Effect of grated coconut and water ratio and commercial cheese starter percentage on characteristics of soft cheese made from coconut milk

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Abstract. The aim and objective of this research was to produce a soft cheese made from coconut milk and to examine the effect of grated coconut:water ratio (1:1, 1:2 and 1:3) and percentage of commercial cheese starter culture (1% and 1.5%) on its characteristics. The study was conducted using a factorial randomized block design. After two weeks of storage at 4°C, the cheeses (18 samples) were analysed for total lactic acid (LAB) counts, pH, and fat content. The lowest-fat coconut cheese was analysed for proximate and spreading ability. The results showed that the grated coconut:water ratio had a significant effect (P≤0.01) on the total LAB counts, pH value, and fat content of the cheese. The optimum formulation for soft cheese was selected based on the lowest pH (4.64) and fat content (42%) which was reached by using coconut and water 1:1. However, the spreading ability of this cheese could be improved by optimising the growth of starter cultures, water removal and adding stabilizers.

1. Introduction
Demand for cheese in Indonesia continues to increase. In 2017, the national cheese consumption was 0.252 ounces per capita per year, an increase of 240% compared to 2014 [1]. The need for this cheese is partly met by imports. Because of the increase in domestic consumption, the production of local cheese also needs to be increased. However, cow's milk is not a major commodity produced in Aceh Province thus it is expensive. Therefore, an alternative milk as raw ingredient is needed to produce cheese.

Cheese is a dairy product made by coagulation of milk casein which is carried out using acid or enzymes [2]. Generally, the milk used in cheese making is cow's, goat's or sheep's milk, but it can be replaced with vegetable milk such as coconut milk [3]. Coconut milk has numerous benefits for human consumption due to the presence of saturated fatty acids such as lauric acid. Unlike cow's milk, coconut milk does not contain lactose [4]. Typically, coconut milk contains fat (17% - 24%), protein (3%), and carbohydrates (2%) which are nutrients favourable for human nutrition [5].
According to Kadbhane et al. 2019 [6], in the manufacture of non-dairy analogue cheese, soy and coconut milk substitution at a ratio of 50:50 produced good appearance, colour, taste, and texture. The cheese contained 52.34% water, 0.19% acidity, 1.72% ash, 16.7% protein, 27.10% fat, and 0.55% crude fibre. The nutritional content of coconut milk also affects the organoleptic preference of the cheese. Other research also demonstrated that making cream cheese using coconut milk is easy and cost effective [7]. Specifically, 15 panelists who have been eat cream cheese, liked cream cheese products made with 100% coconut in terms of texture, taste and colour.

In this study, coconut milk was used for the development of a local cheese. The choice of coconut milk was based on the high coconut production in Aceh Province, Indonesia (62,832 tons per year in 2017) [8]. The similarity of properties and characteristics of coconut milk and cow's milk enables the former to be handled in the same way as the latter. The nutritional content of coconut milk is favourable to the growth of lactic acid bacteria [9]. Fat derived from cow's milk can be replaced with fat derived from coconut [10]. Also, cheese made from coconut milk is suitable for the vegan community.

Coconut milk which was made with a 1:4 ratio of grated coconut and water (g/ml) could reduce the fat content of coconut milk drinks to 0.46% [11]. However, this ratio produced a small amount of curd and a starter culture concentration of 2% produced cheese with a high acidity in the preliminary research (unpublished data). Therefore, the aim of this research was to produce a soft cheese made from coconut milk and the objective of this research was to examine the effect of the ratio of grated coconut and water (1:1, 1:2 and 1:3) and commercial cheese starter percentage (1% and 1.5%) on characteristics of the product.

### 2. Materials and methods

#### 2.1. Materials

The main ingredients used were grated coconut, microbial (vegetarian) rennet and commercial freeze-dried cheese starter cultures contained *Lactococcus lactis* subsp. *lactis*, *Lactococcus lactis* subsp. *cremoris*, *Lactococcus lactis* subsp. *lactis* biovar. *diacetylactis* and *Leuconostoc mesenteroides* subsp. *mesenteroides* which were obtained from commercial retailer in Surabaya, East Java, Indonesia.

#### 2.2. Experimental design

The study was conducted using a factorial randomized block design consisting of two factors. The first factor was the ratio of grated coconut and water (K) consisted of four levels. The second factor was the commercial cheese starter percentage (S) consisted of two levels. The combination of treatments was eight and each treatment was replicated three times so 24 experimental units were obtained. The arrangement of treatment combinations can be seen in Table 1.

| Table 1. Experimental design. |
|--------------------------------|
| **Ratio of Grated Coconut and Water (K)** | **Commercial Cheese Starter Percentage (S)** |
| 1 : 0 (K0; control) | 1.0 % (S1) |
| 1 : 1 (K1) | 1.0 % (S1) |
| 1 : 2 (K2) | 1.0 % (S1) |
| 1 : 3 (K3) | 1.0 % (S1) |
| 1 : 0 (K0; control) | 1.5 % (S2) |
| 1 : 1 (K1) | 1.5 % (S2) |
| 1 : 2 (K2) | 1.5 % (S2) |
| 1 : 3 (K3) | 1.5 % (S2) |
2.3. Production of coconut milk spread cheese (modified from [12])

Coconut milk was made by adding water to grated half old coconut based on treatments shown on Table 1 and it was followed by stirring and filtering. The coconut milk was put into a container and heated (pasteurized) using a water bath at 71°C for 30 minutes. The milk was cooled to 31°C, and rennet (0.05%; v/v) was added, and allowed to rest for 5-10 minutes. Starter culture was then added, and the mixture was incubated at room temperature (37°C) for 8-10 hours until pH 4.6-4.7. The curd was separated from whey using a cheese cloth at room temperature for 10 hours. Salt (10%; w/w) was added into the soft curd and the mixture was kept in the refrigerator for 2 weeks before analysis. Flow diagram of soft cheese production in this research can be seen on Figure 1.

![Flow diagram of coconut milk soft cheese](image-url)

**Figure 1.** Flow diagram of coconut milk soft cheese.
2.4. Product analysis
The coconut milk was analysed for moisture, fat, protein, and ash content. After two weeks of storage at 4°C, the cheese products were analysed for total lactic acid bacteria (LAB) counts on MRS agar (Oxoid CM0361), pH, and fat content. The lowest-fat coconut cheese was analysed for moisture, protein, and ash content as well as spreading ability test.

For spreading ability test, a flat glass sizing 20 cm x 5 cm x 2 mm was used. A 3 g sample was flattened along the glass by a knife until the furthest distance that could be achieved. Then, the distance was measured with a meter ruler. The spreading ability was estimated as the farthest distance in cm. Distance of less than 10 cm indicates very difficult to spread and distance of higher than 20 cm indicates very easy to spread. The desired distance is in the range of 10-20 cm.

2.5. Statistical analysis
The data were analysed for Analysis of Variance (ANOVA) using SPSS software (IBM Statistics version 22). If the treatment has a significant effect \( (F_{\text{table}} > F_{\text{count}} \ (\alpha = 0.05)) \), the test was continued with Least Significant Difference (LSD) test. The LSD was also calculated by the SPSS software.

3. Results and discussion
3.1. Total LAB counts and pH of coconut milk soft cheese
The pH is used to express the level of acidity during cheese production. The pH decreases as a result of acid produced by starter or non-starter microorganisms. Therefore, it may relate to the total number of the starter cells. The results of total LAB count and pH of coconut milk soft cheese can be seen on Figure 2. The ANOVA shows that only ratio of grated coconut and water (K) had a significant effect \( (P\leq0.01) \) on the TCC and pH value. Meanwhile, the starter percentage (S) and its interaction (KS) had no significant effect \( (P>0.05) \) on both parameters.

![Figure 2](image_url)

**Figure 2.** Total LAB count \( (\text{LSD}_{0.01}=1.81; \text{Coefficient Variation 0.43%}) \) and pH \( (\text{LSD}_{0.01}=0.14; \text{Coefficient Variation 0.05%}) \) of coconut milk soft cheese. The same letter value indicates no significant difference \( (P>0.05) \).

Soft cheese has at least a low pH limit (at around 4.0), but in practice it is usually 5.4 or even higher [13]. In this study, the pH of the coconut milk soft cheese ranged from 4.64 to 6.39 with an average of 5.24, while the total LAB counts ranged from 5-8 log CFU/g with an average of 7.2 log CFU/g. The lowest pH (4.64±0.01) of the soft cheese was obtained from coconut milk made with ratio of grated coconut and water 1:1 (K1; Figure 2). This value was followed by the control (K2; 4.94±0.02). The decrease in cheese pH could be caused by microbial activity in forming organic acids.
Interestingly, the lowest TCC was obtained from K1 treatment. *Lactococcus lactis* is not able to survive long after the fermentation. Low pH is one of typical stresses for *Lactococcus lactis* in cheese production besides heat, oxygen, and high salinity [14]. Therefore, the microbes which grew in soft cheese K0, K2 and K3 are expected to be comprised of not only *L. lactis* species. Further study is needed to confirm whether *Leuconostoc mesenteroides* subsp. *mesenteroides* grows better in low or high-water content.

### 3.2. Fat content of coconut milk soft cheese

Cheese with 10-25% of fat content is categorized as a low-fat cheese, cheese with 25-45% of fat content is categorized as a medium-fat cheese, and cheese with 45-60% of fat content is categorized as a full-fat cheese [15]. The fat content of soft cheese made from coconut milk ranged from 38% to 71% with an average of 53.4% indicating that the soft cheese produced in this research has reached medium-fat content. The ANOVA showed that only ratio of grated coconut and water (K) had a significant effect (P≤0.01) on the fat content of the soft cheese made from coconut milk (Figure 3).

![Figure 3](image)

**Figure 3.** Fat content (LSD$_{0.01}$=13.82; Coefficient Variation 0.42%) of coconut milk soft cheese. The values on bars with the same letter indicates no significant difference (P>0.05).

### 3.3. Proximate analysis of coconut milk soft cheese

The best treatment for making soft cheese was obtained from coconut milk made with ratio of grated coconut and water 1:1 (Figure 4). This selection was based on the lowest pH and fat content analysis. Comparison of the proximate analysis between the coconut milk and the best coconut milk soft cheese produced in this research (K1) can be seen in Table 2. Based on Table 2, it is evident that the water content increased as the proportion of water increased when the coconut milk was made. This result was in contrast with the results of protein, fat, and ash content.

![Figure 4](image)

**Figure 4.** The appearance of the coconut milk soft cheese.
Table 2. Comparison of the proximate analysis between the coconut milk and the best coconut milk soft cheese.

| Proximate Analysis     | Coconut Milk (Grated Coconut : Water) | Coconut Milk Soft Cheese made with Grated Coconut : Water 1:1 |
|------------------------|--------------------------------------|-------------------------------------------------------------|
|                        | 1:0                    | 1:1                  | 1:2        | 1:3        | 1:2                          |
| Water content (%)      | 46.0                   | 66.64                | 77.37      | 80.57      | 49.34 ± 0.85                 |
| Protein content (%)    | 3.32                   | 1.44                 | 1.04       | 0.65       | 2.26 ± 0.03                  |
| Fat content (%)        | 40.45                  | 24.63                | 17.21      | 10.95      | 38.6 ± 5.72                  |
| Ash content (%)        | 0.36                   | 0.39                 | 0.16       | 0.16       | 0.47 ± 0.01                  |

The decrease in water content and increase in protein, fat, ash contents as the coconut mass increased in the treatments, were caused by processing steps such as the liquid separation process. The use of rennet is also intended to increase the protein content [16]. Research on chili cream cheese production reported with 43.47% water content [17]. The water content of the coconut milk soft cheese in this study should be reduced to increase the ability of spreading which were 26.75 ± 0.02 cm. However, the soft cheese was easy to melt at room temperature. This physical problem could be solved by optimising the growth of starter cultures [18] and water removal [19] as well as adding stabilizers [20].

4. Conclusion

Only ratio of grated coconut and water (K) has a significant effect (P≤0.01) on total LAB counts, pH value, and fat content of the soft cheese. The lowest fat content of the soft cheese was obtained from coconut milk made with ratio of grated coconut and water 1:1. The coconut milk soft cheese had the following chemical characteristics: 49.34% of water content, 2.26% of protein content, 38.6% of fat content, and 0.47% of ash content. Also, the 3 grams of this cheese can be spread up to 26.75 ± 0.02 cm indicating that the texture of the soft cheese was very easy to spread.

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