Production and Characterisation of Cheddar Cheese-like from *Cocos Nucifera L.*

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Abstract. Traditionally, cheese is made from animal milk and had been introduced a long time ago. The increasing demand for cheese has caused a substantial commercialise production that led to animal exploitation and environmental pollution. Henceforth, this study aims to produce and characterise Cheddar Cheese-like attributes made of coconut cream from *Cocos Nucifera L.* The shelf life analysis, colour analysis used Chroma Meter CR-410, pH value analysis, meltability analysis, and sensory evaluation were conducted through the meltability test, descriptive test, paired comparison test and a consumer preference test. The results illustrated that shelf life is extended below danger zone temperature, and there is a distinct colour of Cheddar Cheese-like colour compared to regular cheese. The Cheddar Cheese-like managed to mimic the effect of melting cheese and was accepted by most of the respondents based on the appearance (93.3 per cent), aroma (86.7 per cent), taste (93.3 per cent), texture (73.3 per cent), and consistency (86.7 per cent) characteristic. Subsequently, preferences analysis shows 56.7 per cent of the respondents prefer Cheddar Cheese-like over the regular cheese. Therefore, based on the result, this study concludes that coconut milk can be an alternative to producing a cheese-like product that will benefit the consumer of different diet and allergies and at the same time preserve the environment for sustainability reason.

1. Introduction
Cheese had been introduced a long time ago and is traditionally made from animal milk. Milk itself is the main raw material in the dairy sector. Indeed, approximately 6 billion people worldwide consume milk and dairy products. The global report indicates 81% of world milk production is cow’s milk, 15% buffalo milk, and 4% is a combination of goat, sheep and camel milk [1]. The statistic in 2018 showed an increase of 1.6% in world milk production which is predicted to grow exponentially in the future [1,2].

However, the increasing demand for cheese from large scale industrial and home-used has led to a vast commercial production of cheese. As a result, dairy farming expended worldwide and has contributed to animal cruelty and exploitation by the breeding industry in order to fulfil the demands [3]. Other than that, the whey from cheese has pollutant characteristics that can affect the environment [4]. Moreover, as consumers’ vegetarian diet group increases, a vegetarian diet substitute is critical [5]. A better and sustainable product should be consumed to preserve the environment better [6]. Besides, the consumer with a common digestive disorder of lactose intolerance can consume coconut milk’s cheese [3]. Indeed, most of the cheese product in Malaysia and Asia is largely imported, resulting in expensive retail prices [3].
The Cocos Nucifera L. is monocotyledon palm under palmaceae family [7] and widely available in Asian countries at a low price. Coconut milk is a thick white liquid extracted from the shredded pulp of coconut that contributed to the rich taste and opacity of the coconut milk. Coconut milk has an important element of coconut as the milk is an oil emulsion in water that is stable with proteins that can serve as thickening agents and emulsifiers [8]. The characteristic contributes to potential use as a substitute for making cheese. The previous studies had tested the combination of fresh milk and coconut to produce Warankashi traditional milk cheese-like product [9,10] and employed traditional cheese coagulation from soy milk and coconut milk in making cheese [11]. However, a paucity of research investigated the use of 100 per cent of coconut milk with other plant-based ingredients to make a 100 per cent vegan and non-lactose-based Cheddar Cheese-like substitute, with a short production time without a traditional coagulation process.

Therefore, this work is directed to study the characteristics and attributes of Cheddar Cheese-like produced using coconut milk from Cocos Nucifera L and plant-based ingredients.

2. Experimental

The extracted, sterilised, and homogenised coconut cream extract from Cocos Nucifera L. originated from Indonesia was used in this study. Agar powder (seaweed gelatine), tapioca (Manihot Esculenta) starch, salt (sodium chloride), water ($H_2O$), garlic powder and nutritional yeast (a strain of Saccharomyces Cerevisiae) were also used. 200 grams (g) of coconut cream, 1 ½ tablespoon (tbsp) of nutritional yeast, 1 tbsp of tapioca starch, 1 teaspoon (tsp) of salt, and ¼ tsp of garlic powder were mixed in a pot. Meanwhile, ½ cup of plain water and 2 tbsp of seaweed gelatine has been mixed in a different pot over medium heat and stir continuously until it transforms into a paste texture. Combine the coconut cream mixture with a seaweed gelatine paste in a pot and boil while continuously stirring using a hand whisk. Once boiling reduce the heat to simmer and constantly stir for 6 minutes until a smooth and thick texture is achieved. Immediately pour into the prepared silicone mould or moulds that were grease with vegetable oil. Let it cool with the lid off for 15 minutes at room temperature, then transfer to the refrigerator (0°C to 4°C) at least for 2 hours to firmly set.

The shelf life of Cheddar Cheese-like was then evaluated to determine how long it is safe to eat if stored in the refrigerator between 0°C to 4°C for 0 day, 3 days and 6 days [12]. The same samples were used for the colour test using Chroma Meter CR-410. The L*, a* and b* value was used in the colour test to signify the colour management. The L* value indicates the luminosity, the extent of lightness from black colour to white colour. The a* value indicates the green colour as negative and the red colour as positive. While b* value indicates the blue colour as negative and the yellow colour as positive [13]. Tapioca starch was added as one of the ingredients to mimic the melting purposes like traditional dairy cheese. Therefore, the meltability experiment was conducted to test whether the cheese-like melting or not.

The Cheddar Cheese-like were tested for acceptability by 30 random respondents using the Comparison Test between traditional dairy cheese and cheese-like as supported by the previous scholar. 30 respondents could lead to about 80 per cent power, which is suggested as a minimum for a study provided a medium to large effect size [14]. Five attributes were used for evaluation: appearance, aroma, taste, texture, and consistency. The assessment of respondents’ preferences and perception of the cheese-like was similarly conducted using the Hedonic Scale. The sensory properties were presented on a seven-point scoring scale (1) Dislike (Extremely) (2) Dislike (Moderately) (3) Dislike (Lightly) (4) Neither like nor dislike (5) Like (Lightly) (6) Like (Moderately) (7) Like (Extremely).

3. Result and discussion

3.1. Shelf life study

The shelf life is a time length of a particular product that can be kept without having spoiled effects [12,15]. For this experiment, the cheese-like was refrigerated between 0°C to 4°C for 0 day, 3 days and 6 days, as shown in table 1.
Table 1. Results of the changes the Cheddar Cheese-like’s shelf life in the refrigerator.

| Sample   | 0 day          | 3 days         | 6 days         |
|----------|----------------|----------------|----------------|
| Sample 1 | No changes     | No changes     | No changes     |
| Sample 2 | No changes     | No changes     | No changes     |
| Sample 3 | No changes     | No changes     | No changes     |

Based on data displayed in table 1, no changes observed in 0, 3, and 6 days when the cheese-like is stored in a refrigerator (4°C to 0°C) as supported by other studies [15,16]. The cheese-like was stored out of danger zone temperature and not affected by other microorganisms that can spoil the product, such as molds or bacteria [17]. The temperature is an important factor controlling cheese-like shelf life, chemical and microbiological consistency, and the inappropriate storage temperature can prolong the microorganisms' survival [15].

3.2. Colour measurement

Based on table 2, the L* value from sample 1 to sample 3 is between 91.30 until 93.93. This result was different from the previous study [18], as the L* value is between 70.9 to 75.6. The finding indicates that Cheddar Cheese-like’s colour is more neutral and whiter compared to dairy cheese. The score of a* value from sample 1 to sample 3 is between 1.02 until 2.15. The finding is contradicted with the previous study [18], as a result of the study was 7.7 until 8.9. It shows that the cheese-like’s has lacked a red colour than normal cheese. The b* value from sample 1 to sample 3 is between 15.18 until 15.49. The value also differs from the previous study [18], as the a* value in their study was 7.3 until 9.2. Thus, Cheddar Cheese-like’s colour has lacked a yellow colour than ordinary cheese. In general, assessing food quality depends on many variables, including taste, colour, texture and nutritional value [13].

Table 2. Results of the changes Cheddar Cheese-like’s colour.

| T¹       | T²       | T³       |
|----------|----------|----------|
| Sample 1 (0 day) | L=91.30  | L=91.90  | L=92.12  |
|          | a=2.15   | a=2.01   | a=2.00   |
|          | b=15.28  | b=15.18  | b=15.18  |
| Sample 2 (3 days) | L=92.32  | L=92.63  | L=92.61  |
|          | a=1.07   | a=1.04   | a=1.02   |
|          | b=15.45  | b=15.47  | b=15.48  |
| Sample 3 (6 days) | L=93.89  | L=93.93  | L=93.90  |
|          | a=1.83   | a=1.84   | a=1.84   |
|          | b=15.48  | b=15.49  | b=15.49  |

3.3. Cheese-like meltability evaluation

The tapioca starch was added for this experiment, and the result can be found in table 3. The tapioca starch was suggested by previous studies to mimic the effect of melting cheese [19–22].
Table 3. Results of Cheddar Cheese-like meltability evaluation

| Changes                      | Sample 1 (200°C) | Sample 2 (180°C) |
|------------------------------|------------------|------------------|
| Samples before heating       |                  |                  |
| Diameter                     | 1mm              | 1mm              |
| Height                       | 1mm              | 1mm              |
| Samples after heating        |                  |                  |
| Diameter                     | 4mm              | 3mm              |
| Height                       | 6mm              | 6mm              |

Cheese-like meltability was tested by heating two cheese-like samples. In a tray, sample 1 and 2 (weight = 20gm; diameter = 1mm, and height 1mm) were heated in an oven at 200°C and 180°C. After 5 minutes, the subjects were removed from the oven. The cheese-like was measured using spread diameter and height. As shown in table 3, sample 1 (diameter = 4mm and height 6mm) while sample 2 (diameter = 3mm and height 6mm).

3.4. Respondents’ acceptability
To examine the consumers’ acceptability of a product, the sensory evaluation was used through a scientific experiment involves humans’ smell, sight, taste, and touch [23]. Therefore, the sensory evaluation was tested for this research using the comparison test between the dairy cheese and Cheddar Cheese-like made from coconut milk and the cheese-like preferences [23]. The result can be accessed from table 4.

3.5. Paired compared test
Based on the results in table 4, most of the respondents accept the appearance, aroma, taste, texture and consistency of the Cheddar Cheese-like made from coconut milk comparable to cheddar cheese made from dairy milk. So, the appearance, aroma, and taste of Cheddar Cheese-like are acceptable and have a better preference than regular cheddar from dairy milk. However, the regular cheddar from dairy milk has better texture preferences compared to Cheddar Cheese-like.
Table 4. Paired Compared Test between Cheddar Cheese-like and dairy cheese

| Characteristic | Cheddar Cheese-like | Frequency (n=30) | Percentage 100% | Regular cheddar | Frequency (n=30) | Percentage 100% |
|----------------|---------------------|------------------|------------------|-----------------|-----------------|------------------|
| Appearance     | Acceptable          | 28               | 93.3             | Acceptable      | 20              | 66.7             |
| Aroma          | Acceptable          | 26               | 86.7             | Acceptable      | 20              | 66.7             |
| Taste          | Acceptable          | 28               | 93.3             | Acceptable      | 21              | 70.0             |
| Texture        | Acceptable          | 22               | 73.3             | Acceptable      | 24              | 80.0             |
| Consistency    | Acceptable          | 26               | 86.7             | Acceptable      | 26              | 86.7             |

3.6. Consumers’ preferences analysis using Hedonic Scale.
Based on table 5, most of the respondents lightly like the Cheddar Cheese-like, which accumulated to 46.7 per cent (n=14). The second highest was neither like nor dislike, which accumulated to 23.3 per cent (n=7). However, some respondents likely dislike the cheese-like in which accumulated 16.6 per cent (n=5). Some respondents chose moderately like in which accumulated to 10 per cent (n=3). Lastly, there was one respondent who answered moderately dislike in which accumulated to 3.3 per cent. To conclude, 56.7 per cent (n=17) of respondents like (lightly and moderately) the Cheddar cheese-like.

Table 5. The Cheddar Cheese-like by using hedonic scale.

| Valid                | Frequency | Per cent |
|---------------------|-----------|----------|
| Dislike (Moderately)| 1         | 3.3      |
| Dislike (Lightly)   | 5         | 16.6     |
| Neither like nor dislike | 7 | 23.3 |
| Like (Lightly)      | 14        | 46.7     |
| Like (Moderately)   | 3         | 10.0     |
| Total               | 30        | 100.0    |

4. Conclusion
This study attempts to find a substitute for cheese from cow milk by experimenting with the character and attributes of Cheddar cheese-like based on coconut milk that is used as the primary raw material. Based on the analysis, the findings suggest that the experimented product can imitate the cheese characteristic despite lacking colour compared to the original product. The findings also indicate that most of the respondents who participate in the test favour the cheese-like from coconut milk and remarks that it is similar to milk-based cheese in terms of appearance, aroma, taste, texture and consistency. Therefore, the product produced from this experiment can be further made on a larger scale and substitute for the cheese from cow milk product in the market.

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