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The effect of Kepok banana starch on yield, moisture content, and firmness of processed cheese coagulated with *Sechium edule* fruit extract

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Abstract
Processed cheese is made by mixing natural and other food additives to produce a homogeneous cheese. Cheese is formed by the coagulant agent rennet enzyme, which coagulates milk proteins. Rennet is only available as an imported product and is relatively expensive, therefore, an alternative to rennet is the protease enzyme from Siam pumpkin extract. The addition of kepok banana starch serves as a thickener, stabilizer, and modifier in processed cheese. This study aims to determine the effect of adding kepok banana starch in the production of processed cheese with siam pumpkin coagulant on yield, moisture content, and compactness (firmness). The research method used a Completely Randomized Design with four treatments of kepok banana starch concentration (P0=0%, P1=3%, P2 =6%, P3=9%) and five replications. The research results were analyzed using analysis of variance (ANOVA) with decision rules based on the comparison of F_calculated and F_table at the 5% level. The addition of kepok banana starch in the production of processed cheese significantly affects firmness but does not significantly affect yield and moisture content. At a concentration of 9% (P3), banana starch yields the best results as it produces processed cheese with the highest firmness value compared to other concentrations.

Keywords: Firmness, kepok banana starch, moisture content, processed cheese, yield

Introduction

One of the dairy products that is widely favored by the Indonesian people is cheese. Cheese can be used as an alternative to meet the need for animal protein and can be made into main or supplementary ingredients in food because it has a relatively high protein content. Indonesia has great and developing potential in cheese production, although domestic cheese consumption is still relatively low due to several factors, including relatively high prices, negative perceptions about cheese, and a lack of education. Therefore, it is necessary to develop and innovate cheese so that the products produced can be accepted by the wider community.

Cheese is classified into three categories based on its raw materials, namely natural cheese, processed cheese, and imitation cheese. Natural cheese is made from milk with the addition of salt and enzymes, processed cheese is made by mixing and grinding natural cheese and heating it, and imitation cheese is made from non-dairy ingredients as a substitute for dairy ingredients. (Riandani *et al*., 2022) [2]. One of the popular types of cheese in Indonesia is processed cheese. The structure of processed cheese is firmer and has a softer texture compared to natural cheese (Riandani *et al*., 2022) [2]. Processed cheese is a cheese product made by grinding, mixing, melting, and emulsifying through heating one or more types of cheese with or without the addition of dairy components and other permitted food additives. (BSN, 2018). An important stage in cheese production is coagulation. Coagulation is the process of curdling milk casein protein into curd and whey. The coagulation agent that curdles milk casein most commonly uses rennet enzymes. Generally, these enzymes are obtained from the stomachs of ruminants or the abdominal stomachs of cud-chewing animals, and in Indonesia, only imported products are available, making cheese relatively expensive. (Nisa *et al*., 2009) [3]. In addition, there is also microbial rennet produced through genetic engineering, which is still a subject of debate, making its use quite rare. Therefore, an alternative coagulant agent is needed to address this issue. Alternative coagulant agents can be obtained from affordable plant or fruit extracts such as chayote. Chayote contains protease enzymes that can coagulate milk proteins. Additionally, chayote extract is rich in vitamins, minerals, and antioxidants, so it is expected that its extract will provide a coagulation effect, thereby increasing the yield produced and adding nutritional value as a health benefit for consumers.

The addition of starch in the cheese-making process can also be an innovative new approach to cheese products. Adding kepok banana starch is a thickener, stabilizer, and modifier in processed cheese. One of the fruits that serves as a source of starch is the kepok banana. (Musa paradisiaca). The best banana for making starch is the kepok banana because it has a higher starch content, which is why the kepok banana belongs to the plantain group that has a more starchy nature compared to other types of bananas (Palupi, 2012) [4]. The kepok banana contains 65.71% starch (Zunggaval, 2017) [5]. Additionally, the starch produced will have a whiter color than the starch produced from other types of bananas. (Razak *et al*., 2022).

The moisture content in cheese can be influenced by the addition of starch. Flour that contains high amylose will increase the water absorption capacity of the flour (Kusnandar, 2011) [6]. For food ingredients with a high starch content, amylose binds water more easily compared to amylopectin. If the moisture content is low, it can affect the yield produced. This also affects the compactness of the resulting cheese. The addition of starch is known to play a role in the formation of processed cheese texture, as it can influence the formation of cross-links within the cheese matrix. Cheese that was originally soft can become semi-solid. (Abbas *et al*., 2010) [7]. Therefore, this study aims to

determine the effect of adding kepok banana starch in the production of processed cheese with siam pumpkin coagulant on yield, moisture content, and firmness.

Materials and Methods

This research was conducted at the Livestock Product Processing Technology Laboratory, Faculty of Animal Science, Padjadjaran University. The manufacturing process used materials including 11 liters of fresh cow's milk sourced from the Dairy Livestock Production Laboratory, Faculty of Animal Husbandry, Padjadjaran University, 11 grams of calcium chloride (CaCl2), 6.8 grams of citric acid (C6H8O7), 10% corn oil branded Tropicana by the weight of the fresh cheese, 220 ml of chayote extract, 13 grams of sodium chloride (NaCl), 41.6 grams of Sodium Tripolyphosphate (STPP), 200 ml of water (H2O), and banana starch at concentrations of 3%, 6%, and 9%.

The equipment used included bowls, juice extractors, beaker glasses, thermometers, gas stoves, mixers, strainers, measuring cups, spoons, spatulas, labels, digital scales, stopwatches, aluminum foil, ovens, analytical balances, desiccators, molds, calculators, texture analyzers, and steamers. The method used in this research is a Completely Randomized Design (CRD) with four treatments, namely four concentrations of added kepok banana starch (0%, 3%, 6%, 9%) and repeated five times, resulting in 20 experimental units. Then, the data were analyzed using analysis of variance (ANOVA) and if there was a significant effect, it was followed by Duncan's multiple range test.

Procedure for making Siam pumpkin extract

The Siam pumpkin is cleaned by washing it under running water, then drained and followed by cutting and crushing using a juice extractor without adding water. The result of the crushing using the juice extractor is Siam pumpkin extract and separated pumpkin pulp.

Procedure for making processed cheese

Fresh milk is pasteurized at a temperature of 72°C for 15 seconds. After reaching that temperature, Calcium Chloride (CaCl2) 0.4%, 2% snake gourd extract, and 0.05% citric acid are added, then stirred until homogeneous and left to stand for 15 minutes until the milk casein coagulates into curd and whey. The formed curd is then cut using a knife. The curd is then filtered until the whey separates from the curd. The filtering is done for 10 minutes using a straining cloth and left to drip until the whey has drained. The curd or fresh cheese that has been separated from the whey is weighed at 65 grams. Next, make Processed Cheese by mixing citric acid 0.1%, sodium citrate 1%, 10 ml of water, kepok banana starch with three different concentrations: P0 (0%), P1 (3%), P2 (6%), and P3 (9%), corn oil 10%, and STTP 3.2% with the weighed fresh cheese. The ingredients were mixed and heated using the double boiling technique at a temperature of ±100°C for 2 minutes. After that, steam for 1 hour to inactivate the protease enzyme from the chayote. The processed cheese that is ready is then molded and cooled in the refrigerator for 5 hours.

Yield

Yield is the percentage of the product compared to the materials used to produce that product. The yield in cheese is obtained by comparing the weight of the curd with the weight of the milk. (Karlina & Herijanto, 2021) [8].

The yield is calculated using the following formula:

$$\textbf{Yield} = \frac{B}{A}\ X\ 100\%$$

Explanation:
A: Weight of the curd used
B: Weight of the cheese formed

Moisture content

The moisture content test procedure is carried out according to the Indonesian National Standard 01-2891-1992 (BSN, 1992) as follows:

a. The dish is dried for 2 hours using an oven, then cooled in a desiccator, and weighed (W1)
b. A 5-gram sample of processed cheese is weighed in a dish (W2) and dried in an oven at 105°C for 3 hours until its weight is constant.
c. The cup containing the sample is cooled in a desiccator and then weighed. (W3).

Moisture content is calculated using the following equation:

$$\textbf{Moisture content (\%bb)} = x = \frac{W2-W3}{W2-W1}$$

Explanation:
W1: Weight of the dish (grams)
W2: Weight of the dish and sample before drying (grams)
W3: Weight of the dish and sample after drying (grams)

Firmness

Firmness is the maximum resistance force during the first compression. Firmness is measured using a texture analyzer. According to Untoro *et al* (2012) [10], the cheese texture testing procedure is as follows:

a. The sample is cut into cubes with a side length of 3 cm.
b. The probe or sample puncturing needle is installed and its position is adjusted, then the device is turned on and the value on the monitor is ensured to be zero.
c. Select the start test menu so that the probe moves to puncture the sample. If the probe returns to its original position, the test is complete.
d. The results can be seen in the form of graphs and numbers.

Results and discussion

The results of the study on the effect of adding various concentrations of kepok banana starch on yield, moisture content, and firmness in processed cheese are presented in Table 1.

Table 1: Average yield, moisture content, and firmness

Variable	Treatment			
	P0 (0%)	**P1 (3%)**	**P2 (6%)**	**P3 (9%)**
Yield (%)	82,65	86,32	84,87	89,00
Moisture content (%)	51,68	51,85	51,53	50,62
Firmness (N)	6,63	7,59	11,89	17,73

Yield

Based on Table 1, the average yield results of processed cheese with the addition of various concentrations of kepok banana starch were obtained, ranging from 82.65% to 89%.

These averages were analyzed using analysis of variance (ANOVA) to determine the effect of the treatment given, resulting in whether or not there is a significant difference. The ANOVA results showed that the addition of various kepok banana starches to the yield of processed cheese had no significant effect ($Fhit \leq F0{,}05$). It can be concluded that the various percentages of kepok banana starch addition in the treatment had the same effect on the yield of processed cheese. (processed cheese).

This could be caused by the kepok banana starch capacity at the level of 3% -9% not being able to increase water binding so that the amount of water released is the same, as evidenced by the same water content of the cheese. The moisture content of the cheese produced in this study did not have a real effect or was not significantly different, this is in line with the yield produced. This research is in line with research by Raisanti *et al*., (2022) that the yield of cheese is influenced by the water content of the cheese. Apart from that, the heating process carried out in making processed cheese causes the banana starch to gelatinize because it undergoes heating twice at a temperature of more than 100^0C. So, the resulting yield experiences a shrinkage of 7% -20% from 100% processed cheese mixture.

Moisture content

Based on Table 1, the average results of the moisture content test on processed cheese with the addition of various concentrations of kepok banana starch were obtained, namely 50.62%-51.85%. The average was analyzed using analysis of variance to determine the effect of the treatment given, resulting in whether or not there was a significant difference. The results of the analysis of variance showed that the addition of various kepok banana starches to the moisture content of processed cheese had no significant effect ($Fhit \leq F0{,}05$). It can be concluded that the various percentages of kepok banana starch addition in the treatment had the same or not significantly different effect on the moisture content of processed cheese. This can be caused because the percentage of starch used is not much different, resulting in water content results that are not significantly different or similar. The results of this research are in line with research by Priadi *et al*., (2018) that the addition of various concentrations of tapioca starch as a filler does not effect on the water content of cheese, because the presence of a tapioca starch complex with processed cheese fat can inhibit the water binding process. Apart from that, it is heated twice when making processed cheese so that the resulting yield shrinks by 7% -20% from the 100% processed cheese mixture. One of the heating processes is steam or steaming, causing the resulting cheese to become brown or a Maillard reaction occurs.

The Maillard reaction is a reaction between carbohydrates, especially reducing sugars, with amino groups. The results of this reaction produce a brown color on the surface of the processed cheese. This can also be caused by gelatinized starch. According to research by Fitriani *et al*., (2023), pre-gelatinized starch results in a significant reduction in the water content of the starch produced compared to flour without pre-gelatinization. Unmodified starch is not good at binding water because the starch granules are still intact and dense so water cannot enter. If starch is heated to an inappropriate temperature, the degree of expansion of starch granules is incorrect, giving undesirable properties (Palupi, 2012) [4].

According to BSN (2018), processed cheese has a maximum moisture content limit of 60% and a minimum total solids content of 40%. This indicates that the moisture content produced is good and in accordance with the SNI for processed cheese. (processed cheese). Higher moisture content will cause the cheese texture to become softer, which can affect the final texture of the produced cheese. In addition, the addition of starch in the production of processed cheese affects the resulting moisture content. Water in cheese will be absorbed into the starch. Cheese with the highest concentration of kepok banana starch, which is 9% (P3), produces an average water content of 50.62%, meaning the water is bound to the starch. However, cheese that is not added with starch or has a low concentration contains more free water compared to chemically bound water. According to Widyastuti (1999) [14], a higher starch content in a material will result in a decrease in the product's water content, due to the interaction mechanism between starch and protein, which prevents water from being maximally bound. The water absorbed in the starch will form a gel, so when heated, the water evaporates slowly, resulting in a decrease in moisture content.

Firmness

Based on Table 1, the average firmness test results on processed cheese with the addition of various concentrations of kepok banana starch were obtained, ranging from 6.63% to 17.73%. These averages were analyzed using analysis of variance (ANOVA) to determine the effect of the treatment given, resulting in whether there is a significant difference or not. The ANOVA results indicate that the addition of various kepok banana starches to the moisture content of processed cheese has a significant effect ($P<0.05$). It can be concluded that the different percentages of kepok banana starch addition in the treatment have a significantly different effect on the firmness of processed cheese. (processed cheese). To see the differences between treatments, a Duncan's post hoc test was conducted, with the results presented in Table 2.

Table 2: Duncan's test results on the firmness of processed cheese

Treatment	Firmness Average (N)	Significant (0,05)
P0	6.62	c
P1	7.59	c
P2	11.89	b
P3	17.73	a

Note: Values followed by the same letter indicate no significant difference ($P>0.05$)

Based on Duncan's post hoc test results, the firmness values in P2 and P3 produced significantly higher average firmness compared to P0 and P1, which were 11.89 N and 17.73 N, respectively. The high firmness values were due to the addition of kepok banana starch at 6% (P2) and 9% (P3). (P3). This is explained by Mounsey and O'Rlodan (1999) that the increased concentration of starch also increases the hardness of the cheese due to the greater number of hydrogen bonds and the denser texture of the cheese. As continued by Alnemr *et al*., (2015) [16] the increased hardness of cheese is due to the reduction in fat content, which causes the protein matrix to become denser.

The starch from kepok bananas contains 20.5% amylose. The amylose-amylopectin content in starch affects the

resulting product. In food products with a main starch content, amylose binds water more easily compared to amylopectin. This also affects the firmness of the produced cheese. Trivedi *et al*., (2008) [17] in their research concluded that the addition of starch in the production of processed cheese can enhance the product's elasticity depending on the type and amount of starch used. Starch can be used as a substitute for protein in milk, which is used as a protein source in processed cheese formulations. The addition of 9% starch produces the best firmness in processed cheese because, at percentages below 9%, the firmness value decreases. This is in accordance with the opinion of Gusnilawati *et al*., (2022) [18], that the addition of starch makes the bonds in the cheese matrix stronger.

Conclusion

The addition of kepok banana starch in the production of processed cheese results in a significantly different firmness but does not significantly affect the yield and moisture content. The 9% (P3) concentration of kepok banana starch gives the best results because it produces processed cheese with a firmness value of 17.73 N, a yield of 89% and a water content of 50.62 %.

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