The Antioxidant Activity and Sensory Quality of Mayonnaise Supplemented with Calamansi Peel Flour (*Citrofortunella microcarpa*)

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Abstract. The study aimed to evaluate the level of costumers preference of mayonnaise with the addition of calamansi peel flour (Citrofortunella microcarpa). The research design used a complete randomized design (CRD) with 4 treatments. Organoleptic evaluation used hedonic test method with 9-point hedonic scale. The test was conducted by 25 semi trained panelists. The treatment levels of calamansi peel flour addition were 0 (P0); 1.5 (P1); 3.0 (P2); and 4.5% (P3). Parameters observed were antioxidant activity (antioxidant content, total phenolics, fiber content) and consumer preference (hedonic test). The results of the analysis of Calamansi peel flour had an antioxidant activity value of 723.92 ppm, a total phenol of 10.36 mg GAE/g, and a fiber content of 35.21%. The average score of perception of sensory attributes was between 4 (dislike slightly) and 5 (neither like nor dislike). The results showed the addition of Calamansi peel flour had a significant effect on organoleptic. In conclusion that the treatment of adding 1.5% calamansi peel flour produces mayonnaise that is acceptable to consumers.

1 Introduction

Eggs are a popular source of animal protein that can be processed using traditional or modern methods to produce a wide variety of products [1]. Eggs are nutritionally complete, easily available, affordable, and widely consumed. The quality of egg protein, which remains high at 91% even after cooking, is often used as a benchmark for other food proteins [2].

Mayonnaise is one of a variety of food products derived from eggs. Mayonnaise is a thick sauce made from egg yolks, oil, vinegar, and other ingredients such as salt and mustard. Mayonnaise has a high fat content, ranging from 60-80% because the main ingredient in making mayonnaise is vegetable oil [3]. Functional foods are foods that contain bioactive components that are beneficial to health such as antioxidant activity and fiber. Along with the increasing public awareness of the importance of body health, the need for functional

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food products is increasing. Functional food development can be done in design, optimization, development of various formulations and processing techniques [4].

In Bengkulu, one of the potential agricultural products is calamansi (Citrus x microcarpa bunge). This type of orange is the main raw material in the syrup processing industry. This syrup processing industry produces processed residue in the form of peels [5]. Utilizing calamansi peel has the potential as a source of micronutrients, antibacterial and antioxidants [6]. Orange peels are rich in bioactive compounds such as flavonoids and phenols [7].

Every final product before being distributed to the market must go through a quality test, one of which is the organoleptic test. Organoleptic is a method used to test a material or product using the five human senses. The aspects tested are color, aroma, taste, texture, creamy, taste and over all [8].

Based on the above background, the researcher is interested in evaluating the hedonic quality of mayonnaise products with the addition of calamansi peel flour containing antioxidants. The strategy is expected to increase consumer preference for mayonnaise.

2 Materials and Methods

2.1 Materials

The research materials used in producing mayonnaise are calamansi peel flour, egg yolk, sunflower oil, vinegar, mustard, salt, sugar, and water. All ingredients used were from commercial and food grade brands. calamansi peel obtained from Bengkulu city. Calamansi peel used is greenish yellow gradation in color and ripe.

The equipment used to produce mayonnaise includes a 600 W Kris hand blender, a beaker glass, a Cheetah JA50003B brand analytical scale with a sensitivity of 0.0001 g (0.1 g), a measuring cup, and a spoon. The equipment used for analysis included test tubes, micropipettes, a centrifuge, Petri dishes, a Brookfield model LV viscometer, a refrigerator, and a measuring cup.

The chemicals used for proximate analysis were DPPH (Sigma), HCl, NaOH, K_2SO_4, H_2SO_4, Na_2CO_3, HgO, a furnace, a centrifuge, a spectrophotometer, a hotplate, an oven, a shaker, DPPH SIGMA (1,1-diphenyl-2picrylhydrazyl), filter paper, methanol, quercetin, aluminum foil, tissue, and distilled water.

2.2 Methods

2.2.1 Preparation of Calamansi peel flour

Drying of calamansi peel flour followed the method [9]. The peels were dried at 60°C for 4 hours using an oven. The dried calamansi peels were pulverized using a blender, then filtered using an 80 mesh sieve.

2.2.2 Analysis of Antioxidant

Determination of antioxidant content using spectrophotometric method with 50 ppm DPPH solution. weighing 0.0025 mg DPPH dissolved in 50 mL methanol in a volumetric flask. The solution was then homogenized. Maximum wavelength measurements were taken using a UV-Vis Spectrophotometer after the DPPH solution was incubated for 35 minutes at 27°C.

Prepare the test solution with a concentration of 10, 50, 100, 150, 200 g/mL. put the test solution into a pipette as much as 1 mL, add 2 mL of 35 g/mL DPPH solution into a test tube that has been covered with aluminum foil, leave for 30 minutes. measure with a UV-Vis spectrophotometer at a maximum absorption wavelength of 517 nm and record the absorbance. Formula the amount of free radical binding showed in Equation 1:

$$\%\text{Free Radical Binding} = \frac{\text{Standard Abs - Sample Abs}}{\text{Standard Abs}} \text{ x } 100\% \quad (1)$$

To determine the IC50 value, a linear regression equation was used. The sample concentration magnitude (x-axis) and the inhibition percentage (y-axis). IC50 formula value shown in Equation 2:

$$\text{IC50} = \frac{50 - b}{a} \quad (2)$$

Description:

y = 50 (50% oxidation inhibitor)
x = IC50 (a number that shows the concentration of the extract that is able to inhibit the oxidation process by 50%)
a = slope
b = intercept

2.2.3 Determination of Total Phenols

UV-Vis spectrophotometry is used to measure the wavelength of the maximum and the absorption in the wavelength range to determine the phenol content. The complementary color of the solution is blue-green, the wavelength range is 600-800 nm. phenol standard curve was prepared from pure phenol. The regression equation obtained from the phenol standard curve is used to confirm the total content of phenol compounds in the sample. By entering the average sample absorption value into the y variable, the x value or total phenol concentration can be determined by the equation obtained. In addition, the determination of total phenol in gallic acid standard solution was carried out with concentrations of 0, 5, 15, 30, 50, and 70 mg/l.

0.1 ml of sample solution was taken and transferred into a volumetric flask. filled the volumetric flask with 0.2 ml of Folin-Ciocalteu reagent and shaken for 1 minute. After one minute, 2.5 ml of 20% Na_2CO_3 was added, and the amount was adjusted with distilled water to the limit. The mixture was homogenized and then allowed to stand in a dark place for 40 minutes. measure the absorbance using a UV-Vis spectrophotometer at the maximum wavelength reached. Formula for determining total phenol showed in Equation 3:

$$\text{Total Phenolic} = \frac{\text{B X V X FP}}{\text{W}} \text{ X } 100\% \quad (3)$$

Description:

B = Concentration sample / x value (mg GAE/L)
V = Volume of sample extract (L)
FP = Dilution factor
W = Sample weight (g)

2.2.4 Determination of Fiber Content

Fiber content measurement was carried out by weighing a 2 g sample. Drying the sample by extraction. Putting the sample into in erlemeyer. Then added 20 ml of 1.25% H_2SO_4

solution, the mixture was boiled for 30 minutes. The suspension is filtered through filter paper and the residue remaining in the Erlenmeyer flask is washed with boiling distilled water. Quantitatively transfer the residue from the filter paper into Erlenmeyer. The remaining residue was washed with 50 ml of boiling 1.5 N NaOH solution until all the residue entered the Erlenmeyer. Simmer with cooling for 30 minutes. filtered through filter paper that has been known by weight, while washing with K_2SO_4 solution. The residue was washed again with boiling distilled water and then with ±10 ml of 95% alcohol. filter paper containing the residue was put into a petri dish and dried in the oven (105°C) for 60 minutes. Cooling and weighing until constant weight. formula for calculating fiber content showed in Equation 4:

$$\text{Crude fiber content (\%)} = \frac{b - a}{x} \times 100\% \quad (4)$$

Description:

a = Weight of filter paper + sample after oven
b = Filter paperweight
x = Sample weight

2.2.5 Preparation of Mayonnaise Samples

Each mayonnaise making procedure followed the method of [10]. Egg yolk was put in a beaker glass, pasteurized at 60ºC for 3.5 minutes, vinegar, mustard, salt and sugar were added. All mayonnaise ingredients except sunflower oil were further homogenized. Sunflower oil was added slowly and stirred with a hand blender for 15 minutes until a mayonnaise emulsion occurred [11]. Before testing, the emulsion was stored in a closed container for 24 hours at room temperature (25-30.8ºC). The mayonnaise formulations are shown in Table 1.

Table 1. Formulation of mayonnaise

Component	P0 (%)	P1 (%)	P2 (%)	P3 (%)
Egg Yolk	14	14	14	14
Sunflower Oil	74	65	65	65
Vinegar	9	9	9	9
Mustard	1	1	1	1
Salt	1	1	1	1
Sugar	1	1	1	1
Calamansi Peel Flour	-	1.5	3.0	4.5
Water	-	7.5	6.0	4.5
Total	100	100	100	100

2.2.6 Hedonic Test

The panelists used in this study were semi-trained consisting of 25 people, who met the requirements of the research method. Typically, sensory quality tests using untrained panelists require a range of 25 to 100 panelists [11]. Panelists were selected by being asked questions in the form of a questionnaire regarding matters related to mayonnaise, including possible allergies to eggs or egg products, level of customers preferences, and frequent consumption of mayonnaise. In the favorability test, the selected panelists were given a willingness form and a worksheet containing a 9-point hedonic scale. Panelists tasted each mayonnaise sample by ticking (✓) on the points on the worksheet, according to the level of acceptance of the tested panelists from “disliked extremely” to “ like extremely” [12].

To neutralize the taste after each sample test is completed, the panelists drink water and eat original crackers [13]. The 9-point hedonic scale is shown in Table 2. The definition of each attribute in the sensory quality test is shown in Table 3.

Table 2. 9-point hedonic scale (consumer acceptance)

Number	Consumer Acceptance
1.	Dislike extremely
2.	Dislike very much
3.	Dislike moderately
4.	Dislike slightly
5.	Neither like nor dislike
6.	Like slightly
7.	Like moderately
8.	Like very much
9.	Like extremely

Table 3. Descriptive General Definition of Mayonnaise Organoleptic Test Attributes

Organoleptic	Information
Color	The yellow color that appears in mayonnaise through the sense of sight[14]
Texture	The external appearance of mayonnaise is thick and creamy[15]
Creamy	Something related to the characteristic of mayonnaise being soft on the palate[15]
Aroma	A smell that is felt when holding mayonnaise to the nose[16]
Taste	The basic taste sensation of mayonnaise is obtained from the taste on the palate[15]
Flavor	Sensory results from the combination of taste and aroma in mayonnaise[14]
Overall	The level of acceptance of panelists that arises as a result of the assessment of color, taste, aroma, flavor, and overall. There is a preference for an object that is perceived[17]

2.2.7 Statistical Analysis

The study design used a completely randomized design (CRD) with 4 treatments. Sensory quality used hedonic test method with 9-point hedonic scale. The test was conducted by 25 semi trained panelists. The treatment levels of calamansi peel flour addition were 0 (P0); 1.5 (P1); 3.0 (P2); and 4.5% (P3). Data were analyzed using ANOVA to determine the effect of treatment. Data were analyzed using IBM SPSS Statistics 23 software, while antioxidant analysis used Microsoft Excel 2021 [18].

3 Results

The results of the antioxidant activity analysis of calamansi peel flour consist of antioxidant content, total phenols, and fiber content which is shown in Table 4.

Table 4. Results of analysis of calamansi peel flour

Type	Results	Results (Literature)
Total phenols of calamansi peel flour	10.36 mg GAE/g	9.40 mg GAE/g [19]
Antioxidant content of calamansi peel flour	723.92 ppm	777.0 ppm [20]
Calamansi peel flour fiber content	35,21%	29,85% [21]

3.1 Analysis of Calamansi Peel Flour

Antioxidant capacity expressed as IC50 is the concentration of calamansi peel flour that produces 50% inhibition. antioxidant content obtained in calamansi peel flour is 723.92 ppm, the total phenol value is 10.36 mg GAE/g and the value of fiber content is 35.21%.

3.2 Organoleptic Analysis

The results of the calamansi peel flour had a very significant effect ($P<0.01$) on the sensory quality of mayonnaise. This test is conducted by utilizing the human senses in identifying the sensory attributes of the product. Organoleptic testing in this study was assessed by 25 panelists on mayonnaise samples. The hedonic test in this study included evaluations of color, texture, creaminess, aroma, taste, flavor, and overall. The results of consumer acceptance are shown in Figure 1.

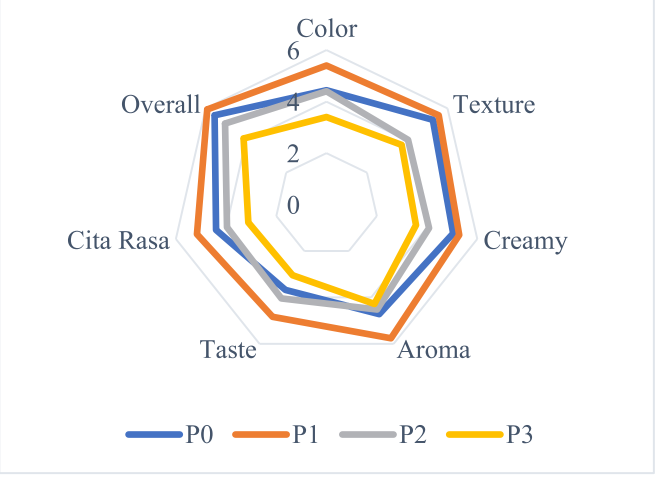

Fig 1. the average value of the customers acceptance for mayonnaise with the addition of calamansi peel flour

Based on the results of the analysis of variance, the overall mayonnaise with the addition of calamansi peel flour is significantly different ($P <0.01$). The costumers preference for mayonnaise aroma ranged from 4.40 “dislike slightly” to 5.66 "neither like nor dislike". The highest score was in treatment P1, while the lowest was in treatment P3. Based on the results of the analysis of variance, the color of mayonnaise with the addition of calamansi peel flour is significantly different ($P< 0.01$). The customers preference for mayonnaise color ranged

from 3.4 "dislike moderately" to 5.4 "neither like nor dislike". The highest score was in treatment P1, while the lowest was in treatment P3. The texture of mayonnaise with the addition of calamansi peel flour is significantly different (P <0.01). The costumers preference for mayonnaise texture ranged from 3.72 "dislike moderately" to 5.56 "neither like nor dislike". The highest score was in treatment P1, while the lowest was in treatment P3. The creamy mayonnaise with the addition of calamansi peel flour is significantly different (P< 0.01). costumers preference for creamy mayonnaise ranged from 3.56 "dislike moderately" to 5.28 "neither like nor dislike". The highest score was in treatment P1, while the lowest was in treatment P3. The aroma of mayonnaise with the addition of calamansi peel flour is significantly different (P<0.01). The costumers preference for mayonnaise aroma ranged from 4.28 “dislike slightly” to 5.76 "neither like nor dislike". The highest score was in treatment P1, while the lowest was in treatment P3. The taste of mayonnaise with the addition of calamansi peel flour is significantly different (P <0.01). The costumers preference for taste of mayonnaise ranged from 3.04 "dislike moderately" to 4.84 “dislike slightly”. The highest score was in treatment P1, while the lowest was in treatment P3. The flavor of mayonnaise with the addition of calamansi peel flour is significantly different (P <0.01). costumers preference for mayonnaise flavor ranged from 3.12 "dislike moderately" to 5.16 "neither like nor dislike". The highest score was in treatment P1, while the lowest was in treatment P3. The overall mayonnaise with the addition of calamansi peel flour is significantly different (P <0.01). The costumers preference for mayonnaise aroma ranged from 4.12 “dislike slightly” to 5.92 "neither like nor dislike". The highest score was in treatment P1, while the lowest was in treatment P3.

4 Discusion

4.1 Analysis of Calamansi Peel Flour

The smaller the IC50 value, the more active the test extract or fraction is as a radical capture compound or antioxidant compound [19]. Calamansi peel powder showed an IC50 value of 723.92 ppm. The antioxidant content in the study is similar to the literature (Table 4) so that it can be but the antioxidant content is still low. The factors that affect the stability of antioxidants are temperature, pH changes, light and oxidants and other factors [22]. In research [20] states that lime peel contains 1.41 ± 1.2 mg/100 ml flavonoids, 777.0 ± 1.7 mg/100 ml antioxidant capacity, and 40.20 ± 0.5 mg/100 ml ascorbic acid.

The total phenol content found in calamansi peel flour is due to calamansi peel which is rich in ascorbic acid, flavonoids, and phenolic compounds. According to [23] calamansi extract produces higher total phenolics (3.84 mg/kg gallic acid). According to the results of the analysis of baby java orange peel powder, the total phenol content was 0.50 mg GAE/g, the results of research [19] resulted in a total phenol content of 9.40 mg GAE/g. Total phenol content in the methanol extract of lime peel with maceration extraction method amounted to 4.83 [11]. The higher the phenol content in a material, the higher the antioxidant activity.

The crude fiber content in calamansi peel flour is due to the fact that calamansi peel is rich in vitamin C, antioxidants, and fiber. According to the results of research [21] orange peel flour contains fiber content of 29.85%. Calamansi peel contains flavonoids, which are phenol compounds and one part of antioxidants. Food fiber is rich in bioactive compounds, such as flavonoids, vitamin C, carotenoids, phenolics and antioxidants so that it becomes an added value to the product in addition to being a substitute for fat, it is also able to provide health-enhancing effects [21]. The results of the study are in line with previous researchers [24], who stated that orange peel flour contains antioxidants, fiber, and other elements that

improve health.

4.2 Organoleptic Analysis

Mayonnaise generally has a white to yellowish white color depending on the ingredients used for making mayonnaise. According to [25], the color produced by emulsion products such as mayonnaise comes from the absorption and dispersion of light waves from the continuous phase and dispersed phase of mayonnaise. Color is an important attribute in food products because it determines quality and consumer acceptance [26]. Consumers will be attracted to mayonnaise colors that have high color intensity compared to low intensity colors [27]. The more addition of calamansi peel flour results in a darker color. This is caused by the browning reaction. The reaction of carbohydrates (phenol compounds) with oxygen leads to oxidation, resulting in a browning process that is regulated by enzymes. The color of calamansi peel flour is generated through the enzymatic activity of polyphenol oxidase, which acts on phenolic chemicals as its substrate. Polyphenol oxidase enzyme activity has a significant effect on the color of calamansi skin flour [28]. The color will appear brownish if the polyphenol oxidase enzyme activity is not regulated [29]. The use of egg yolk in making mayonnaise serves as an emulsifier and coloring agent due to the presence of xanthophyll pigment [30]. According to [10], the color produced by mayonnaise comes from egg yolk, vegetable oil, and mustard. Mayonnaise made with vegetable oils that are high in unsaturated fatty acids, such as corn oil and sunflower oil, will have a brighter color than mayonnaise made with other vegetable oils.

The more the addition of calamansi peel flour, the thicker and coarser the mayonnaise. This is because calamansi peel flour has a high fiber content. The fiber components of calamansi peel flour are hemicellulose, cellulose, and lignin [31]. Calamansi peel flour has large crystal grains with non-uniform size and larger air cells [32]. Oil also greatly affects the texture of mayonnaise. According to previous research [33], the presence of oil, which is the primary constituent of fat, significantly influences the sensory properties of the end product.. Costumers preference for treatment P1 was due to the thick and soft texture. Starch in calamansi peel flour functions as a stabilizer, so the addition of peel flour will produce a more stable and thicker mayonnaise.

The addition of calamansi peel flour to mayonnaise has a significant effect on creaminess. This assessment may be influenced by the results of a softer mayonnaise texture. [11] stated that the softer the mayonnaise, the higher the level of consumers preferences. The level of smoothness of mayonnaise affects the creaminess of mayonnaise, consumers prefer a creamier mayonnaise because it is easier to chew and swallow [34].

The higher the level of addition calamansi peel flour, the more balanced the aroma of calamansi and the sour aroma of mayonnaise. Panelists gave the highest score to treatment P1 because calamansi peel flour absorbs the sour aroma of vinegar. Calamansi peel flour has a distinctive odor. Calamansi peel stores the aroma obtained from citrus fruits, the distinctive aroma still appears in calamansi peel flour [35]. This is because the smell is not too sour, unique, and distinctive [29].

Consumers preference mayonnaise with a distinctive taste, namely sour taste from vinegar, sweet taste from sugar, and salty taste from salt. Taste is a factor that greatly influences consumer or panelist acceptance of processed food products [36]. Panelists gave the highest value to treatment P1 due to the addition of calamansi peel flour which produces a distinctive flavor. The taste of a food ingredient can be better than the original taste due to the addition of other ingredients during the processing and cooking process or the character of the material itself [37]. The more the addition of calamansi peel flour, the more bitter the mayonnaise flavor.

Phenolic chemicals such as limonin and tannins found in calamansi peel flour give a bitter and sour taste.

Control mayonnaise has a strong and standard sour taste [38]. The addition of calamansi peel flour in P1 can reduce the sour taste and stabilize it, thus giving a balanced taste to the mayonnaise. Adding calamansi peel starch can help stabilize the taste of mayonnaise. Adding starch to mayonnaise can help stabilize [39]. This is in accordance with research [37], which states that the flavor of a foodstuff comes from its properties or other substances added during the preparation and cooking process.

The costumers preference of mayonnaise with the addition of calamansi peel flour was most favorable at the 1.5% level. [17] States that the results of the assessment of color, taste, aroma, taste and off taste are the overall level of preference for the sample tested. This is because the addition of calamansi peel flour can form a smoother texture and the right viscosity and coarse grains are few, the color is slightly yellow-brown, a distinctive aroma but does not cover the typical aroma of mayonnaise, a taste that is not too bitter, a distinctive sour taste and is still acceptable. This is likely because the mayonnaise produced is close to the characteristics of mayonnaise on the market, so the mayonnaise is relatively favored by panelists [40].

5 Conclusion

Based on this research, calamansi peel flour had an antioxidant activity IC50 value of 723.92 ppm, a total phenol of 10.36 mg GAE/g, and a fiber content of 35.21%. The addition of calamansi peel flour to mayonnaise improves sensory quality (color, texture, creamy, aroma, taste, flavor, and overall). The addition of Calamansi peel flour at 1.5% is acceptable to panelists.

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