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The effect of Kepok Banana starch on meltability, pH, and acceptability of processed cheese coagulated with *Sechium edule* fruit extract

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Abstract
Processed cheese is made by mixing natural cheese and food additives to produce a homogeneous cheese. The protease enzyme from chayote extract can provide a coagulation effect and become an alternative coagulant. The addition of kepok banana starch as a filling/stabilizer in processed cheese. This study aims to determine the effect of adding kepok banana starch on the solubility, pH, and acceptability of processed cheese with chayote extract coagulants. This study used a Complete Random Design with four treatments of kepok banana starch concentration (P0=0%, P1=3%, P2=6%, P3=9%) and five replicates. The analysis of the fingerprints was carried out with the rule of decision based on the P-value comparison of 0,05. If the treatment is declared to be significantly different, it will be continued with the Duncan double-distance test. Acceptability parameters, using the Kruskal-Wallis non-parametric statistical test with the Mann-Whitney. If the results differ, the analysis is continued with the Mann-Whitney test to determine the specific differences between treatments with a significance level of 5%. The results showed that the addition of kepok banana starch with concentrations (P0=0%, P1=3%, P2=6%, P3=9%) did not have a real effect on solubility and pH but had a real effect on acceptability. The use of 3% Kepok banana starch concentration produced the best-processed cheese with a meltability of 0,246 cm, pH 6,48 and acceptability value with a numerical scale of texture 3.73 (like), colour 4.13 (like – slightly like), aroma 3.93 (like), taste 3.53 (slightly like) and total acceptance 3.60 (slightly like – like).

Keywords: Acceptabilit, kepok banana starch, pH, processed cheese, solubility

Introduction

Cheese is also one of the food products that has high nutritional value. This makes cheese one of the alternatives meeting the animal protein in food. Among the various types of cheese, processed cheese is made by mixing one or more natural cheeses with or without food additives and produces homogeneous and pliable cheese (Dewi, 2007) [6]. The primary pupose of making processed cheese is to extend the product's shelf life, maintain nutritional content, increase economic value, and create functional food products (Yulia *et al*., 2015) [33].

The coagulation process is a stage that plays a significant role in the success of cheese making. This coagulation occurs due to the addition of coagulant materials. Generally, the coagulant material often used is rennet, derived from the ruminant stomach. However, commercial rennet has a reasonably high price, and there is still doubt about its halalness. Therefore, coagulant materials derived from vegetable materials were developed. Chayote is a plant that grows a lot in Indonesia and is often used as a vegetable because it has nutritional content for the human body. Chayote has sap, and it is known that the sap in chayote contains the enzyme protease (Daulay & Wahyuni, 2022) [5]. This enzyme can clump casein in milk during the cheese making process, similar to the function of renin. Protease enzymes help to hydrolyze peptide bonds on proteins (Fatimah & Wardani, 2014) [7]. The study of the use of protease enzymes from chayote extract is expected to provide a coagulation effect on the manufacture of processed cheese so that it can be an alternative coagulant.

Adding starch to the manufacture of processed cheese is a stabilizing agent, where starch is expected to play a role in forming the texture of processed cheese. Bananas are one of the fruits that have a relatively high carbohydrate content. One of the best types of bananas to be used as starch is the kepok banana because it has a reasonably high starch content, that is why the kepok banana belongs to the plantain group which has more starchy characteristics than other types of bananas (Palupi, 2012) [23]. The starch content in kepok bananas ranged from 53.36% - 83.29% (Nairfana & Rizaldi, 2022) [19]. The addition of kepok banana starch can be one way to modify the meltability and can give a different taste to the final cheese product and add nutritional value in the final cheese product. The addition of starch plays a very important role in the formation of the texture of processed cheese, because it can affect the formation of cross-links in the structure of cheese (Gusnilawati *et al*., 2022) [9]. The purpose of adding starch as a filler is to improve the texture of processed cheese and improve the ability to maintain water bonds (Priadi *et al*., 2018) [25]. In addition, the addition of kepok banana starch is one way to diversify products by utilizing local food additives.

Kepok bananas also have a significant amylose content, where this amylose content plays a role in the formation of texture. The amylose content in kepok banana starch ranges from 27.4% - 48.2% (Nairfana & Rizaldi, 2022) [19]. Higher amylose content generally increases the gel strength and elasticity of the final product. The meltability of cheese can be modified by adding starch. In addition, the addition of starch as a filler is used as a fat substitution (Gusnilawati *et al*., 2022) [9]. The fat content in the filler can affect the meltability of cheese, the higher the fat content, the higher the meltability will also produce high meltability (Oommen *et al*., 2002) [22]. pH measurements in cheese making are

carried out because they can affect the quality and safety of cheese products. In addition, pH will also affect the acceptability value of the final cheese product.

Materials and Methods

The research used various equipment that supports the cheese-making process. A juice extractor crushed chayote, while a beaker glass served as a sample container. Measuring equipment such as thermometers, measuring cups, and digital scales help with process accuracy. Heating equipment included stoves, pots, steamers, and ovens for various processing stages. Other supporting equipment, such as mixers, filter cloths, wooden spatulas, and documentation equipment, also supported the success of the research. The main ingredient of the study was 11 liters of fresh cow's milk from the Dairy Production Laboratory of Padjadjaran University. Additional ingredients included calcium chloride, citric acid, corn oil, and chayote extract as coagulants. Salt and preservatives such as sodium chloride, sodium citrate, and STPP enhanced flavor and texture. Kepok banana starch with variations in concentrations of 3%, 6%, and 9% was the main ingredient in this study.

The procedure for making chayote extract: Chayote is washed clean, drained, cut, and crushed using a juice extractor. This melting process produces chayote extract and pulp that have been separated.

The procedure for making processed cheese: The procedure for making processed cheese adapts from the research of Raisanti *et al*. 2022 [26], with several adjustments. Fresh milk is pasteurized by the high temperature short time (HTST) method for 15 seconds at a temperature of 72°C. After that, add 0.05% citric acid, 1% calcium chloride, and 2%- or 20-ml chayote extract, and homogenize for 1 minute by stirring. The milk is left to sit for 15-30 minutes until curd or milk casein clumps form. Curd clumped is cut using a knife in stages to maximize the whey separated from the curd. Next, the curd is strained using a strainer cloth and left until the whey separates. The resulting curd was separated and weighed as much as 65 grams. Furthermore, the manufacture of processed cheese with the addition of NaCl 1%, STPP 3.2%, citric acid 0.1%, corn oil 10%, sodium citrate 1%, then stirred until homogeneous and double boiling for 2 minutes at a temperature of 100°C, at the same time added kepok banana starch with three different concentrations: P0 (0%), P1 (3%), P2 (6%), and P3 (9%). The finished processed cheese is molded, then steamed for 1 hour at 100°C to inactivate the protease enzyme, and cooled in the refrigerator for 5 hours.

Meltability: The meltability test method was modified from the measurement method in the research of Kiiru *et al*. (2018) [15]. The meltability of cheese was measured by heating a 5-gram sample in an oven at 110°C for 10 minutes. This test was carried out by measuring the length of the melted cheese using a caliper of 0.05mm.

pH: The pH value is used to measure an ingredient's acidity. The pH test is carried out by calibrating the cathode tip on the pH meter with a buffer solution. Then, the cathode tip on the pH meter is cleaned with equates and dried using a tissue. After ing the cathode tip to the sample, wait a few moments until the pH meter shows the scale and take notes; the next stage is to clean the cathode tip with equates again every time you replace the test sample (Yunivia *et al*., 2018) [34].

Acceptability Test: The acceptability test involved 15 trained panelists from the Faculty of Animal Husbandry, Padjadjaran University. The test uses a 5-level hedonic scale to assess the cheese's texture, colour, aroma, taste, and total acceptance. The test procedure includes providing labeled samples, allowing panelists to taste, and cleaning the mouth with water between samples. This method refers to the research of Nasution & Marya, (2021) [20].

Result and Discussion

The results of the research on the manufacture of processed cheese with the addition of kepok banana starch are in Table 1.

Table 1: Results of the study on the observed parameters

Variables	Treatments			
	P0 (0%)	**P1 (3%)**	**P2 (6%)**	**P3 (9%)**
Meltability (cm)	0,576	0,246	0,336	0,218
pH	6.40	6.48	6.46	6.44
Acceptability				
- Texture	3,87^{a}	3,60^{a}	4,07^{a}	3,93^{a}
- Colour	4,67^{a}	4,20^{b}	3,13^{c}	2,47^{d}
- Aroma	4.00^{a}	3,93^{a}	4,07^{a}	4,00^{a}
- Taste	4,20^{a}	3,60^{b}	3,73^{b}	3,13^{c}
- Total Acceptace	3,67^{a}	3,60^{a}	4,07^{a}	3,60^{a}

Remarks: the number in the column followed by the same letter shows no real difference (P > 0.05)

Meltability

Meltability is one of the functional properties that processed cheese must have. Various factors, such as the fat and protein content of the added ingredients, the concentration of fillers, and the processing technique of the cheese itself, influence the meltability. The results of the the one-way analysis (ANOVA) of the variety of additions of kepok banana starch of various concentrations had no significant difference in effect (P > 0,05) on the meltability. This is because adding starch to processed cheese can increase the hardness of the cheese. Starch forms a hydrogen bond with a protein matrix, which makes the cheese denser texture and reduces its ability to melt when heated (Gusnilawati *et al*., 2022) [9]

The relatively high amylose content in banana starch, ranging from 27.4% - to 48.2%, can also affect the gel structure of processed cheese (Nairfana & Rizaldi, 2022) [19]. This is in line with the opinion of Černíková *et al*. (2017) [4], that cheese's texture and meltability are affected by the composition and concentration of fillers used. However, the use of starch concentration varies. Similar characteristics of Kepok banana starch will influence the meltability of cheese. The fat and protein content in the final product also affects the meltability of the cheese. Oommen *et al*. (2002) [22], stated that the fat content in the filler material plays an important role in determining the meltability characteristics. This statement is supported by research by Priadi *et al*. (2018) [25], where lower fat content increases hardness in the cheese's texture and decreases its meltability.

The gelatinization process can also affect the meltability of cheese. Palupi, (2012) [23] stated that Kepok banana starch has a gelatinization temperature of about 84 °C; slight differences in processing conditions, such as temperature and heating time, can produce the same melting characteristics at various starch concentrations. Mounsey & O'Riordan, (2008) [18] showed that the increase in starch concentration is directly proportional to the increase in cheese hardness and inversely proportional to the meltability. This supports the findings in this study, where the difference in the concentration of kepok banana starch does not significantly affect the meltability of processed cheese.

pH

pH testing on processed cheese products is very important to determine the acidity level of the product, which will later affect the quality and characteristics of processed cheese. The results of the one-way analysis (ANOVA) of the variety of additions of kepok banana starch of various concentrations had no significant difference in effect (P > 0,05) on pH. This is because the characteristics of kepok banana starch have a stable pH. Based on research by Riyanto & Pasaribu, (2021) [27] shows that the starch of kepok bananas has a stable pH ranging from 6.7 to 7.3. Processed cheese has a buffer system that regulates the pH during cheese-making. The buffer system in this processed cheese includes added protein, calcium, and emulsifying salts. According to Hamzah *et al*. (2022) [11], the use of shared salt has a buffer capacity, where it can regulate the final pH of the product. This is in line with the research of Guinee, (2004) [8] the content of emulsifying salts in processed cheese can inhibit starter activity. Because a stable pH can help control both good and bad bacteria during storage.

The addition of kepok banana starch can also help maintain the pH stability of processed cheese during the heating process because the amylose and amylopectin content in the starch can bind water. According to the research of Hendrasty *et al*. (2022) [12], the moisture content in processed cheese affects the pH stability of refined cheese, where a high moisture content will affect the acidity level of cheese because the activity of microorganisms will multiply. The use of chayote extract does not affect the pH value because chayote has a pH that is close to neutral. This opinion is supported by the research of Hidayat *et al*. (2017) [13], which found that chayote extract has a pH of 6.45. Therefore, in this study, the characteristics of processed cheese using chayote extract coagulant and the addition of kepok banana starch prove that the variation in starch concentration is not always directly proportional to the change in pH.

Acceptability Test

Texture

The texture of processed cheese is one of the important parameters in the acceptability assessment, and it includes the physical and sensory properties of processed cheese. The Kruskal-Wallis test was carried out to determine the effect of the treatment on texture parameters. Table 1. showed that the treatment of various concentrations of kepok banana starch had an unreal effect (P > 0.05) on the texture of processed cheese. This can be seen from each treatment having the same level of preference. Adding kepok banana starch to processed cheese can act as a water binder, affecting the texture of processed cheese. According to the opinion of Winarsih & Rosyidah (2022) [31], the higher the moisture content in food, the softer and fluffier the texture, while the low moisture content will become dense and complex. This is in line with the opinion of Komar *et al*. (2009) [16], who states that the product's moisture content also determines the cheese's texture. Supported by research by Sunarya *et al*. (2022) [30], mozzarella cheese with low moisture content and high fat content provides products with the best texture.

Calcium and protein can also be factors that affect the texture of cheese. This is in line with the opinion of Metzger *et al*. (2001) [17], when total calcium decreases, the number of cross-linking between calcium and casein polymer decreases, causing the texture to be too soft. Also supported by the opinion of Abbas *et al*. (2014) [1], the more calcium, the more complex the texture of the cheese. In addition to the moisture and calcium content in cheese, pH also affects the texture of cheese. In line with the opinion of Nugroho *et al*., (2018) [21] at low pH, the curd formed will get a mushy result, while at high pH, it will get a chewy cheese texture. The addition of kepok banana starch does not really affect the level of preference for the texture of the processed cheese produced.

Colour

Colour is one of the parameters seen visually for the first time. In the acceptability test, the colour of processed cheese is an important parameter affecting consumers' product assessment. The Kruskal-Wallis test showed that the treatment of various concentrations of kepok banana starch had a real effect ($P \leq 0.05$) on the colour of processed cheese. Processed cheese with various concentrations of kepok banana starch has a noticeable difference in the colour of processed cheese. This is because the more you add banana paste to processed cheese, the darker the colour of the processed cheese. According to Nairfana & Rizaldi, (2022) [19] opinion, the colour of banana starch undergoes browning when compared to the colour of banana flesh. Young kepok bananas have a yellowish-white flesh colour, and after processing, they become darker to moderate yellow. This Maillard colour change occurs due to the Maillard reaction between amino acids and reducing sugars (Permatasari *et al*., 2020) [24].

This Maillard reaction occurs during the heating process; this reaction changes the original colour of the starch to a darker one. The starch of kepok bananas contains phenolic compounds, which play a role in colour change. According to Wiriani *et al*. (2016) [32], the polyphenol oxidase enzyme contained in banana starch contributes to the browning reaction, decreasing the starch colour's brightness. Likewise, the sugar content in banana starch also contributes to browning in the heating and processing processes. This is supported by the opinion of Azizah & Adianti, (2019) [3] that the high levels of sugar, fiber, and phenol compounds in bananas will also affect the colour of the starch. Therefore, in this study, processed cheese without adding starch (P0) is preferred because it has a bright colour.

Aroma

Aroma of processed cheese plays an important role in the acceptability of the product. The aroma in processed cheese can affect consumer perception of product quality and

likeability. The Kruskal-Wallis test showed that the treatment of various concentrations of kepok banana starch had an unreal effect (P > 0.05) on the aroma of processed cheese. The aroma of processed cheese has almost the same level of liking. Processed cheese, without adding other food ingredients, has a distinctive cheese aroma that comes from breaking down fat into fatty acids and glycerol. According to Setyawati *et al*. (2014) [29], the fat found in milk has volatile compounds such as esters, methyl ketones, aldehydes, and methyl thioalcohol, which contribute to the aroma of cheese.

The aroma of a food product can be known if the ingredients added have volatile compounds (Haliza *et al*., 2012) [10]. Bananas are fruits with volatile compounds; according Amanda *et al*. (2023) [2], volatile compounds in bananas include esters (especially amyl esters and butyl esters), aldehydes, and ketones so that bananas have a distinctive aroma. Processed cheese with kepok banana starch has a typical banana aroma but gets a lower level of liking than processed cheese without treatment. This is because the aroma of bananas is too strong, as stated by Amanda *et al*. (2023) [2], that products with the addition of banana ingredients or whole bananas that go through the ripening or processing process will increase volatile compounds. It can be concluded that the addition of kepok banana starch does not really affect the level of preference for the aroma of processed cheese produced.

Taste

Taste is a sensation felt by the sense of taste when food or drink is consumed. In the context of processed cheese with the addition of banana starch, the interaction between the added ingredients can affect the taste. The Kruskal-Wallis test showed that the treatment of various concentrations of kepok banana starch significantly affected the taste of processed cheese (P ≤ 0.05). Processed cheese with a concentration of 0% kepok banana starch (P0) had a significant difference with concentrations of 3% (P1), 6% (P2) and 9% (P3). In comparison, at a concentration of 3% (P1), there was no significant difference between the concentrations of 6% (P2) and 9% (P3) Banana starch has a natural sugar content, such as glucose and fructose, which can give processed cheeses a sweet taste. Similar to Pratomo's (2013) opinion in Khodijah *et al*. (2021) [14], adding banana flour can affect the taste because banana flour contains three carbohydrates: sucrose, fructose, and glucose. As the concentration of starch increases, sweetness becomes more dominant, increasing the complexity of the cheese flavor. Adding kepok banana starch to processed cheese results in a taste interaction between the salty taste of cheese and the ketok banana starch which tends to be sweet. Meanwhile, the saltiness of the cheese is produced by the salt added to the processed cheese, which contributes to the taste parameters. The research of Coker (2002) in Raisanti *et al*. (2022) [26], states that the salt added to cheese plays a role in enhancing the taste and is supported by the opinion of Legowo *et al*. (2009) that salt applied to cheese aims to produce a characteristic taste of cheese that is somewhat salty.

Total acceptance

Total acceptance is an essential parameter in assessing the acceptability of processed cheese. It includes the overall evaluation of consumers of the product based on organoleptic aspects, such as taste, aroma, colour, and texture. The Kruskal-Wallis test showed that the treatment of various concentrations of kepok banana starch had a real influence (P > 0.05) on the total accepted processed cheese. The total acceptance of processed cheese with various additions of kepok banana starch has the same level of preference. According to Raisanti *et al*. (2022) [26], the total acceptance of the panelists towards cheese is greatly influenced by the taste and texture of the cheese. Meanwhile, according to Setiyaningsih *et al*. (2010) [28], the acceptability value of a product is usually influenced by taste and aroma.

Based on the value of the acceptability attribute of the results of the crucial Wallis test, the best treatment for adding kapok banana starch is treatment with 3% kapok banana starch. This is seen from the acceptability attributes that received relatively consistent scores such as texture getting texture 3.60 (likes), colour 4.20 (likes – somewhat likes), aroma 3.93 (likes), taste 3.60 (somewhat likes – likes) and total acceptance 3.60 (somewhat likes – likes). This means that the total product acceptance between treatments is relatively tiny. In addition, treatment with 3% kapok banana starch was considered to have the characteristics closest to 0% (P0).

Conclusion

The addition of kepok banana starch at various concentrations (0%, 3%, 6%, and 9%) did not significantly influence the meltability and pH of the processed cheese but had a significant effect on its acceptability. Among the tested concentrations, the use of 3% kepok banana starch resulted in the best-processed cheese, characterized by a meltability of 0.246 cm, a pH of 6.48, and high acceptability values. On a numerical scale, the texture was rated at 3.60 (like), colour at 4.20 (slightly like), aroma at 3.93 (like), taste at 3.60 (slightly like-like), and overall acceptance at 3.60 (like).

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