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Quality of Mayonnaise Supplemented with Calamansi Peel Flour (*Citrofortunella microcarpa*) as a Potential Functional Food

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ABSTRACT

This study aims to evaluate the physicochemical properties and consumer preferences of mayonnaise containing calamansi peel flour (Citrofortunella microcarpa) as a functional food ingredient. It used a completely randomized design (CRD) with four treatments: 0% (P0), 1.5% (P1), 3.0% (P2), and 4.5% (P3), each consisting of six replications. The observed parameters included antioxidant activity (DPPH, total phenolics), physical properties (pH, viscosity), and chemical properties (moisture, ash, protein, fat, carbohydrate, crude fiber content), as well as consumer preferences assessed through a hedonic test. The IC_{50} value for the antioxidant activity of calamansi peel flour was 723.92 ppm, while the total phenol content was 10.36 mg GAE/g. Increasing the level of calamansi peel flour raised the viscosity, moisture, ash, protein, carbohydrate, and crude fiber content of mayonnaise, but it decreased the fat content. In conclusion, the addition of 1.5% calamansi peel flour produces the finest quality mayonnaise and is regarded as acceptable by consumers as a functional food component.

Keywords: *Calamansi peel flour, Antioxidant, Physicochemical, Organoleptic*

Introduction

Eggs, especially the yolks, play a vital role in making mayonnaise. The lecithin in egg yolks acts as a natural emulsifier that helps blend oil and water (typically vinegar or lemon juice) into a smooth and stable mixture. This emulsifying property is essential for achieving the creamy consistency that defines mayonnaise. In addition to their emulsifying function, eggs also enhance the texture, flavor, and richness of the mayonnaise, making them an essential ingredient in its creation (Evanuaraini *et al*., 2016).

Moreover, eggs are an important source of essential nutrients that contribute to the overall health benefits of mayonnaise. As a key ingredient in this widely consumed condiment, eggs offer not only functional properties but also nutritional value. Understanding how eggs impact both the texture and nutritional profile of mayonnaise is crucial for improving its quality and ensuring it supports healthy consumption. healthy consumption (Eddin *et al*., 2019).

Mayonnaise is a food product made from an emulsion of vegetable oil in water or acid using an emulsifier (Amertaningtyas and Jaya, 2011). It usually consists of an emulsifier (egg lecithin), vegetable oil, acid components (vinegar, citric acid, and maleic acid), texture enhancers, flavoring ingredients, and stabilizers (Mirzanajafi-Zanjani *et al*., 2019). The fat level derived from vegetable oils is elevated (Anisa *et al*., 2021).

Conventional mayonnaise often falls short in terms of nutritional value, being primarily composed of fats and lacking any real health benefits. It's usually high in saturated fats and preservatives, which don't add much in terms of promoting well-being. This has led to a growing demand among consumers for healthier alternatives that not only taste good but also provide added health benefits (Granato *et al*., 2020). Incorporating calamansi peel flour into mayonnaise as a natural antioxidant provides an exciting opportunity to enhance its nutritional profile. Calamansi, rich in antioxidants, can help reduce oxidative stress, offering potential health benefits. This addition not only improves the overall quality of the mayonnaise but also extends its shelf life, addressing the increasing consumer demand for healthier, functional food options (Noviyanty *et al*., 2019)

In Bengkulu, calamansi (Citrofortunella microcarpa) represents a significant agricultural commodity (Rosalina *et al*., 2017) that is the by-product of the syrup production process. Calamansi peels possess several bioactive components, including essential oils, flavonoids, tannins, phenols, and alkaloids like methanol and

ethyl acetate, which are effective in combating detrimental free radicals (Arifin and Ibrahim, 2018). A study was conducted to add calamansi peel flour to mayonnaise as an antioxidant to develop functional food products. The research showed that the addition of calamansi peel flour could improve oxidative stability and extend the shelf life of mayonnaise (Nguyen, 2020)

The study aims to assess the physical, chemical, and hedonic qualities of mayonnaise products with calamansi peel flour. This technique is expected to improve the quality of mayonnaise and offer an alternative to egg-derived functional food products. Calamansi peel flour, rich in flavonoids and polyphenols, enhances the oxidative stability of mayonnaise, extending its shelf life and preserving its quality. The process of converting calamansi peel into flour ensures that these beneficial compounds are evenly distributed, improving both the texture and the antioxidant properties of the mayonnaise. As a result, the product becomes more durable and offers potential health benefits.

Materials and Methods

The ingredients for the mayonnaise. All ingredients used were from commercial brands and food-grade. The ingredients used for making mayonnaise are vegetable oil (sunflower oil), calamansi peel flour, eggs, vinegar, yellow mustard, sugar, salt, and water. The ripe calamansi peels from Bengkulu were washed and cut into small pieces, heated in an oven to dry and sieved with 80 mesh.

The tools used in making mayonnaise are a hand mixer (ACE Kris), a glass beaker (Pyrex), an analytical balance (ME204), a refrigerator, and a spoon. Tools and materials used for analysis include: pH meter, viscometer, analytical balance, Kjeldahl flask, centrifuges, Erlenmeyer flask, measuring flask, scales, volume pipette, stirrer, Soxhlet extraction tube, and oven.

Chemicals used for proximate analysis were DPPH solution (Sigma), Folin-Ciocalteu reagent, HCl (Merck), NaOH (Merck), K_2SO_4, (Merck), H_2SO_4 (Merck), Na_2CO_3, HgO (Merck), and distilled water.

Preparation of mayonnaise samples. Each mayonnaise-making procedure followed the method of (Shen *et al*., 2011). Calamansi peel flour is typically incorporated into mayonnaise formulations at concentrations ranging from 1.5% to 4.5%, primarily due to its bioactive compounds, especially its antioxidant properties. At these levels, the flour helps improve the oxidative stability of the mayonnaise, extending its shelf life and preserving its overall quality. Additionally, it plays a key role in preventing the degradation of fats and oils, which is essential for maintaining the product's texture, flavor, and nutritional value. Importantly, this amount is enough to deliver the desired functional benefits without compromising the taste or texture of the mayonnaise. The formulation of the mayonnaise is presented in Table 1.

Table 1. Formulation and composition of mayonnaise

Ingredients	Treatment (%)			
	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

Chemical parameters. analyzed include Fat content using the Soxhlet method (Muchtadi *et al*., 2010), Moisture content using the gravimetric method (AOAC, 2005), Protein content using the micro Kjeldahl method with three stages, namely digestion, distillation, and titration (AOAC, 2005), Ash content using the gravimetric method (Sudarmadji *et al*., 1997), Carbohydrate content using the Luff-Schoorl method (Asquieri *et al*., 2019), and Crude fiber using the gravimetric method (AOAC, 2005).

Antioxidant activity. Antioxidant activity parameters analyzed included antioxidant content using UV-Vis DPPH spectrophotometer method (Blois, 1958) and total phenols using the Folin-Ciocalteu reagent method (Singleton and Rossi, 1965).

Hedonic Test. The sensory assessment employed the 9-point hedonic scale method (Wichchukit and O'Mahony, 2015). The organoleptic test was conducted with 30 semi-trained panelists (Soeharto, 2013). Before evaluating the mayonnaise product, consumers first read, filled in, and dated the consent form, confirming that they did not have an egg allergy. Additionally, we asked the panelists to express their preferences for mayonnaise products using the provided form. The test procedure is to provide 4 samples placed in a cup, and each sample is coded. Then, each panelist is asked to assess one sample at a time and fill in the organoleptic test form according to the characteristics (Table 3). Panelists fill in responses to color, texture, aroma, taste, and overall taste on a 9-point hedonic scale in the organoleptic test form provided (Table 2). Each sample is neutralized using wafers and mineral water.

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

(Wichchukit and O'Mahony, 2015)

Table 3. A descriptive general definition of mayonnaise hedonic test attributes

Organoleptic	Information
Color	The yellow color that appears in mayonnaise through the sense of sight[1]
Texture	The external appearance of mayonnaise is thick and creamy[2]
Creamy	Something related to the characteristic of mayonnaise being soft on the palate[2,3]
Aroma	A smell that is felt when holding mayonnaise to the nose[4]
Taste	The basic taste sensation of mayonnaise is obtained from the taste on the palate[2]
Flavor	Sensory results from the combination of taste and aroma in mayonnaise[1]
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[5]

(1) Winarno, 1992, (2) Shewfelt, 2009, (3) Laca *et al*., 2010, (4) Lawlor *et al*., 2010, (5) Kovalcuks *et al*., 2016)

Statistical analysis. The data obtained were analyzed using analysis of variance from a completely randomized design (CRD) with 4 treatments, and each treatment consisted of 6 replicates. Research data were analyzed using ANOVA to determine the effect of treatment. If there was a difference between treatment means, it was followed by the Duncan Multiple Range Test (DMRT). Data were analyzed using IBM SPSS Statistics 23 software (Mooduto *et al*., 2022).

Results and Discussion

Physical characteristics of mayonnaise

pH is considered a physical analysis in mayonnaise research because it measures the acidity or alkalinity of a solution or substance, which affects its physical properties. In the context of mayonnaise, pH can play a role in determining the texture, emulsion stability, and taste. The results of pH testing on mayonnaise with the addition of calamansi peel flour ranged from 3.95 - 4.18 (Table 4). Based on (USDA, 2017), the pH of mayonnaise is not less than 3.1 and not more than 4.1. Mayonnaise with high antioxidant activity has a pH range of 3.7-4.7 (Djaeni *et al*., 2017). The pH content of mayonnaise in this study is still within the normal range. The antioxidant properties of calamansi peel compounds in mayonnaise are influenced by its pH level. Since acidic conditions enhance the ability of antioxidants to neutralize free radicals, this plays a significant role in mayonnaise, which often contains vinegar or calamansi peel, making it naturally acidic. The pH level also impacts the texture and stability of mayonnaise. By incorporating calamansi peel flour, which is rich in antioxidants, the product can benefit from improved preservation and enhanced sensory characteristics. A slightly acidic environment helps maintain the stability of the emulsion while increasing the effectiveness of the antioxidants. This synergy helps prevent lipid oxidation and extend the shelf life, resulting in a mayonnaise with better nutritional value and taste.

Table 4. The average physical analysis of mayonnaise

Variable	Treatment			
	P0	P1	P2	P3
pH	4,18±0,15^{b}	4,08±0,16^{ab}	4,01±0,04^{a}	3,95±0,09^{a}
Viscosity	6,33±0,03^{a}	6,79±0,05^{b}	8,79±0,01^{c}	10,33±0,02^{d}

Notes: $^{a, b, c, \text{and } d}$ in the same column show a very significant effect ($p<0.01$)

Based on the results of the analysis of variance, it shows that the addition of calamansi peel flour has a significant effect ($p<0.01$) on the pH of mayonnaise (Table 4). The more the addition of calamansi peel flour, the pH content of mayonnaise decreased. This decrease is thought to be due to the citric acid content in calamansi. The statement by (Kumalasari *et al*., 2019) suggests that the pH of the final product is influenced by the pH of the raw materials used. The pH level of raw materials plays a vital role in shaping the final product, influencing chemical reactions and production processes. Ingredients with acidic properties, like vinegar and citric acid, lower the pH by releasing hydrogen ions (H^+), while alkaline substances, such as sodium hydroxide, raise the pH by releasing hydroxide ions (OH^-). Certain additives, like phosphates or citric acid, act as buffers to stabilize pH levels, helping maintain the desired texture, flavor, and color of the product. The decrease in pH could be attributed to the high pectin content in calamansi flour. According to research by (Rosalina *et al*., 2024) calamansi peel has a pectin yield of 15.3%. Pectin, being acidic in nature, may contribute to lowering the pH during processing.

The average viscosity value of mayonnaise with the addition of calamansi peel flour ranged from 6.33-10.33 mPa.s (Table 4). This viscosity value is close to the research, according to (Setiawan *et al*., 2015), the mayonnaise viscosity ranged from 9.36 to 10.45 mPa.s. However, it is higher than the viscosity of mayonnaise according to (Al-Bachir and Zeinou, 2006), where the standard viscosity on the market is 3.346 Pa.s.

Based on the results of the analysis of variance, it shows that the addition of calamansi peelflour has a significant effect (p<0.01) on the viscosity of mayonnaise. the higher the concentration of calamansi peel flour, the higher the viscosity of the mayonnaise produced (Table 4). The increase in viscosity is due to the high fiber content of the flour, this is because pectin functions as a thickening agent. (Mistrianu *et al*., 2022) stated that adding by-product powder to mayonnaise samples caused the viscosity of mayonnaise to increase significantly, thus contributing to the development of mayonnaise consistency.

The higher the viscosity value, the better the mayonnaise, as it indicates a more viscous and emulsion-stable mayonnaise (Sarungallo *et al*., 2021). Differences in viscosity are caused by the water content and the type of vegetable oil used (Usman *et al*., 2016). According to (Depree and Savage, 2002) the viscosity of mayonnaise can increase if a certain amount of continuous phase (egg yolk) and other ingredients are added.

Chemical characteristics of mayonnaise

Table 5 shows that the average value of water content ranged from 13.04% to 19.53%. Based on the results of the analysis of variance showed that the addition of calamansi peel flour had a significant effect (p<0.01) on the moisture content of mayonnaise. Calamansi peel flour, that are rich in fiber, can serve as a natural desiccant. This type of flour has the ability to absorb moisture, and when incorporated into mayonnaise, it draws out water. As a result, the more calamansi peel flour is added, the less water remains in the mixture, leading to a reduction in the moisture content of the final product. According to the research of (Zubairu *et al*., 2018), the proximate analysis of calamansi peel flour is in the form of water content of 9-10%. This aligns with the findings of (Romdhane *et al*., 2017), stated that fruit peels have the ability to absorb 2 grams of water and bind 4 grams of fat. The addition of other ingredients in the product and the chemical content of calamansi peel flour, such as protein and polysaccharide fiber, can affect water absorption (Putri *et al*., 2016). The difference in moisture content is also caused by the fatty acid content of the oil.

Table 5. The average chemical analysis of mayonnaise

Variable	Treatment			
	P0	P1	P2	P3
Water	13,04±0,58^{a}	19,53±1,00^{c}	18,22±0,74^{b}	17,82±0,32^{b}
Ash	1,23±0,17^{a}	1,56±0,17^{b}	1,61±0,17^{b}	2,37±0,26^{c}
Protein	1,22±0,02^{a}	1,62±0,02^{b}	1,63±0,01^{b}	1,94±0,02^{c}
Carbohydrate	1,29±0,01^{a}	1,75±0,01^{b}	1,79±0,01^{c}	1,91±0,00^{d}
Fat	41,95±0,73^{c}	34,55±1,01^{b}	34,13±0,33^{b}	27,60±1,30^{a}
Fiber	1,35±0,11^{a}	1,61±0,13^{b}	1,92±0,11^{c}	2,24±0,24^{d}

Notes: $^{a, b, c, \text{and } d}$ in the same column show a very significant effect (p<0.01)

Based on the results of the analysis of variance, the addition of calamansi peel flour had a significant effect (p<0.01) on the ash content of mayonnaise. Further test results showed that the ash content (%) of P0 (1.23) was significantly different from P1 (1.56), P2 (1.61), and P3 (2.37). The results showed that the higher the level of calamansi peel flour addition in mayonnaise, the higher the ash content. This is due to the addition of ash content from the addition of calamansi to mayonnaise. According to (Ananda *et al*., 2023)The ash content of dried calamansi peel is 6-7% with acid insoluble ash content (Mg, Ca, Na, and K) of 1.19%.

The results of the mayonnaise ash content range are 1.23-1.37%, so it meets the ash content requirements. Where the requirements for good ash content are in the range of 1-5% (Voight, 1994). The ash content of the study was smaller than that of the study using ethanol extract of Gerga peel (Citrus nobilis Lour) of 2.40%. This difference can be caused by inorganic or mineral components found in food ingredients (Astuti *et al*., 2023). Ash content in mayonnaise has not been listed in the mayonnaise quality requirements (SNI 01-4473-1998).

The analysis of variance shows that the addition of calamansi peel flour has a significant effect (p<0.01) on the protein content of mayonnaise (Table 5). Further test results showed that the protein content (%) of P0 (1.22) was significantly different from P1 (1.62), P2 (1.63), and P4 (1.94). The highest protein content was found in P3 with the highest level of calamansi peel flour addition. Protein content in mayonnaise tends to increase along with the addition of calamansi flour. This increase is thought to be due to the protein component of calamansi peel flour. Calamansi peel contains high protein, which is 1.5 g. Mayonnaise emulsion becomes more stable due to the high protein content of calamansi peel (Elbadrawy and Sello, 2016). In addition, the increase in protein content is also influenced by other ingredients. The type of oil and egg yolk can affect the protein content of mayonnaise products (Fransisca *et al*., 2023).

The protein levels produced by the four treatments have met the quality requirements of

mayonnaise (SNI 01- 4473-1998), which contains at least 0.9. The results of the study of protein levels are higher. The difference is influenced by the ingredients used (Ahmad *et al*., 2020). In this study, in addition to using egg yolks, oil, and calamansi peel flour were also used, so that the resulting protein levels were higher. The results obtained in the study meet the requirements of SNI 01-4473-1998. The value of mayonnaise protein content in the market is 1.4%.

Analysis of variance showed that the addition of calamansi peel flour had a significant effect ($p<0.01$) on the fat content of mayonnaise (Table 5). Further test results showed that the fat content (%) of P0 (41.95) was significantly different from P1 (34.55), P2 (34.13), and P3 (27.60). Fat content in mayonnaise decreased as the level of calamansi peel flour increased. It is suspected that calamansi peel flour has a low fat content. Mayonnaise can attain a reduced fat content by replacing oil with flour and other supplementary ingredients (Carcelli *et al*., 2020). This is also because calamansi peel flour absorbs more oil, and the proportion of total solids is replaced by added carbohydrates. Previous studies have shown that adding carbohydrate-containing foods can reduce the fat content of mayonnaise. (Evanuarini *et al*., 2020). The fat content of calamansi peel is 0.2% (Tutuarima, 2017).

The results obtained in the study have not met the quality requirements of mayonnaise (SNI 01-4473-1998), which contains at least 65%. The decrease in fat content is due to differences in the use of ingredients such as eggs, oil, water, and other additional ingredients. According to (Rahmawati *et al*., 2015) low-fat mayonnaise is made by reducing the oil phase and increasing the water phase. The fat content in low-fat mayonnaise is 30-50% (Evanuarini and Susilo, 2020).

Based on the results of the analysis of variance showed that the addition of calamansi peel flour had a significant effect ($p<0.01$) on the carbohydrate content of mayonnaise (Table 5). Further test results showed that the carbohydrate content (%) of P0 (1.29) was significantly different from P1 (1.75), P2 (1.79), and P3 (1.91). The highest carbohydrate content was found in P3, with the highest level of calamansi peel flour. This is due to the additional carbohydrate component of calamansi peel flour. orange peel contains a large amount of carbohydrates. Carbohydrate is the most abundant macronutrient in citrus peel. This is in accordance with other studies (Adewale *et al*., 2014) which revealed that carbohydrates in orange peel are the highest macronutrient.

The carbohydrate content produced by the four treatments has met the quality requirements for mayonnaise in SNI 01-4473-1998, which is a maximum of 4%. According to (Araújo *et al*., 2014) the increase in carbohydrates is influenced by soluble materials and the stability of the emulsion formed in mayonnaise. Carbohydrates in mayonnaise as a thickener will increase as the amount of oil decreases and the amount of water used increases (Amin *et al*., 2014).

The results of the analysis of variance showed that the addition of calamansi peel flour had a significant effect ($p<0.01$) on the crude fiber of mayonnaise (Table 5). Further test results showed fiber content (%) P0 (1.35) was significantly different from P1 (1.61), P2 (1.92), and P3 (2.24). This can be caused by the addition of fiber from the addition of calamansi peel flour, which has fiber content (pectin). The crude fiber content in calamansi peel flour is because citrus peel is rich in vitamin C, antioxidants, and fiber. According to the results of research (Rahardjo *et al*., 2022) orange peel flour contains a fiber content of 29.85%. Food fiber is rich in bioactive compounds, such as flavonoids, vitamin C, carotenoids, phenolics, and antioxidants. The results of the study are in line with previous researchers (Indrastuti and Aminah, 2020) who stated that orange peel powder contains antioxidants, fiber, and other elements.

The results of the range of mayonnaise fiber content are 1.35-2.24%, so it meets the requirements of fiber content. In general, mayonnaise has a fiber content between 0.8% to 3.0% (Cambero *et al*., 2011). This is also in accordance with (Damayanti *et al*., 2022) the increase in crude fiber content in food products is also caused by high fiber content in the ingredients.

Antioxidant analysis

Antioxidant activity was measured using the DPPH method, in which antioxidant activity is calculated based on the ability to inhibit oxidation caused by free radicals in DPPH. The results of the analysis of variance showed that the treatment had a significant effect ($p<0.01$) on antioxidant activity (Table 6). Further test results showed that the antioxidant content (%) of P0 (1220.51) was significantly different from P1 (1078.11), P2 (751.00), and P3 (732.39). The highest antioxidant activity was found in P3, with the highest level of calamansi peel flour. The higher the addition of calamansi peel flour in mayonnaise, the lower the average value, the higher the antioxidant activity in mayonnaise. The lower the antioxidant activity value, the higher the antioxidant (Gallego, *et al*. 2018). It is suspected that the addition of calamansi peel flour gives a response to mayonnaise. This is due to the presence of antioxidants and bioactive compounds in calamansi peel. Calamansi peel also contains several secondary metabolites that are antioxidants, including essential oils, flavonoids, tannins, and alkaloids (methanol and ethyl acetate) (Wulandari *et al*., 2013; Noviyanty *et al*., 2019a). Calamansi peel also contains vitamin C and limonene can also increase antioxidant activity (Noviyanty *et al*., 2020). Flavonoid groups that are antioxidants include flavones, flavonols, kaateksin, and chalcones (Wulandari *et al*., 2013). Flavonoids, terpenoids, and phenolics can substantially influence antioxidants (Gomes *et al*., 2016). Temperature, pH, light, oxidants, and

additional variables influence the stability of antioxidants (Febrianti *et al*., 2019).

Table 6. The average antioxidant activity of mayonnaise

Variable	Treatment			
	P0	P1	P2	P3
Antioxidant	1220,51±94,47^{c}	1078,11±23,47^{b}	751,00±16,17^{a}	732,39±6,11^{a}
Phenol	9,10±0,00^{a}	9,23±0,00^{b}	9,32±0,01^{c}	9,37±0,00^{d}

Notes: $^{a, b, c, and\ d}$ in the same column show a very significant effect (p<0.01)

The results of the analysis of variance showed that the addition of calamansi peel flour had a significant effect (p<0.01) on total phenols. Further test results showed that the total phenols (%) P0 (9.10) were significantly different from P1 (9.23), P2 (9.32), and P3 (9.37). Increased calamansi peel flour content correlates with elevated total phenol content, related to the peel's abundance in antioxidants, fiber, and vitamin C. Fruit peels contain more than 40 polyphenolic constituents, including fiber, phenolic compounds, and flavonoids, so peel flour can be used as a useful food ingredient (Putranti, 2013). The higher the phenol content in a material, the higher the antioxidant activity (Soeharto, 2013).

Hedonic analysis

The analysis of variance indicates that the colour of mayonnaise with calamansi peel flour is significantly distinct (p<0.01) (Tabel 7). The customers preference for mayonnaise color ranged from P1 3.40 “dislike moderately” to P3 5.50 “neither like nor dislike”. Mayonnaise generally has a white to yellowish white color, depending on the ingredients used to make mayonnaise (Fernandes and Mellado, 2018). Customers will be more attracted to mayonnaise colors that have high intensity (bright) compared to low intensity (dark) (Astriana *et al*., 2013). Egg yolks, vegetable oil, and mustard are the three components that are responsible for the color that is created by mayonnaise, as stated by (Shen *et al*., 2011). Mayonnaise that is prepared using vegetable oils, specifically sunflower oil and maize oil, will have a more vibrant colour compared to mayonnaise that is made with other kinds of vegetable oils.

Table 7. The average hedonic test of mayonnaise

Variable	Treatment				Ket
	P0	P1	P2	P3	
Color	4,45^{b}	5,50^{c}	4,20^{b}	3,40^{a}	**
Texture	5,16^{c}	5,53^{d}	4,06^{b}	3,73^{a}	**
Creamy	5,07^{b}	5,20^{b}	3,97^{a}	3,60^{a}	**
Aroma	4,50^{a}	5,66^{b}	4,56^{a}	4,40^{a}	**
Taste	3,63^{ab}	4,73^{c}	3,86^{b}	3,13^{a}	**
Flavor	4,40^{b}	5,00^{c}	3,93^{b}	3,23^{a}	**
Overall	5,50^{c}	5,86^{d}	5,06^{b}	4,10^{a}	**

Notes: $^{a, b, c, and\ d}$ in the same column show a very significant effect (p<0.01)

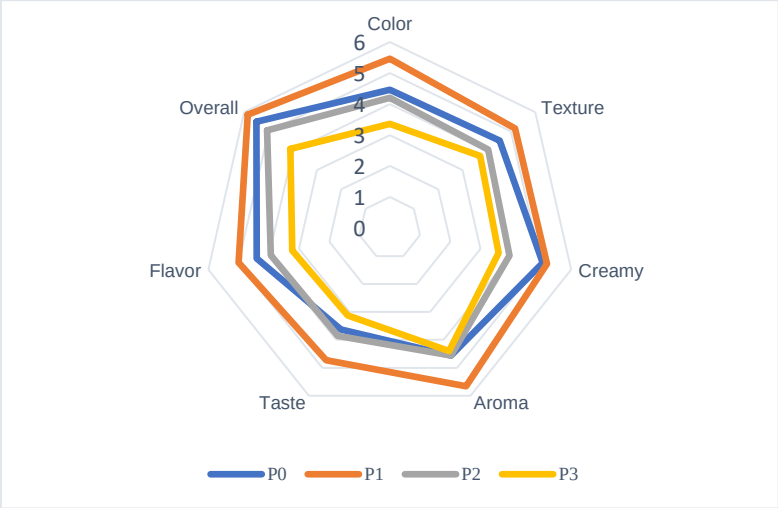

Figure 1. Spider graph of the average sensory quality

The analysis of variance indicates a substantial difference in the texture of mayonnaise with calamansi peel flour (p<0.01). The customer's preference for mayonnaise texture ranged from 3.73 “dislike moderately” to 5.53 “neither like nor dislike”. In treatment P1, the score was greatest, and in treatment P3, it was lowest. The mayonnaise became thicker and grainier as the amount of calamansi peel flour increased. The more calamansi peel flour was added, the thicker and grainier the mayonnaise was. This is due to the elevated fiber content of calamansi peel flour (Dika

et al., 2021). Calamansi peel flour has large crystal grains with non-uniform size and larger air cells (Asih and Mujdalipah, 2019). (Gaikwad *et al*., 2017) indicate that oil, as the primary component of fat, significantly influences the organoleptic characteristics of the final product. The decrease in panelists' preference for mayonnaise texture, along with the addition of calamansi peel flour, is thought to be caused by the starch content, which causes the texture of mayonnaise to become sticky and too thick so that panelists like it less (Mokodompit *et al*., 2023).

Based on the results of analysis of variance, creamy mayonnaise with the addition of calamansi peel flour was significantly different ($p<0.01$). The customer's preference for the creaminess of mayonnaise ranged from 3.60 “dislike moderately” to 5.20 “neither like nor dislike”. The treatment P1 achieved the highest score, whereas treatment P3 achieved the lowest score. The mayonnaise's softer creaminess may have influenced this assessment (Soeharto, 2013) asserts that consumers prefer mayonnaise with a creamier texture. The creaminess of mayonnaise influences its viscosity; consumers favor creamier mayonnaise as it is easier to chew (Pradhananga and Adhikari, 2015). The customer's preference of creamy mayonnaise decreased with the increase of calamansi peel flour used. Excessive addition of kalamansi peel flour will result in higher viscosity and reduce customer preferences. This is because very thick mayonnaise is difficult to apply to food (Wati *et al*., 2022).

The results of the analysis of variance showed that the aroma of mayonnaise with the addition of calamansi peel flour was significantly different ($p<0.01$). The customer's 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. Panelists gave the highest score to treatment P1 because it has a distinctive odor. Calamansi peel stores the aroma obtained from calamansi fruit, and the distinctive aroma still appears in calamansi peel flour (Novita *et al*., 2017). The smell is characterized as fresh, unique, and distinctive (Evanuarini and Susilo, 2021). The addition of calamansi peel flour lowers the level of panelist preference because it is thought to have a dominant aroma that eliminates the distinctive aroma of mayonnaise. Aroma shows sensory properties that require sensitivity in feeling and smelling food (Setyaningsih *et al*., 2010).

The results of the analysis of variance show that the taste of mayonnaise with the addition of calamansi peel flour is significantly different ($p<0.01$). The customer's preference for mayonnaise taste ranged from 3.13 “dislike moderately” to 4.73 “dislike slightly”.

The panelists favored the flavor profile of the mayonnaise in treatment P1, as it seemed to strike a better balance between the key flavors—sourness from vinegar, sweetness from sugar, and saltiness from salt. The amount of calamansi peel flour in P1 was also moderate, ensuring it didn't overpower the other flavors. On the other hand, as the amount of calamansi peel flour increased, particularly in treatment P3, the bitterness became more pronounced. This observation aligns with the panel's preference, as the addition of more calamansi peel flour seemed to reduce the overall appeal of the mayonnaise, with P3 receiving the least favorable feedback due to its higher bitterness. Taste is a factor that greatly influences consumer or panelist acceptance of processed food products (Setiawan *et al*., 2015). The addition of additional ingredients during the processing and cooking process can enhance the product's taste, provided it is not excessive (Irawati *et al*., 2015). Phenolic chemicals such as limonin and tannins in calamansi peel flour give a bitter and sour taste. The bitter taste of oranges is influenced by naringin, neohesperidin, neoeriocitrin, and poncirin (Li *et al*., 2014).

Based on the results of the analysis of variance, the flavor of mayonnaise with the addition of calamansi peel flour was significantly different ($p<0.01$). The customer's preference for mayonnaise flavor ranged from 3.23 “dislike moderately” to 5.00 “neither like nor dislike”. P1 scored the highest, while P3 scored the lowest. The addition of calamansi peel flour, which is not excessive, gives the mayonnaise a balanced flavor and stabilizes the flavor. The incorporation of starch into mayonnaise can enhance its stability (Lee *et al*., 2013). This is in line with research (Irawati *et al*., 2015) which states that ingredients or a mixture of ingredients that are not naturally part of the product's raw material, but are added to food, will affect the properties of the product and consumer preference for flavor. The addition of calamansi peel flour is thought to reduce consumer preference because it is not as strong as the typical mayonnaise flavor. Winarno (1993) asserts that customer preference for flavor will intensify if the scent and acidity are sufficiently pronounced, as this imparts a refreshing sensation when sampling mayonnaise.

The results of the analysis of variance show that the overall mayonnaise with the addition of calamansi peel flour is significantly different ($p<0.01$). Customers' preference for overall mayonnaise ranged from 4.10 “dislike slightly” to 5.86 “neither like nor dislike”. The highest score was in treatment P1, while the lowest was in treatment P3. (Shewfelt, 2011) states that the results of the assessment of color, taste, aroma, flavor, and off flavor are the overall level of customers' preference for the sample tested. The panelists' overall assessment of mayonnaise with the addition of calamansi peel flour is most preferred at the 1.5% level, because it 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 distinctive aroma of mayonnaise, a taste that is not too bitter, a distinctive sour taste and is still acceptable. This is probably because the mayonnaise produced is

close to the characteristics of mayonnaise on the market, so mayonnaise is relatively favored by panelists (Wardani, 2012). The addition of calamansi peel flour decreased the customer's preference, allegedly because it did not match the typical characteristics of mayonnaise. (Wardani, 2012) states that the overall organoleptic assessment of mayonnaise is influenced by the assessment of consumer likes or dislikes.

Conclusion

The conclusion of the research that has been done mayonnaise formulation with the addition of 1.5% calamansi peel flour is the best in terms of antioxidant activity (antioxidant content and total phenol), physical properties (pH and viscosity), chemical properties (water content, ash content, protein content, fat content, carbohydrate content, and crude fiber) and increased panelist preference for organoleptics (color, texture, creamy, aroma, taste, flavor, and overall).

Conflict of interest

No potential conflict of interest relevant to this article was reported. All authors have agreed with the contents of the manuscript.

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Author’s contribution

The authors confirm contribution to the paper as follows: study conception and design: AMPN, LRK, NA; data collection: NA; analysis and interpretation of results: AMPN, LRK, NA; draft manuscript preparation: AMPN, LRK, NA. All authors reviewed the results and approved the final version of the manuscript.

Ethics approval

There are no human subjects in this article, and informed consent is not applicable.

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