2021) that mayonnaise with a somewhat thick texture, but not very thick, tends to be preferred by panelists. Besides, viscosity and emulsion greatly affect the texture of mayonnaise (Anwar et al., 2016) stated that the use of high concentrations of oil and porang flour will produce high emulsion viscosity values. In an oil in water (o/w) emulsion system, the addition of porang flour will increase the viscosity so that it can form a more stable emulsion system. The addition of 0,3% porang flour with an oil concentration of 50% can make the texture of RFM similar to the texture of FFM, which is characterized by no significant differences.

Taste is something received by the tongue (Yue, 2020). Mayonnaise has a distinctive taste and it has a sour taste due to the addition of vinegar, a sweet taste resulting from the addition of sugar, a salty taste resulting from the salt, and it has a slightly spicy and slightly stinging taste on the tongue due to the presence of mustard and pepper (Umma, 2018). The taste assessment scores for FFM and RFM for the selected samples are 4,31 (neutral-somewhat like) and 4,54 (neutral-somewhat like) respectively. This shows that the panelists preferred the taste of the selected RFM compared to the FFM. Panelists indicated that the FFM had a strong sour taste and oil aroma, although relatively little. This is because the FFM uses less water than the selected RFM samples, so that the vinegar acid is less soluble in water, causing a

strong sour taste. In addition, the use of a high oil concentration of 70% in the FFM makes the oil taste quite pronounced. (Hui, 1992) stated that oil or fat, namely the volatile compounds in salad cream, can affect the taste of the product.

Overall acceptance includes assessment of taste, aroma, color, and texture. Based on the results of the t-test on the overall organoleptic response, it shows that the FFM is significantly different from the RFM of the selected samples. From the overall organoleptic test results for parameters, it can be seen that the panelists gave a value for this parameter of 4,43 for FFM and 4,80 for RFM for selected samples, where these values fall into the neutral-rather like category. Based on this result, it is known that the panelists overall preferred RFM in the selected samples and overall the mayonnaise in this study is quite acceptable to the public, indicated by the score obtained by 4-5 (neutral-somewhat liked).

4. Conclusion

Porang flour can be used as a stabilizer in Reduced Fat Mayonnaise (RFM). RFM formula with 50% of oil concentration and 0.3% of porang flour (M2P3) was the selected formula with more favorable sensory properties than the Full Fat Mayonnaise (FFM) for all parameters. Further research needs to be carried out regarding the shelf life and testing of microbial content in RFM.

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