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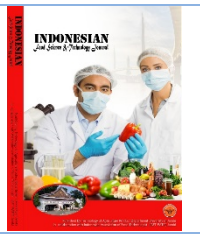

Effect of Substituting Coconut Milk with Palm Milk on Shelf Life, Physicochemical and Sensory Properties of Nasi Dagang

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***Abstract*— A popular Malaysian dish called Nasi Dagang (ND), which originated in Terengganu, consists of steamed rice in coconut milk (CM), fish curry, and additional ingredients such as pickled cucumber and carrots. However, CM with high saturated fat content is always associated with many diseases due to the increased amount of high-density lipoprotein cholesterol. Thus, palm milk (PM) at various concentrations (ND0 with 100% CM, ND1 substituted with 25% PM, ND2 substituted with 50% PM, ND3 substituted with 75% PM and ND4 substituted with 100% PM) were investigated in the present study to examine its effect on the physicochemical and sensory characteristics of ND. Substitution of PM in ND demonstrated an apparent effect on its nutritional value, shelf life, and quality, as evidenced by a greater calcium (4.51 ppm), carbohydrates (16.51%), and lesser fat (5.93%) contents in ND4 than that of ND0. This study discovered that although ND with PM substitution took a longer time to retrograde and turn rancid, the rising moisture content fostered the growth of microorganisms. According to this study, ND prepared with PM has a softer texture since it contains less amylose content (0.37%). Next, sensory acceptability analysis demonstrated that ND1 obtained a higher score than other ND for all aspects, including overall acceptance (7.24). The results showed that substitution of PM in ND had a strong influence on its nutritional value, shelf life, and sensory acceptability. Hence, it can be concluded that PM has a potential to replace CM in ND with certain amount of concentration.**

***Keywords*— Coconut milk; Nasi Dagang; Palm milk; Steamed rice; Traditional Cuisines.**

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I. INTRODUCTION

Malaysia is a multicultural nation that its culture and history are reflected in its food. Malaysian traditional cuisines are passed down via generations and successors. Besides, Malaysians prefer their meals to be flavourful with coconut milk and most of the traditional dishes comprises of a perfect combination of spicy, sweet, and sour flavours. In addition, rice is an essential food for Malaysians, and it has been consumed daily whereby their traditional dishes are mostly based on rice. One of the famous Malaysian traditional cuisines is Nasi Dagang (ND) that consists of steamed rice in coconut milk, fish curry, and additional ingredients such as pickled cucumber and carrots which originates from Terengganu [1]. Other than that, ND is also popular in Kelantan. ND has been a staple food for the Malaysian and the travellers because when traveling long distances, the traders will bring rice filled with curry and pickles wrapped in banana leaves [1]. The difference between ND Terengganu and Kelantan is the types of rice that has been used. Nasi Dagang Terengganu (NDT) is white in colour and slightly glossy and it is traditionally served with cod fish curry and pickles while Nasi Dagang Kelantan (NDK) uses specific rice that make it purplish white in colour, more glutinous and it is

served with cod fish curry, pickles, hardboiled egg, and 'sambal kelapa'.

In fact, the aroma and flavour qualities of NDT are determined by the quality of the coconut milk used in the recipe. Coconut milk is important to the Malaysian's socioeconomic standing and widely used in many traditional dishes. Coconut milk is important in Malay cuisine because it adds a strong creamy and richness to dishes [2]. Other than that, coconut milk is a plant-based milk that has been used as a substitute for animal-based milk due to its minerals and vitamins such as iron and folate, as well as a variety of other biomolecules [3]. Lactose intolerance, milk protein allergies, cultural factors, or diet selection might all be contributed to the growth of the plant-based milk replacement sector [4].

However, coconut milk contains high level of saturated fat, lauric acid that may contribute to many diseases such as a raise of blood cholesterol levels due to the increased amount of high-density lipoprotein cholesterol. Therefore, coconut milk is susceptible to chemical breakdown induced by oxidation due to its high fat content [5]. The chemical deterioration happens because of the auto-oxidation and hydrolysis of triglycerides into acylglycerol and FFA that can be determined by the kinetics of lipid oxidation [5]. All disadvantages make researcher want to substitute coconut milk to other superior ingredients.

To solve the issue, palm milk has been proposed as a healthier alternative to coconut milk in ND due to its lower FFA and higher vitamins content. Palm milk is a novel agro-based research product developed by the Malaysian Palm Oil Board (MPOB) in 2008 and has been commercialised by Premium Food Corporation SDN BHD since 2010 under the trademark Khalis Santan Sawit that tastes, looks, and stores similarly to coconut milk. The proximate compositions of palm milk and coconut milk are said to be comparable [6]. The primary benefits of palm milk are cholesterol-free, low fat, healthy, includes vitamins E, has a longer shelf-life of up to five months in packaging and 30 days after opening, can save up to 50%, and it is simply tasty [7]. Hence, the objective of the present study is to analyse the physicochemical and sensory acceptability of ND with the substitution of coconut milk with palm milk, at varied concentration.

II. MATERIAL AND METHODS

A. Materials

The raw materials that were used in this study are fragrant rice (Brand: Floral Brand), commercial coconut milk (Brand: Kara Brand), palm milk (Brand: Khalis Brand), onion, salt, sugar, ginger, and fenugreek. All ingredients were purchased from a local supermarket located in Shah Alam, Malaysia. All chemicals and apparatus used were of analytical grade.

B. Formulation of Nasi Dagang Terengganu

There were five formulations used to determine the physicochemical and nutritional value of the NDT when coconut milk was replaced with palm milk. The percentages of rice, onion, ginger, salt, sugar, and fenugreek in every formulation remained the same, while the percentages of coconut milk and palm milk varied depending on the substitution level at 25%, 50%, 75%, or 100%. Based on that, there were NDT with 100% coconut milk that would be labelled as "ND0", NDT with 75% of coconut milk and 25% of palm milk as "ND1", NDT with 50% of coconut milk and 50% of palm milk as "ND2", NDT with 25% of coconut milk and 75% of palm milk as "ND3", and NDT with 100% of palm milk as "ND4". The required ingredients were listed in **Table 1** and had been modified based on the work of [1].

C. *Preparation of coconut milk and palm milk*

Thick coconut milk was prepared by weighing 40 g of commercial coconut milk, while thin coconut milk was derived by diluting 10 g of commercial coconut milk with 50 g of potable water. Then, 2 g of salt and 10 g of sugar were added to the mixture to mitigate excessive thinning and achieve the acceptable thin viscosity, using the method modified from [1]. This procedure was repeated to prepare thick palm milk and thin palm milk. Both thick and thin coconut milk and palm milk were used in the preparation of NDT.

D. Preparation of Nasi Dagang Terengganu

About 100 g of fragrant rice was washed, rinsed, and soaked with potable water for 5 hours. The fragrant rice was fully immersed in the potable water to distribute water uniformly throughout the grain, resulting in less cooking time and energy consumption [8]. The hydrated rice was steamed for 5 minutes to enable gelatinization. Then, about 60 mL of thin coconut milk was added for the customary aroma and flavour characteristics of NDT. It was thoroughly mixed with the rice to achieve homogeneity. Approximately 15 minutes were needed to let all the thin coconut milk solution absorbed by the hydrated rice before the steaming process was extended for another 10 minutes. Next, to enhance the flavour profile, about 40 mL of thick coconut milk was added and mixed thoroughly with rice to attain homogeneity. Next, about 9 g of onion, 3 g of ginger, and 1 g of fenugreek were added concurrently. This final mixture was steamed for another 15 minutes to achieve acceptable sensory appeal and texture palatability, which was good in aroma and have a soft texture [1].

E. Sample preparation for determination of crude ash, fat, and protein

NDT was dried in a cabinet dryer at 50 ^{o}C for 24 hours. Then, dried NDT was homogeneously powdered using a laboratory grinder and packed in a High-density polyethylene (HDPE) bag. The sample powder was stored at 4 ^{o}C prior to further extraction and analysis.

TABLE 1:
FORMULATION OF MODIFIED RECIPE FOR 1 PORTION OF NDT.

Ingredients	ND0 (g)	ND1 (g)	ND2 (g)	ND3 (g)	ND4 (g)
Fragrant Rice	100	100	100	100	100
Coconut milk	50	37.5	25	12.5	0
Palm milk	0	12.5	25	37.5	50
Onion	9	9	9	9	9
Ginger	3	3	3	3	3
Salt	2	2	2	2	2
Sugar	10	10	10	10	10
Fenugreek	1	1	1	1	1
Total	175	175	175	175	175

Source: Slight modification from Arshad *et al.* (2019). ND0 with 100% coconut milk, ND1 substituted with 25% palm milk, ND2 substituted with 50% palm milk, ND3 substituted with 75% palm milk and ND4 substituted with 100% palm milk.

F. Chemical analysis

Moisture content

Moisture content was determined using the oven-drying method [9]. An aluminium dish was used in this method, whereby it has been dried in the oven before being weighed (A). Then, triplicates of about 3 g (B) were accurately weighed and put in a weighed aluminium dish, followed by subsequent heating in the oven at 105 °C for 24 hours. Samples were cooled in a desiccator for 30 minutes before reweighing (C) and calculation, using method modified from [9]. The calculation was calculated following the equation below:

$$\% \text{ moisture} = (C - A / B) \times 100\%$$

Determination of ash

The determination of the ash of NDT was determined by the dry ashing method [10]. A known porcelain dish with a fixed weight (A) was used. The sample (5 g) was weighed (B) in the clean porcelain dish. Then the sample was charred on top of the Bunsen burner with a small flame until it ceased smoking. Then, the sample was put in a muffle furnace at a temperature of 550 ºC for 3 hours, or until it becomes white ash. The dish containing ash was cooled in the desiccator and weighed after attaining room temperature (C). Ash content was calculated following the equation below:

$$\%\text{Ash} = [\text{weight of ash (C)} - \text{weight porcelain dish (A)} / \text{weight of sample (B)}] \times 100\%$$

Determination of crude fat

The determination of crude fat was done using the Soxhlet extraction method [10]. A thimble was dried in the oven (110 ºC for 1 hour), cooled in a desiccator, and weighed to a fixed weight (A). About 5 g of sample (B) was wrapped in filter paper, inserted into a Soxhlet flask, and the condenser was installed. The petroleum ether solvent was poured into the fat flask, about 180 mL. Reflux was carried out for a minimum of 8 hours until the solvent drops back into a clear-coloured fat flask. The solvents inside the fat flask were distilled and accommodated. Then, the extract was evaporated in a water bath. The extracted fat was heated in the oven at 105 ºC, cooled in a desiccator, and weighed until a fixed weight (C) was obtained. Fat content was determined following the equation below:

$$\%\text{Crude fat} = [(C-A) / B] \times 100\%$$

Determination of crude protein

Protein content in NDT was determined by the Kjeldahl method [10]. About 0.8 g of the sample was weighed and put in the digestion tube. Then, 2 pills of Kjeltabs containing potassium sulphate (K_2SO_4) and copper II sulphate ($CuSO_4$) were added. About 20 mL of concentrated sulfuric acid (H_2SO_4) was added and mixed with it. A blank sample was prepared for this analysis. Then, acid digestion was done by heating the mixture with digestion block that was warmed to 420 ºC, and the mixture was boiled for 6 hours. A clear green colour was formed, which indicates a complete digestion process. Then, it was cooled until the colour changes to blue. A Thermoplate was used to prevent heat loss from the sample. For the distillation process, the distillation unit's power system was turned on and warmed up for at least 15 minutes. In the receiving flask, 60 mL of 2% boric acid was added. Then, the digestion tube was placed in the distillation block, and the steam was turned on. When the distillation process was done, about 200 mL of the distillate was collected. Lastly, a titration process was conducted in which the distillate is titrated with 0.1 M HCl until it changes colour. The volume of HCl used was recorded [11]. Total nitrogen was determined from the titration results, and the protein content of the sample was calculated by multiplying total nitrogen by the conversion factor (5.95), because the range of factors for vegetable protein that supply substantial quantities of protein in cereal and legume-based diets is generally in the range of 5.7 to 6.25 [12]. Crude protein content was calculated following the equation below:

$$\text{Total Nitrogen (\%)} = [(\text{mL HCl} - \text{mL blank}) \times 1.4 \text{ mg N} \times 100)] / (1000 \times \text{g sample})$$

$$\text{Total protein (\%)} = \text{total nitrogen} \times \text{correction factor}$$

Correction factor for NDT = 5.95 [13].

Determination of carbohydrate

Carbohydrates content was calculated by difference using the following formula: 100 % - (Crude Protein % + Moisture % + Crude Fat % + Ash %) as described in AOAC (2006).

Determination of calories

Determination of calorie was calculated by 4:4:9 kcal/g conversion based on protein, carbohydrate, and a fat component [14] using the following formula:

$$\text{Calorie (kcal/g)} = (\text{Carbohydrate} \times 4) + (\text{Protein} \times 4) + (\text{Fat} \times 9)$$

Amylose analysis

The NDT was defatted by soaking it in hexane with the ratio of sample to hexane at 1:4. In the beginning, 5 mg of pure potato amylose were weighed into a beaker. The mixture was then topped up to 100 mL with distilled water after 1 mL of 95% ethanol and 9 mL of 1 N NaOH were added. The above produced solutions were then transferred into 1 mL, 2 mL, 3 mL, 4 mL, and 5 mL volumetric flasks. Then, 0.2 mL, 0.4 mL, 0.6 mL, 0.8 mL, and 1 mL of 1 N Acetic acid solution were added respectively into the volumetric flask to make a series of standard solutions. The flasks were then filled with 2 mL of 0.2% Iodine solution. The UV-VIS spectrophotometer was used to determine the absorbance at 620 nm, and the standard curve was built against the absorbance and amylose concentration, using the modified method from [15].

Around 50 mg of defatted NDT was weighed and transferred to a 50 mL volumetric flask. 0.5 mL of alcohol was slowly added and stirred in, followed by 5 mL of 1 N NaOH solution. The contents were quantitatively transferred to a 50 mL volumetric flask and kept at room temperature overnight. In a 50 mL volumetric flask, 5 mL of dispersion was added to 1 mL of 1 N acetic acid and 2 mL of 0.2% iodine in 2% potassium iodide solution, and the volume was made up to 50 mL with distilled water. The solution was incubated at room temperature for 20-30 minutes before the absorbance was measured at 620 nm, using the modified method [16].

Mineral analysis

About 0.5 g of sample was weighed and placed in Teflon TFM flasks. Then 8 mL of 65% HNO_3 and 1 mL of 30% H_2O_2 were added. The flasks were left open for 20 minutes to avoid a process delay caused by a sudden increase in pressure. The flasks were then closed and placed inside the microwave rotor, where they were digested in two stages: 200 °C for 10 minutes and 200 °C for 20 minutes until solution become colourless and free of particle material. The final solution was transferred quantitatively to a polypropylene tube with a capacity of 5 mL, using modified method from [17].

For analysis, the ICP OES works settings was set as follows: 1200 W RF power, 12 L/min plasma gas flow rate, 0.5 L/min auxiliary gas flow rate, 0.65 L/min nebulizer gas flow rate, and 0.6 mL/min sample flow rate, with concentric nebulizer and cyclonic spray chamber. Argon with a purity higher than 99.999% of a carrier gas. The original data obtained from ICP-OES analysis was transformed into a matrix format X (5 × 4), containing 4 elements (variables) and 5 samples, using modified method from [17].

Rancidity

Peroxide value was determined to measure the rancidity of NDT [18]. NDT was dried in a cabinet dryer at 50 °C for 12 hours. Then, dried NDT was homogeneously powdered using a laboratory grinder [19]. About 100 g of powdered sample was used to extract fat. The sample was immersed in methanol with ratio weight of sample to volume of methanol, 1: 15. The mixture was continuously stirred for 1 hour at 32 °C at 170 rpm. Then, the liquid of the mixture was filtered into the conical flask. Extracted fat was done by using rotary evaporator for 45 minutes at 50 °C with 200 Pa, using modified method from [20] Extracted fat was stored at freezer for further analysis.

About 1 g of extracted fat was weighed and mixed with 20 mL of acetic-chloroform mixture in an Erlenmeyer flask. About 20 mL of 5% Potassium iodide solution was added, swirled, and boiled on the water bath. Then, the mixture was titrated with 0.002 M sodium thiosulphate solution with starch indicator. The titration is done when yellow colour appears. A blank solution was performed as a reference for this analysis [21]. Peroxide value was calculated following as below:

$$\text{Peroxide value} = (Vs - Vb) / \text{weight sample} \times T \times 103$$

Where,
T = Molarity of sodium thiosulphate
Vs = Volume (mL) titration of sample
Vb = Volume (mL) titration of blank

G. Physical analysis

Colour

A Chroma Meter CR-400 model was used to determine colour for NDT. The white tile was used to calibrate this instrument. The chromameter was calibrated with a D65 (medium daylight) illumination condition and a 10° field of view standard observer. Colour measurements were taken at least five times on samples (about 10 g) placed on a clear petri dish. Each sample was protected by a white plate. The colour spaces were measured using CIE 1976 were L*, a*, and b*. L* is a measure of brightness ranging from black (0) to white (100). The colour red-green is described by the parameter a*, with positive a* values indicating redness and negative a* values indicating greenness. Yellow-blue colour is described by the parameter b*, with positive b* values indicating yellowness and negative b* values indicating blueness [22].

Texture

For the texture, the textural parameters determined for NDT were hardness, cohesiveness, springiness, and adhesiveness. This analysis was done using a Ta. XT-Plus Upgrade Texture Analyzer that was equipped with an aluminium cylinder probe (P/20) with a 5 kg load cell. The probe was positioned 15 mm above the base. Then, roughly 10 g of cooked rice was placed in a beaker with diameter 3 cm and placed parallel on the aluminium plate base under the centre of the probe. A two-cycle penetration test was used to obtain the TPA force-deformation curve. The test and post-test speeds on the instrument was set to 0.5 mm/s. The hardness was measured based on the peak force of the first compression divided by the height of the first curve, while the adhesiveness was determined by the negative force area under the first bite. Then, cohesiveness was calculated by dividing the value of the second graph area by the first graph area (A2/A1), and springiness was calculated by dividing the value of peak 2 by the time of peak 1 (T2/T1). All values were processed by using Exponent Lite Software (version 3.0.5.0). Texture analysis was carried out in triplicate [23].

Shelf-life study

For the shelf-life study, Total Plate Counts (TPC) of sample were determined. The finished product was allowed to cool naturally at room temperature (27 °C). Then, it was stored in a sanitary and microwavable polyethylene (PET) tray and sealed with cling film. They were stored at room-temperature storage for two days. Then, about 10 g of samples were placed in a stomacher bag with 90 mL of 0.1% sterile peptone water. This mixture was then pumped into a stomacher for 60 seconds before being diluted into seven serial dilutions. Samples for microbiological plating were taken from these repeated dilutions. About 100 µL of serial dilutions were placed onto duplicate Plate Count Agar (PCA). A sterile L-spreader aided in the spread of the solution across the media. The PCA incubation duration was 24 hours at 37 °C, and the results were shown as a growth curve of CFU/g versus time [1].

H. Sensory acceptance test

A sensory acceptance test was conducted at the Food Sensory Laboratory, UiTM Shah Alam, Selangor. Five NDT samples with a random three-digit number were rated using the 9-point hedonic scale for each attribute (1: dislike extremely, 9: like extremely). About 50 untrained panellists from the university community were involved in this sensory acceptance test to assess six attributes, i.e., colour, aroma, taste, texture, mouthfeel, and overall acceptance. Each sample was served of approximately 30 g in the clear and closed container at room temperature and coded with a three-digit number in random order. There were five different samples in total for the panellists to evaluate. The samples were served to the panellists once, and they were allowed to rinse their mouths with potable water after tasting each sample. The results of evaluations were presented as the average of 50 replications. The study was approved by the Faculty Ethics Review Committee (FERC), Faculty of Applied Sciences UiTM, with the reference number FERC/FSG/22/062.

I. Statistical and data analysis

One-way ANOVA was used to analyse the significant differences in triplicate results using Statistical Package for Social Science (SPSS) version 29.0. When $p<0.05$, the results were considered statistically significant [24].

III. Result and Discussion

A. Chemical Analysis

The chemical composition of ND is presented in **Table 2**. Moisture content is a critical proximal characteristic for product stability and shelf-life extension. To match consumer tastes, freshly cooked rice has a higher moisture content, is softer and stickier in texture. Seki *et al.* [25] discovered that the moisture level of newly cooked rice ranged from 57 to 66%. According to **Table 2**, the moisture content of ND was within the theoretical range. ND0 has a lower moisture content of 60.08% than ND4, which was substituted with 100% palm milk and has a moisture value of 66.64%. The moisture content of the milk used may have led to the increase in ND moisture content. According to certain research, palm milk has a lower moisture level 62.5% than raw coconut milk 65.3% [6]. This interpretation, however, contradicts the results observed because this study used commercial coconut milk. Raw coconut milk was not the ideal option for this investigation since its moisture content was difficult to manage. The moisture content of raw coconut milk is determined by the amount of water added during the extraction of coconut milk from its meat without any specific ratio of water to weight of meat coconut which led to data errors [26]. As a result, Kunchitwaranont *et al.* [27] discovered that the moisture content of commercial coconut milk was 51.2%, while Maghazechi *et al*. [28] discovered that the moisture content of coconut cream milk was 61.35%. One probable reason for the data is that commercial coconut milk used was a coconut cream extract, which contains less moisture than palm milk.

The mineral content of the sample was indicated by the ash composition [29]. As shown in **Table 2**, the ash composition of ND0 was greater at 13.15% than that of ND4 at 4.17%. The mineral content of coconut milk and palm milk had a significant impact ($p<0.05$) on the ND's ash composition. Several research have shown that coconut milk contains a high concentration of important minerals such as iron, calcium, potassium, magnesium, and zinc [3], but palm milk contains a high concentration of vitamins A and E [7]. As a result, ND with 100% coconut milk has a greater ash composition than ND with palm milk.

Coconut milk contains 41.5% lipid, which is made up of medium and long chain FA such capric acid (C10:0), lauric acid (C12:0), and myristic acid (C14:0) [30]. Several studies have shown that 50% of the fat in coconut milk is medium chain triglyceride [31], while Alyaqoubi *et al*. [32] claim that the majority of the fat in coconut milk is medium chain saturated FA. There has been extensive research on the fat content of palm milk, which shows that it includes a high amount of monounsaturated FA, a low amount of saturated FA, or a balanced quantity of monounsaturated, polyunsaturated, and saturated (1:1:1) FAs [33]. As demonstrated in Table 2, the fat content of ND0 was higher than that of ND4 (7.97% vs. 5.93%). This is due to the high fat content of the milk used in the manufacturing of ND. As previously stated, the fat composition of coconut milk was higher in saturated FA, which can raise blood cholesterol levels [34] than palm milk.

Table 2 shows that there were no significant differences in protein content amongst the samples ($p>0.05$). This finding contradicts with the findings of Samsu *et al*. [6], who discovered that protein levels in coconut milk were twice as high as those in palm milk, which were 2.2% and 1.2%, respectively. One probable explanation is that used of milk in ND did not contribute more to the protein of whole sample. It is because only 3.5% of milk was used in the entire process.

Carbohydrates were a vital component coming from starchy foods such as ND that met our energy needs. According to **Table 2**, the total carbohydrate of ND with 100% coconut milk was lower than ND with 100% palm milk substitution, which is 11.89% and 16.51%, respectively. This is in part, due to particle size, degree of processing, cooking method, starch structure, and the number of food components (dietary fibre, protein, fat) present [35]. This finding is corroborated by the calculation of the carbohydrate itself, as detailed in AOAC (2006).

According to one finding, the perception of a food's healthfulness can be described as high in nutrients, low in fat, and low in calories, as well as being beneficial for your body and overall healthy [36]. Surprisingly, the calories of the sample were not statistically significant ($p>0.05$) in **Table 2**. These findings assist us in understanding that the calorie content was primarily dependent on the fat content, which was the most concentrated source of energy and yields [37]. These findings are most likely connected to the fat content of the samples, which does not differ much from one another and has no effect on the total number of calories.

TABLE 2:
CHEMICAL ANALYSIS OF THE NDT

Sample	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Carbohydrate (%)	Calories (kcal/g)
ND0	60.08 ± 0.56^{d}	13.15 ± 0.69^{a}	7.97 ± 0.75^{a}	6.91 ± 0.11^{a}	11.89 ± 1.88^{c}	146.93 ± 0.55^{a}
ND1	61.46 ± 0.49^{c}	11.99 ± 0.84^{a}	6.95 ± 0.73^{ab}	6.76 ± 0.15^{a}	12.85 ± 1.19^{bc}	140.96 ± 3.74^{a}
ND2	63.71 ± 0.64^{b}	8.17 ± 0.76^{b}	6.54 ± 0.72^{b}	6.89 ± 0.22^{a}	14.70 ± 0.23^{ab}	145.18 ± 6.59^{a}
ND3	65.76 ± 0.68^{a}	6.74 ± 0.46^{c}	6.34 ± 0.56^{b}	6.70 ± 0.32^{a}	14.46 ± 0.35^{ab}	141.67 ± 4.21^{a}
ND4	66.64 ± 0.41^{a}	4.17 ± 0.39^{d}	5.93 ± 0.24^{b}	6.75 ± 0.45^{a}	16.51 ± 1.00^{a}	146.45 ± 0.79^{a}

Note. Different superscripts within the same column indicate a significant difference ($p<0.05$) in each sample (mean ± SD; n = 3). ND0 with 100% coconut milk, ND1 substituted with 25% palm milk, ND2 substituted with 50% palm milk, ND3 substituted with 75% palm milk and ND4 substituted with 100% palm milk.

Amylose Analysis

According to Li *et al.* [38], the main starch component thought to affect the textural qualities of cooked rice were amylose and amylopectin. This investigation supports the finding by Ramesh *et al*. [39] that cooked rice with a greater amylose content (AC) is harder and less sticky. **Table 3** shows that ND0's AC was higher than ND4's, which has a positive correlation with **Table 6**'s data showing that ND0 has a higher hardness than ND4. Rice with low AC has a soft and sticky texture when it is cooked, according to Adi *et al.* [40]. These results are consistent with **Table 3**'s data, which revealed that ND4 has the lowest AC and the least amount of hardness in its texture qualities. The current investigation discovered that higher AC starch has a higher rate of retrogradation [38]. Therefore, it is suggested that ND4 retrogrades slower than ND0.

Mineral Analysis

Numerous micronutrients such as calcium, magnesium, potassium, and iron were determined. Coconut milk contains high amount of iron, calcium, potassium, magnesium, and zinc [3]. It can be seen in **Table 4** that magnesium and potassium in ND0 were higher than ND4. However, calcium content of ND4 was higher than ND with coconut milk that is in an opposite trend with study by Tulashie *et al*. [3]. There are several possible explanations for this result. Finding by Paul *et al*. [41] stated that coconut milk contains a very low calcium content that makes it one of the calcium deficit non-dairy milk beverages. Another possible explanation was mineral content of commercial coconut milk and palm milk may vary depending on the brand and the processing method used. Iron content in coconut milk and palm milk stated in previous studies were 149

ppm and 11.1 ppm, respectively [42]. From **Table 4**, it clearly shows an inconsistency in the data of Iron. This inconsistency may be due to on the ingredient's variety, geographical origin, cultural practices, and environmental conditions [43]. Another important finding was that washing, soaking, and cooking of rice may result in direct loss of minerals and vitamins [44].

TABLE 3:
AMYLOSE CONTENT AND RANCIDITY DETERMINATION OF THE ND

Sample	% Amylose	Peroxide value (meq)
ND0	0.58±0.01^{a}	5.53±0.28^{a}
ND1	0.54±0.02^{b}	3.82±0.66^{b}
ND2	0.51±0.01^{c}	3.66±0.13^{b}
ND3	0.40±0.01^{d}	2.98±0.32^{b}
ND4	0.37±0.01^{e}	2.04±0.37^{c}

Note. Different superscripts within the same column indicate a significant difference ($p<0.05$) in each sample (mean ± SD; n = 3). ND0 with 100% coconut milk, ND1 substituted with 25% palm milk, ND2 substituted with 50% palm milk, ND3 substituted with 75% palm milk and ND4 substituted with 100% palm milk.

Rancidity Determination

Peroxide value was used to determine the development of lipidic hydroperoxides in ND. **Table 3** displays that there was significant difference between the sample ($p<0.05$) for its peroxide value. ND0 has a higher peroxide value than ND4. This happens due to the amount of free fatty acid (FFA) content in coconut milk and palm milk. Finding by Rohyami *et al.* [45] stated that higher FFA content could lead to the rancidity of the sample. According to Su'I *et al*. [46], coconut milk contains lauric acid (52.26%), myristic acid (16.82%), caprilic acid (8.21%), capric acid (7.79%), caproic acid (0.24%), palmitic acid (6.59%), stearic acid (1.51%), oleic acid (4.83%) and linoleic acid (1.33%). Another study found that coconut milk contains 92% of saturated fatty acids and the rest was unsaturated fatty acids [47]. Study by Ng and Es [48] stated that coconut milk provided 27.6 g of saturated FA while palm milk contains 12.1 g of saturated FA.

The possible explanation for high peroxide value of ND0 may due to the presence of lipase enzyme in coconut milk. This study has been confirmed by the research from Su'i *et al*. [46] that claimed that coconut milk contains naturally lipase enzyme that can hydrolyses fat from ND to become FFA and 40.20% was the produced from the hydrolyzation process. Another related finding by Raghavendra & Raghavarao [49] stated that hydrolysis of an ester bond of oil can be accelerated by high temperatures and excessive amount of moisture.

TABLE 4:
MINERAL ANALYSIS OF THE ND

Sample	Ca (ppm)	Mg (ppm)	K (ppm)	Fe (ppm)
ND0	2.25±0.02^{d}	2.07±0.02^{a}	17.33±0.46^{a}	0.06±0.00^{d}
ND1	2.02±0.06^{e}	1.80±0.03^{b}	12.48±0.09^{b}	0.23±0.00^{b}
ND2	3.57±0.03^{c}	1.51±0.12^{c}	10.25±0.38^{c}	0.39±0.00^{a}
ND3	4.32±0.06^{b}	1.24±0.03^{d}	6.77±0.01^{d}	0.05±0.00^{e}
ND4	4.51±0.05^{a}	1.12±0.00^{e}	4.16±0.07^{e}	0.08±0.00^{c}

Note. Different superscripts within the same column indicate a significant difference ($p<0.05$) in each sample (mean ± SD; n = 3). ND0 with 100% coconut milk, ND1 substituted with 25% palm milk, ND2 substituted with 50% palm milk, ND3 substituted with 75% palm milk and ND4 substituted with 100% palm milk.

B. Physical Analysis

Colour

The results of the colour analysis for NDT generated from five different recipes based on the proportion of palm milk replacement are shown in **Table 5**. Consumer approval of rice is significantly influenced by its colour [50]. The outcome showed that the addition of palm milk increased the sample's lightness (L*). In comparison to ND with coconut milk, which has a lightness of 64.61, ND with 100% palm milk has a lightness of 66.68. The milk's colour had a significant impact ($p<0.05$) on the sample's lightness (L*). The results have been supported by displayed in **Figure 1**. In the sample, the yellow (b*) hue was the least noticeable. **Table 5** makes it clear that there are not many notable differences there. The investigation revealed that palm milk has high levels of β-carotene (56%) and α-carotene (35%), which is stated from Choudhary & Grover [51]. The food will be orange or yellow due to the carotene pigment [52]. This offers some justification for how palm milk affects the sample's yellow (b*) tint.

TABLE 5:
COLOUR ANALYSIS OF NDT

Sample	L*	a*	b*
ND0	64.61±0.36^{b}	-1.02±0.40^{a}	1.72±0.41^{a}
ND1	64.33±0.31^{b}	-1.20±0.08^{a}	1.88±0.17^{a}
ND2	65.97±0.43^{a}	-1.26±0.21^{a}	2.39±0.55^{a}
ND3	66.77±1.00^{a}	-1.06±0.07^{a}	1.63±0.07^{a}
ND4	66.68±0.47^{a}	-0.92±0.32^{a}	1.95±0.66^{a}

Note. Different superscripts within the same column indicate a significant difference ($p<0.05$) in each sample (mean ± SD; n = 3). ND0 with 100% coconut milk, ND1 substituted with 25% palm milk, ND2 substituted with 50% palm milk, ND3 substituted with 75% palm milk and ND4 substituted with 100% palm milk.

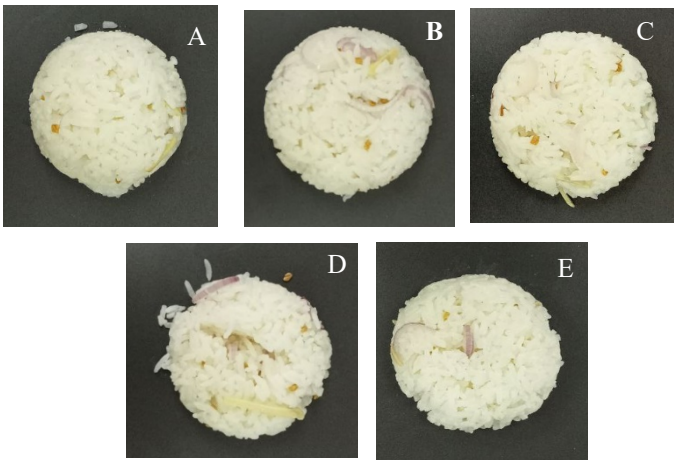

Fig. 1 Appearance image of ND (A) with 100% coconut milk, (B) substituted with 25% palm milk, (C) substituted with 50% palm milk, (D) substituted with 75% palm milk and (E) substituted with 100% palm milk.

Texture

Texture analysis of the rice was determined based on their hardness (maximum force of first compression), adhesiveness (negative force area under the first bite), springiness, and cohesiveness (resistance to the first deformation). The ability of cooked rice to satisfy consumer sensory acceptability was the most crucial analysis for the texture of rice [53]. According to this investigation, there was a substantial difference between the hardness of the sample as shown in **Table 6**. The difference between ND0 and ND4 was 1761.11 g and 776.96 g, respectively. The cause to the hardness of cooked rice has rarely been investigated in studies. Study by Yu *et al*. [54] reported that amylose affects the characteristics of cooked rice's texture. Another research from Abd Hamid *et al.* [55] claimed that the hydration process, in which rice granules absorb moisture, swell, and leach, was related to the hardness of cooked rice. An additional source for this investigation was the fact that higher water absorption resulted in a loss of texture and that higher levels of leached components may have significantly increased the sample's hardness [56]. **Table 6**'s findings suggest that the reduced hardness of ND made with palm milk is caused by the increased moisture content mentioned in **Table 2**.

The following characteristic was noticed to be adhesiveness and cohesiveness. According to **Table 6**, cohesiveness and adhesiveness are negatively correlated. These findings are corroborated by research by Seki *et al*. [25], who discovered a link between adhesiveness and cohesiveness, defining the former as the stickiness between individual rice grains and the surface, and the latter as the stickiness between the two. Regarding cooked rice, stickiness is a crucial consideration. According to Abd Hamid *et al.* [55], the amount of milk added has a beneficial impact on stickiness rather than the amylose concentration. There was no discernible variation in the sample's stickiness, as reported in **Table 6**. The amount of milk added to each sample was the same, which may have contributed to the potential explanation. Further study is required to see whether there is a correlation between stickiness and the type of milk added to ND.

TABLE 6:
TEXTURE PROFILE ANALYSIS OF THE ND

Sample	Hardness (g)	Adhesiveness (g/s)	Springiness	Cohesiveness
ND0	1761.11±0.91^{a}	-66.20±8.15^{c}	0.74±0.10^{a}	0.44±0.04^{a}
ND1	1467.93±84.01^{b}	-45.79±2.82^{b}	0.67±0.09^{a}	0.43±0.03^{a}
ND2	1332.67±57.87^{c}	-38.88±3.65^{ab}	0.68±0.03^{a}	0.39±0.05^{ab}
ND3	1203.83±54.40^{d}	-37.10±1.33^{a}	0.59±0.05^{a}	0.39±0.01^{ab}
ND4	776.96±48.40^{e}	-36.59±1.03^{a}	0.65±0.09^{a}	0.34±0.02^{b}

Note. Different superscripts within the same column indicate a significant difference ($p<0.05$) in each sample (mean ± SD; n = 3). ND0 with 100% coconut milk, ND1 substituted with 25% palm milk, ND2 substituted with 50% palm milk, ND3 substituted with 75% palm milk and ND4 substituted with 100% palm milk.

Shelf-life Analysis

The shelf-life of the NDT was determined via total plate count (TPC). The results shown in **Table 7** pertained to the total plate count (TPC) of the five different types of NDT, which was calculated over a period of two days at room temperature (27°C). According to **Table 7**, the proliferation of microorganisms increased with longer storage periods, and ND with 100% palm milk provided an ideal environment for their development. The discovery that coconut milk has been connected to anti-microbial, anti-bacterial, and anti-viral activities by Tulashie *et al*. [3] is intriguing. Anti-microbial activity of coconut milk against negative and positive gram of microbe that can cause food poisoning [57]. Because of this,

using coconut milk in ND can reduce the growth of microbes and extend the shelf life of the product.

Rice-based products have also been linked to *B. cereus*, according to reports from the Centres for Disease Control (CDC) and the European Food Safety Authority (EFSA) [58]. Temperature, pH, and the sample's water activity or moisture content all had an impact on the growth circumstances or growth probabilities of *B. cereus* [59]. According to another finding [60], cross-contamination during food manufacturing might result in the creation of pathogenic bacteria, which compromises food safety and poses a risk to customers' health. Its higher moisture content that was listed in **Table 2** may be the reason why ND4 was so easily spoiled by *B. cereus*. According to Food and Drug Administration (FDA) laboratory investigations, $>10^6$ CFU/g of *B. cereus* are necessary for toxin generation. It was demonstrated that ND, even when coconut milk was substituted with palm milk, could not be consumed after the first day of storage. One important finding stated that to prolong shelf-life of cooked rice, preheated or stored at cold temperature to slow the growth of microbes [61].

TABLE 7:
TOTAL PLATE COUNT (TPC) OF THE ND

Sample	(TPC) log CFU/g		
	0 (day)	1 (day)	2 (day)
ND0	0.00	2.0×10^7	3.1×10^8
ND1	0.00	6.0×10^7	8.4×10^8
ND2	0.00	1.4×10^8	TNTC
ND3	0.00	1.5×10^8	TNTC
ND4	0.00	2.4×10^8	TNTC

Note. ND0 with 100% coconut milk, ND1 substituted with 25% palm milk, ND2 substituted with 50% palm milk, ND3 substituted with 75% palm milk and ND4 substituted with 100% palm milk.

C. Sensory Acceptability

The sensory characteristics resulting from panellist preferences for the samples made from five different NDT recipes were represented graphically in **Figure 2**. Reiterating that, the outcomes were a subjective assessment of the material qualities connected to the sensory acceptability of the five different samples.

TABLE 8:
SENSORY ACCEPTABILITY OF THE ND

Sample	Colour	Texture	Taste	Aroma	Overall Acceptability
ND0	7.40 ± 1.11^a	6.66 ± 1.70^a	6.62 ± 1.81^{ab}	6.72 ± 1.87^{ab}	6.98 ± 1.70^{ab}
ND1	7.50 ± 0.97^a	7.22 ± 1.22^a	7.02 ± 1.32^a	7.10 ± 1.47^a	7.24 ± 1.22^a
ND2	7.36 ± 1.16^a	6.72 ± 1.47^a	6.50 ± 1.53^{ab}	6.72 ± 1.57^{ab}	6.72 ± 1.41^{ab}
ND3	7.30 ± 1.39^a	6.98 ± 1.63^a	6.32 ± 1.52^b	6.50 ± 1.27^{ab}	6.60 ± 1.55^b
ND4	7.12 ± 1.53^a	6.72 ± 1.43^a	6.22 ± 1.53^b	6.10 ± 1.75^b	6.40 ± 1.48^b

Note. Different superscripts within the same column indicate a significant difference ($p<0.05$) in each sample (mean ± SD; n = 50). ND0 with 100% coconut milk, ND1 substituted with 25% palm milk, ND2 substituted with 50% palm milk, ND3 substituted with 75% palm milk and ND4 substituted with 100% palm milk.

According to **Table 8** sensory evaluation results, ND1 was more preferred than other NDs for all attributes, including overall acceptability. For the attributes of colour and texture, there was no significant difference ($p>0.05$) across the samples. It demonstrated that the panellists were able to accept the sample's colour and texture even when it was replaced with 100% palm milk. Based on findings by Arshad *et al*. [1], all samples were in the off-white colour as shown in **Figure 1**, which is a typically accepted feature of NDT. The panellists acceptability on the sample's colour and texture were not statistically significant, indicating that all samples could be considered satisfactory.

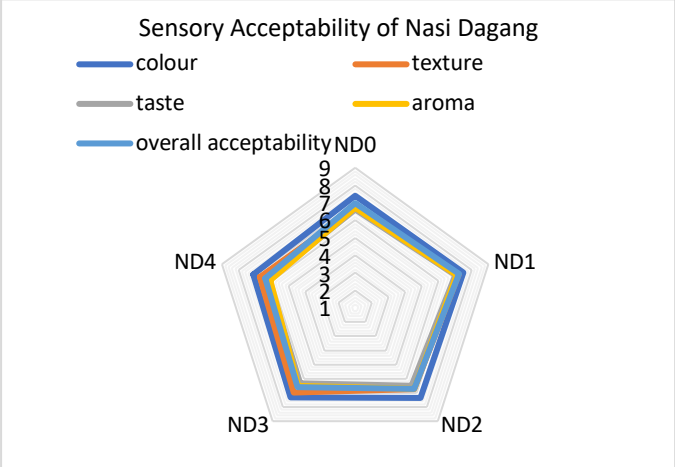

Fig. 2 Means Value for Sensory Attributes of ND. ND0 with 100% coconut milk, ND1 substituted with 25% palm milk, ND2 substituted with 50% palm milk, ND3 substituted with 75% palm milk and ND4 substituted with 100% palm milk.

There are modest variations amongst them in terms of taste, scent, and general acceptance. Overall, most panellists chose ND1 for its taste and aroma qualities. The presence of coconut milk's flavour and aroma could be the cause of this, according to one theory. The creamy, nutty flavour of coconut milk and its impact on sensory acceptance are both significant. Other than that, palm milk creates a new odour for the panellists that they find to be insignificant, resulting in a lower score for ND4's aroma qualities. The aroma and flavour of ND depended on the quality of milk used, which provided strong support for the conclusion [1].

IV. CONCLUSION

The purpose of this study was to determine how switching from coconut milk to palm milk affected the physicochemical and sensory characteristics of ND. According to the results of the current study, the physicochemical features of ND had an impact on its nutritional value, shelf life, and quality. The findings of this study indicate that ND4 has a higher calcium content, higher carbohydrate content, and lower fat content than ND0. This study found that ND4 took a longer time to retrograde and get rancid, but the increasing moisture content created favourable conditions for microbial development. This study also showed that ND4 has a soft texture because it contains less AC. To conclude, ND1 received higher scores than other ND for all qualities, including overall acceptance, when it came to the sensory acceptability of the samples. Further research into amylose-lipid complex between amylose in ND and fat from coconut milk and palm milk can be done in the future to discover the effect on the hardness of the rice. This finding will help other researchers to understand the relationship between amylose-lipid complex and the hardness of the ND.

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CONFLICT OF INTEREST

Authors declare no conflict of interest to disclose.

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