

A Comparative Study on the Sensory Acceptance and Shelf Life of ‘Nasi Dagang Terengganu’ Prepared from Modified Rice Recipes Using Various Combinations of Coconut, Skim and Evaporated Milk

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Abstract ‘Nasi Dagang’ is a signature Malaysian dish consisting of rice steamed in coconut milk, fish curry and extra ingredients such as pickled cucumber and carrots. It is a well-known breakfast food in the states on the East Coast of Peninsular Malaysia, southern Thai Malay provinces of Pattani, Yala and Narathiwat. Being a food preparation meant for immediate consumption, it naturally has short shelf life. Traditional preparations usually soak rice in fresh coconut milk with subsequent gelatinization facilitated via steaming process. As an objective to mitigate the adverse property of this food product, the scope of study undertaken focused on improvements of the formulation of the recipe using ultra-high temperature (UHT) coconut, skim and evaporated milk to replace the fresh coconut milk. In attempting to meet this objective of shelf life enhancement, modifications to the rice base utilized predetermined levels of various combinations of ultra-high temperature (UHT) coconut, skim, and evaporated milk to replace the fresh coconut milk. Sensory preference test and colour analysis were performed on resultant modified rice recipe samples. Subsequent evaluation of shelf stability quality of the rice samples were conducted on samples stored in room temperatures for three days and at chilled temperatures (4°C) for four weeks. The results showed that rice formulated with UHT coconut milk had the highest score for taste, texture, aroma, and overall acceptability, as compared to skim milk and evaporated milk. Shelf life evaluation indicated that rice stored at room temperatures (25°C) deteriorated due to increased presence of total bacteria count, which exceeded the safety level. Meanwhile at chilled temperatures, there was no evidence of microbial growth in the rice formulated with UHT coconut milk.

Keywords Rice, Nasi dagang, Shelf Life, Sensory acceptability, Malaysia

1. Introduction

‘Nasi Dagang’ is a signature Malaysian dish consisting of rice steamed in coconut milk, fish curry and extra ingredients such as pickled cucumber and carrots. It is a well-known breakfast food in the states on the East Coast of Peninsular Malaysia, southern Thai Malay provinces of Pattani, Yala and Narathiwat. As a staple food in Malaysia, rice is a principal ingredient for a wide range of recipes such as ‘Nasi Goreng’ (Fried Rice), ‘Nasi Lemak’ (Coconut Milk Rice),

‘Nasi Minyak’ (Oily Rice), ‘Nasi Ayam’ (Chicken Rice), ‘Nasi Dagang’ (Dagang Rice), and a host of other rice based food preparations. Each rice-based food creation has a story to tell and signifies the method of preparation. Nasi Dagang literally refers to rice eaten by traders in the course of their business ventures (Wan Ahmad *et al.*, 2011). With its origins from the eastern corridor of Peninsula Malaysia, namely Terengganu and Kelantan, the advent of the life-cycle of this signature dish has grown by leaps and bounds, from a popular consumable among local Malaysians to a globally sought after food preparation especially in foreign countries where the Malaysian traditional and cultural culinary influences thrive (Wan Ahmad *et al.*, 2011).

The legacy of ‘Nasi Dagang Terengganu’ has its roots among the rural folks. The dish is formulated from a mixture of rice and glutinous rice, flavoured with coconut milk. It is

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eaten with tuna curry and vegetable pickles. Over the last decade, the evolution of Nasi Dagang Terengganu has seen a progressive transformation from a food preparation for private and domestic consumption into a commercially driven market offering. However, commercially prepared offerings were not much different from domestic purpose preparations as the product processing of the former was a mere replication of the latter, which inevitably had to be consumed immediately, before the rapid onset of spoilage (Lani *et al.*, 2015). With purveyors of this market offering unaware and unwilling to incorporate technology on the aspects of shelf life enhancement, the boundaries for commercial exploits to capitalize on time expanse and translocation opportunities were limited. Thus, it was impossible to maintain the keeping quality of this food preparation for more than one day, and with such shelf life attributes, transporting 'Nasi Dagang Terengganu' beyond its borders was never an equation that could be solved by the customary method of processing.

The aroma and flavour precursors as well as the keeping quality of 'Nasi Dagang Terengganu' is due to the quality of the coconut milk used in the recipe. This principal ingredient is widely used for preparing coconut milk rice and curry dishes. Coconut, a Malaysian crop, however, is beginning to show a declining trend within an incongruent economic landscape over the years, in view of the shrinking land acreage designated for coconut plantations, albeit in a high demand environment. Previous statistics showed that in 2013, the area was about 87,974 hectares, gradually decreasing to about 82,917 hectares in year 2017 (Habshah, 2018).

Coconut owes its flavour and aroma enhancement properties to two nutritional components which is fat and protein. These components are susceptible to microbial spoilage in products that use coconut in their recipe (Lani *et al.*, 2015). In meeting with the objective of shelf life enhancement of 'Nasi Dagang Terengganu', the fresh coconut milk is substituted for ultra-high temperature (UHT) coconut milk. In addition, evaporated and skim milk is experimented to substitute coconut milk, so as to develop a low cost 'Nasi Dagang Terengganu'.

2. Materials and Methods

2.1. Sample Preparation and Experimental Design

Raw materials used in this study were rice (Brand: Jati), glutinous rice (Brand: Nagasari), UHT coconut milk, onion, salt, sugar, ginger, and fenugreek. All ingredients were purchased from a local supermarket located at Kuala Terengganu, Malaysia. Two types of coconut milk used in the recipe with respect to viscosity were thick and thin coconut milk. The former is the common, commercially available coconut milk, while the latter is prepared by diluting 50% thick coconut milk with 50% potable water. Evaporated milk and skim milk were other milk variants used in this study. Thick skim milk was prepared by diluting 1 part of powdered skim milk with 2 parts of hot water. In the formulated recipe, modifications were made by substituting equivalent amounts of thin and thick coconut milk for thin and thick Evaporated and skim milk, respectively. The required processing for preparing Nasi Dagang Terengganu was carried out in a control and aseptic environment at the Food Technology Laboratory, Universiti Sultan Zainal Abidin, Terengganu, Malaysia. The modified recipe formulation is shown in Table 1.

2.2. Preparation of Coconut Milk, Evaporated Milk and Skim Milk

Thick coconut milk was prepared by weighing 100g of commercially available UHT coconut milk and thickened with 3 g of salt, which is a viscosity enhancer. Conversely, thin coconut milk was derived from diluting 100g of commercially available coconut milk with 100g of potable water. To mitigate excessive thinning and achieve the acceptable thin viscosity, 5 g of salt and 3 g of sugar were added to the mixture. Thick and thin evaporated and skim milk, respectively were prepared in accordance to the method prescribed above (Lani *et al.*, 2015) with some modification of the method.

Table 1. Formulation of modified recipe for 1 portion of Nasi Dagang Terengganu, Malaysia

	Formulation A (%)	Formulation B (%)	Formulation C (%)
Rice	34.5	34.5	34.5
Glutinous rice	17.3	17.3	17.3
Thin coconut milk	27.6	0.0	0.0
Thick coconut milk	13.8	0.0	0.0
Thin evaporated milk	0.0	27.6	0.0
Thick evaporated milk	0.0	13.8	0.0
Thin skim milk	0.0	0.0	27.6
Thick skim milk	0.0	0.0	13.8
Onion	4.1	4.1	4.1
Salt	1.1	1.1	1.1
Ginger	0.7	0.7	0.7
Sugar	0.4	0.4	0.4
Fenugreek	0.4	0.4	0.4
Total	100	100	100

2.3. Preparation of 'Nasi Dagang Terengganu'

A mixture comprising 250g of polished rice and 125g of glutinous rice was initially washed, rinsed and soaked with potable water for 2 h. The hydrated rice mixture thereafter underwent steaming for 20 min to enable gelatinization. To attain the customary aroma and flavour characteristics of 'Nasi Dagang Terengganu' thin coconut milk was added into the steamer and thoroughly mixed with the rice to achieve homogeneity. The steaming process was extended for another 20 min. Next, to enhance the flavour profile, thick coconut milk was added and likewise mixed thoroughly with the rice to attain homogeneity. At this stage, onion, ginger and fenugreek were added concurrently. This final mixture was steamed for another 20 min to achieve the acceptable sensory appeal and texture palatability.

2.4. Shelf-life Study

The finished product was left to undergo natural cooling at ambient temperatures (25°C). Subsequently, it was packed in sterile and microwavable Polyethylene (PET) tray and sealed with a cling film. Storage was at room temperatures for 2 days and under chilled conditions (temperature 3-4 °C) for 4 weeks. The whole procedure was repeated for evaporated and skim milk, respectively, reference being made to the modified formulations, as per Table 1.

2.5. Method of Analysis

2.5.1. Colour Attributes

The equipment deployed for colour analysis was a Chroma Meter CR-400 (Konica Minolta Sensing Inc., Japan) which was initially calibrated using calibration plates. This portable colorimeter was positioned above samples of 'Nasi Dagang Terengganu' placed on small trays, about 0.5 cm from the surface of the sample, and at 5 different locations. Colour measurement and analysis were performed on samples with respect to their L^* (Lightness), a^* (redness) and b^* (yellowness), respectively.

2.5.2. Microbiological Analysis

Samples for analysis used standard procedures to evaluate aerobic plate counts (APC), and yeast and mould counts with certain modifications (Lani *et al.*, 2015). Approximately, 10 g samples were placed in a stomacher bag filled with 90 ml 0.1% sterile peptone water. This mixture was subsequently pumped into a stomacher for 60 s, after which it was further diluted into 7 serial dilutions. From these serial dilutions, samples were extracted for microbial plating. Approximately, 100 μ L portions of serial dilutions were transferred onto duplicate Plate Count Agar (PCA) (Oxoid, UK) and Dicloran Rose Bengal Chloramphenicol (DRBC) Agar (Merck, Germany). A sterile L-spreader facilitated the solution spreading on the media. The incubation period for PCA was 24 hours at 35°C, while DRBC was incubated for 3 to 5 days at 25°C. Microbiological analysis was reported as a growth curve of CFU/g versus time.

2.6. Sensory Preference Test

Sensory preference test was conducted at the Food Sensory Laboratory involving 43 semi-trained panellists on 5 attributes. The attributes evaluated were colour, texture, odour, taste, and overall preference by using the ranking method (Diane, 2010). Three random, three digit numbered samples of Nasi Dagang Terengganu were ranked by sensory panellist according to their preferences for each attribute.

2.7. Statistical Analysis

Sensory preference and colour attributes were analysed using SPSS (Version 20.0) software (SPSS Inc., Chicago, USA). Data analysis used One-Way Analysis of Variance (ANOVA) and Duncan Test. Significance level was set at $p < 0.05$.

3. Results and Discussion

3.1. Sensory Preference of 'Nasi Dagang' Terengganu

The graphical representation from Figure 1 portrayed the sensory attributes derived from panellist preferences for the samples prepared from 3 different recipes of Nasi Dagang Terengganu. In reiteration, the results were a subjective measure of the physical properties related to the sensory appeal of the 3 different samples.

Colour attribute shows that evaporated milk is significant as compared to skim milk and coconut milk. Sample of evaporated milk is less preferred by the panel while the sample which highest preference for colour is coconut milk, followed by skim milk. However, invoke the overall acceptability evaluation, and it becomes apparent that despite the customary acceptance that cooked rice being white is a subjective standard measure, in contrast for Nasi Dagang Terengganu, the off white colour is the normally accepted attribute and thus contributes to higher scores for overall acceptability. Colour is invariably imperative in most sensory analysis, being a critical attribute affecting and effecting the perception and taste. It is no wonder that, globally, food scientists consider colour to be a major quality contributing factor of food (Gray, 2013).

The relationship and impact of colour imparted by the various milk compositions in the recipe to sensory analysis is further augmented by similar trends exhibited by aroma and texture and taste, which incidentally was significantly different ($p < 0.05$) across all 3 different samples. With these results in view, it was no surprise that the UHT Coconut milk recipe was most acceptable while the Evaporated milk recipe with subdued sensory properties became least acceptable.

The least acceptable texture experienced from the evaporated milk recipe, the higher protein content, as compared to either skim milk or UHT coconut milk (United State Department of Agriculture, 2018), will denature during steaming causing more hydrophobic protein unfolding, leading to the harder texture of rice (Lani *et al.*, 2015). Related to the above aspects, the denatured protein has the

potential to exude an uncommon odour to the sample and resulting in the score for aroma attribute being least as compared to skim milk and UHT coconut milk (Steele, 2004).

A certain shortcoming exists underlying the benign biasness that potentially influenced the outcome of the analysis. Among panellist, the appreciation that traditionally and widely accepted recipes of 'Nasi Dagang Terengganu' is strongly pegged to coconut milk. This perceptibly entrenched factor could be one of the main reasons that

formulations derived from evaporated and skim milk received significantly lower preference ratings than the coconut milk formulation. The taste profile and overall acceptability in Figure 1 might be a manifestation of the above phenomenon, concurring with the culmination of significantly higher scores for these attributes pertaining to coconut milk formulations. Incidentally, the taste and aroma of UHT coconut milk almost resembles that of fresh coconut milk.

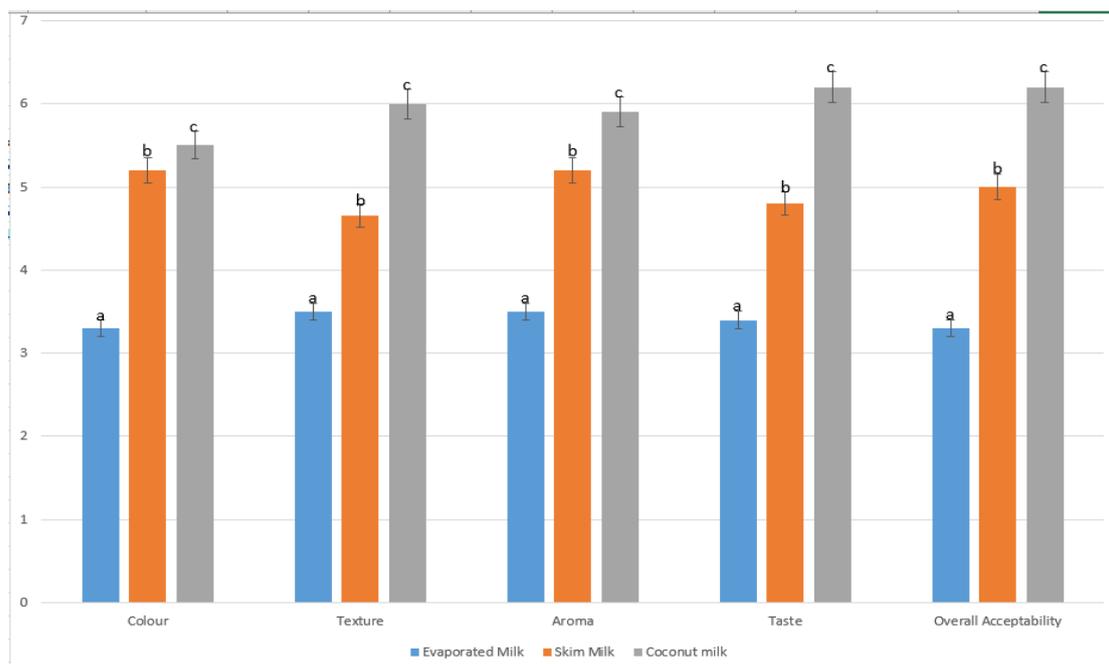


Figure 1. Sensory attributes of 'Nasi Dagang' Terengganu' as per panel preferences

3.2. Colour Coordinates

Table 2 displays the result of colour coordinates of Nasi Dagang Terengganu derived from three different recipes based on specific milk constituents. In ascending order towards most lightness in appearance, the shade of lightness (L^*) registered by the recipe with evaporated milk reflected a solid prominent whiteness, thus resulting in a reading of least lightness. In this aspect, the lightness of the coconut milk recipe moderated between the evaporated milk recipe and skim milk recipe. Variations between samples of the 3 recipes were significant ($p < 0.05$). A similar positioning of the coconut milk recipe could be observed pertaining to redness (a^*), whereby the results obtained indicated a shade-moderating influence between that of recipes with skim milk and recipes with evaporated milk. Recipes with skim milk showed a significant redness variation ($p < 0.05$) with respect to the coconut milk. As for the yellow hue (b^*) this unfavourable tinge was least detected in samples derived from recipes with coconut milk, samples with evaporated milk presence displayed a prominent yellow shade. Variations between all samples across the three different recipes were significant ($p < 0.05$). In relation to the colour

preference based on sensory evaluation, the objective measurement of colour seems to concur and agree with the perceptive preference of panellist, inclined to rate the recipe with coconut milk as superior against the rest, whereby the sample hue manifested moderate lightness, least redness and yellowness.

Table 2. Colour coordinates of 'Nasi Dagang Terengganu'

Formulation	L^*	a^*	b^*
Evaporated milk	60.8000 ± 0.93 ^a	-1.3733 ± 0.28 ^a	11.7400 ± 1.21 ^a
Skim milk	72.5467 ± 0.72 ^b	-3.0600 ± 0.19 ^a	7.8500 ± 0.12 ^b
Coconut milk	67.0267 ± 0.62 ^c	-1.5900 ± 0.12 ^b	5.3700 ± 0.07 ^c

3.3. Aerobic Plate Count of 'Nasi Dagang Terengganu'

The results displayed in Figures 2 and 3 referred to the aerobic plate count (APC) of the three types of Nasi Dagang Terengganu, subjected to two different storage conditions, which were at room temperatures ($\pm 35^\circ\text{C}$) and chilled temperatures ($\pm 4^\circ\text{C}$) respectively. The current Microbiological Standards for Malaysia Food Law and Food Regulation is invoked, providing guidance to the safety level

for APC for ready-to-eat food as 10^6 CFU/g. As the comparative benchmark, the values indicated from the Food Standards Australia/New Zealand concur and thus justify the former standard as measure of safety compliance (NSW Food Authority, 2009).

At room temperatures, APC results showed that the two days sample storage created conditions conducive for incremental growth of microorganisms, thus exceeding above the acceptable level of 10^6 . Meanwhile, at chill

temperatures, the APC results showed that rice formulated by evaporated milk exceeded its safety level after one week storage. However, for skim milk, it is notable that after four weeks, despite progressive growth of microorganisms, the results indicate that the samples remained resiliently safe for consumption. Interestingly, coconut milk showed no growth of microorganisms during the storage period under consideration.

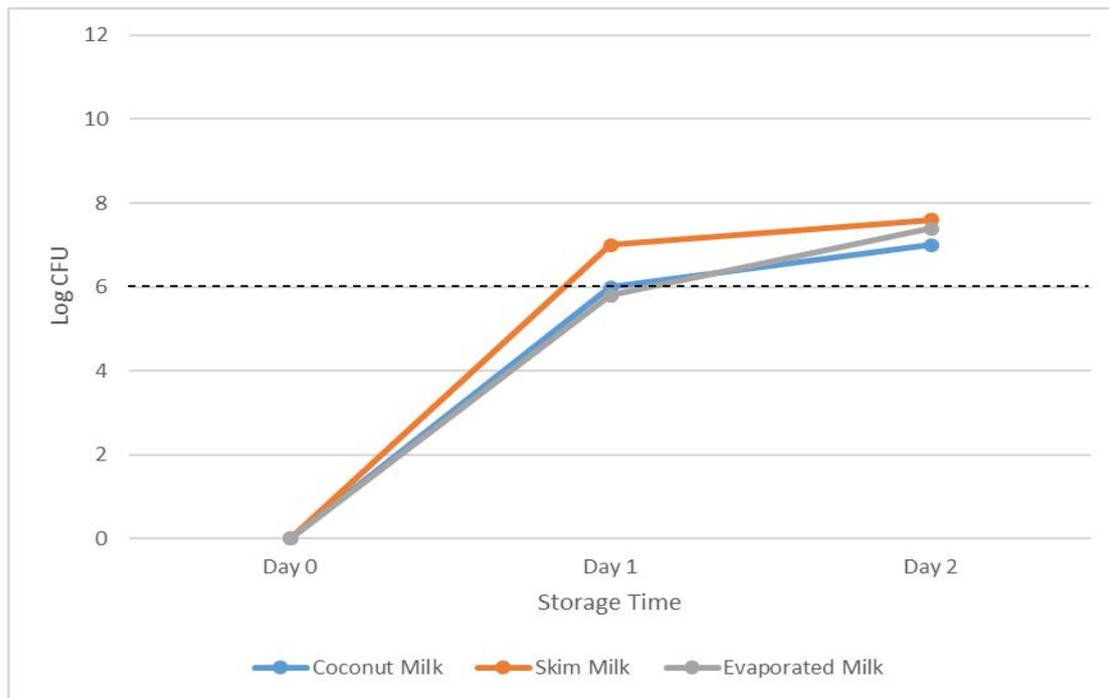


Figure 2. Aerobic Plate Count of Nasi Dagang Terengganu stored at room temperature

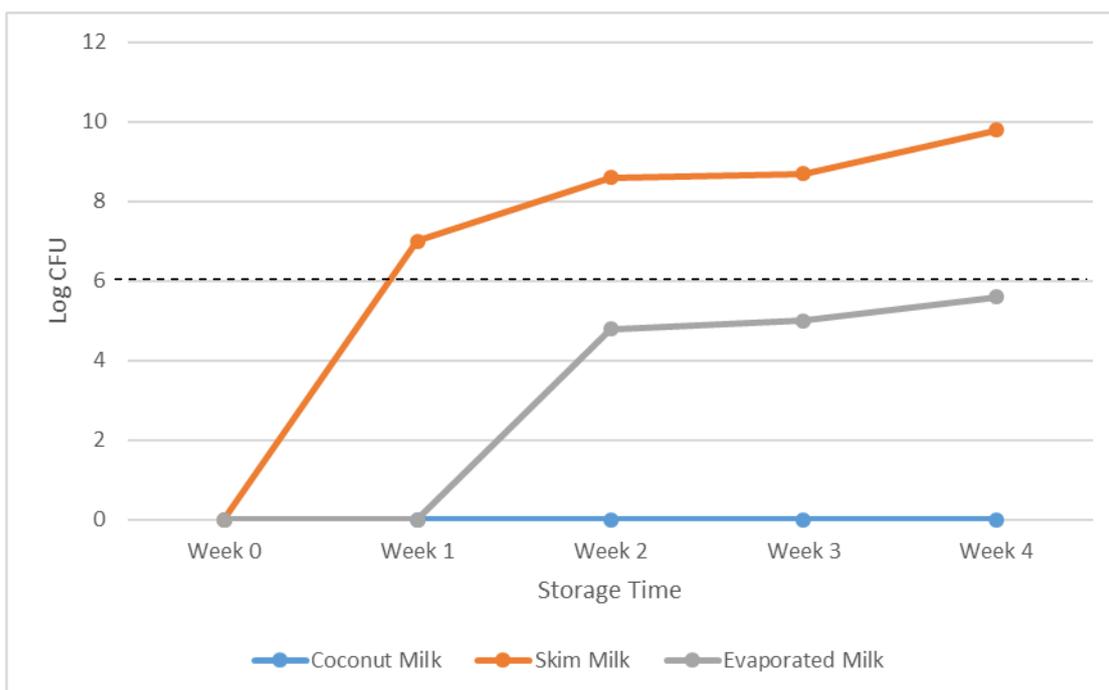


Figure 3. Aerobic Plate Count of Nasi Dagang Terengganu stored at chiller temperature

At room temperatures of approximately 35°C, rapid growth of microorganisms occurred due to the optimum conditions which prevailed (FDA, 2011). However, growth rate of the microorganisms can be altered by manipulating storage temperatures and conditions. Storage of food products below 8°C will impede the proliferation of most food-borne pathogens but not of spoilage organisms (Agency, 2009). Thus, by lowering the storage temperatures, a retardation of microorganism growth rate occurs, which invariably will facilitate shelf life extension of the food product.

Aerobic plate counts exceeding 10^6 CFU/g are usually associated with the prevalence of a predominant organism, as typified by cases of lactic acid bacteria in meat products, and it grows well under refrigerated conditions (FDA, 2011). Production of lactic acid will lead to the spoilage of targeted food products. Additionally, the presence of predominant Gram-negative bacteria will progressively cause food spoilage, which is indicative especially when detectable at 10^7 - 10^8 CFU/g, and the common indicator for the presence of these bacteria is the production of slime in the food product (Agency, 2009).

3.4. Yeast and Mould Count of 'Nasi Dagang Terengganu'

Figure 4 and 5 represented the yeast and mould counts of Nasi Dagang Terengganu stored at room and chill temperatures respectively. At room temperatures as observed in Figure 4, growth of yeast and mould were evident after a 2 days storage period for the rice recipe with coconut and skim milk, respectively. However, this phenomenon was not

detectable in the rice recipe with evaporated milk. This might be explained by the reduced water activity required by evaporated milk as the name implies in comparison to either skim milk or coconut milk during their heat treatment processes. However, within the specified test period, microorganism presence was within the tolerable safety level of 10^5 albeit with a taste profile undeniably deteriorating towards the food product being totally discarded due to spoilage (Lani *et al.*, 2015). Occurrence of spoilage is due to production of gas and acid by the presence of yeast and mould in the food (Agency, 2009).

Meanwhile, growth of yeast and mould were undetected for all the rice samples stored at chilled temperatures after four weeks. During chill storage, moisture in the food was progressively absorbed by the operating system towards attaining equilibrium with respect to the humidity of the chilled environment (Ali *et al.*, 2010). Additionally, during chilling, the water to ice transformation process reduced the available hydration, thus the receding water activity inhibited the rate of growth of microorganisms. Under such unfavourable conditions for growth as evident from Figure 5, the non detectable presence of yeast and mould in Nasi Dagang Terengganu implied that they were unable to thrive within chill temperatures. However, as the moisture properties of the samples were in effect dynamically changing, this might present certain repercussions to the taste profile of the food product if chilled under prolonged storage. Further in-depth investigations will be required in future to determine its impact on the eating quality of this food product.

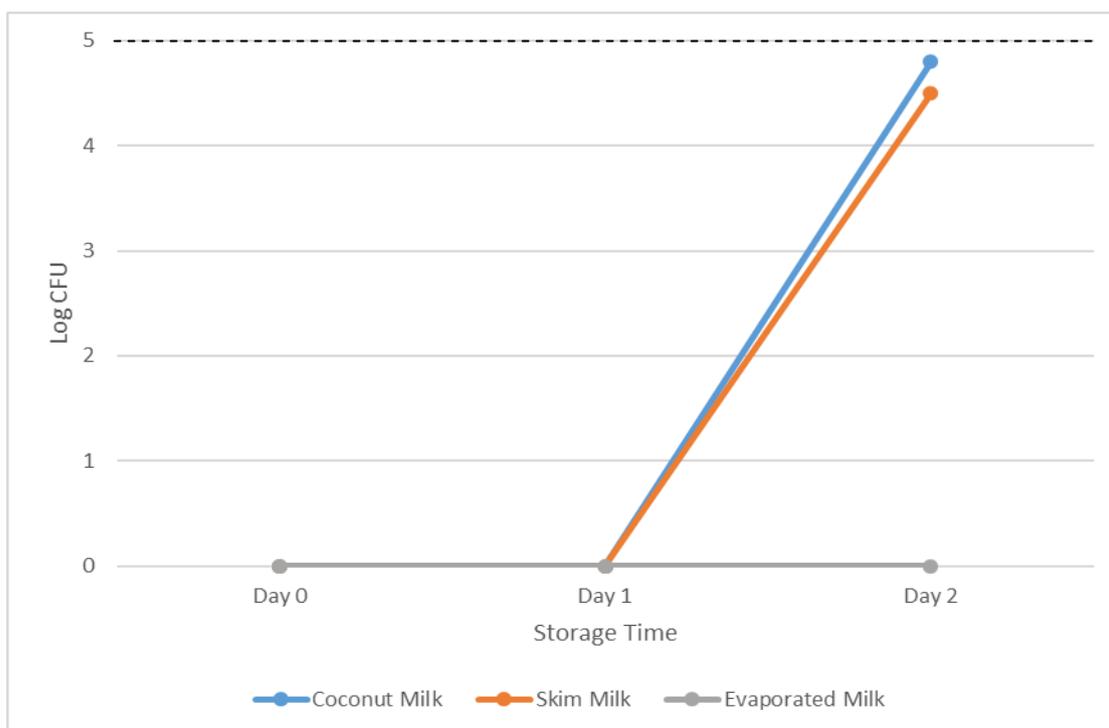


Figure 4. Yeast and mould count of Nasi Dagang Terengganu stored at room temperature

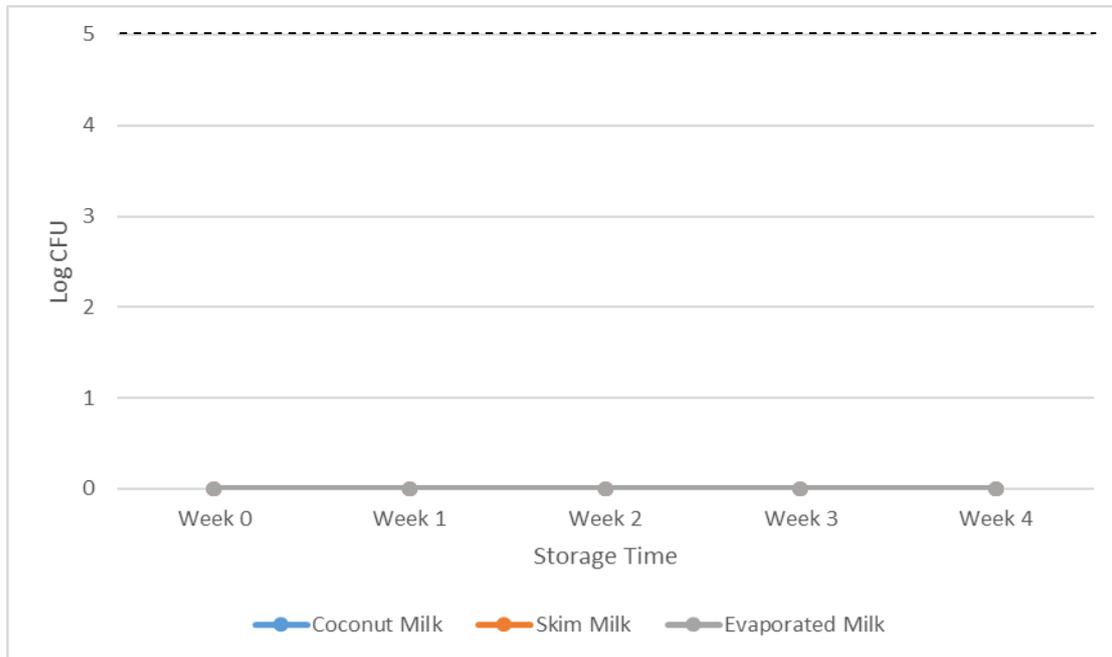


Figure 5. Yeast and mould count of Nasi Dagang Terengganu stored at chiller temperature

4. Conclusions

The objective within the study scope of modifying the 'Nasi Dagang Terengganu' recipe was to investigate the effect of substituting fresh coconut milk for UHT coconut milk, Evaporated milk and Skim Milk respectively. Incorporation of UHT coconut milk resulted in a recipe with the highest sensory preference scores for texture, aroma, taste, and overall acceptability, as compared to skim milk and evaporated milk. These scores were an explicit testament to UHT Coconut milk recipe being the most preferred choice by virtue of the panellist acceptance ranking, thus closely mimicking the original recipe with fresh coconut milk.

Stability test performed under the specified conditions produced results which were within expectations. Samples stored at room temperatures were naturally prone to propagate the microorganism count as derived from the Aerobic Plate Count (APC) test due to the facilitative conditions conducive for growth, to the extent that after 2 days of storage, the samples were no longer tenable for consumption. A peculiarity observed for UHT coconut milk recipe samples under chilled storage was the non-detectable microorganism colony from the APC test, despite undergoing 4 weeks storage. Possibly this could be attributed to the therapeutic and anti-microbial properties of coconuts as professed by other researchers.

Yeast and mould counts were suppressed for all respective samples under chilled conditions. However, with moisture dynamics in play to achieve equilibrium with the environment of the chill system, further in depth work is needed to justify the sensory profile which would render the food product to be considered as edible or near equivalent to the freshly prepared samples.

With cultivated acreage of coconuts progressively showing a declining trend, it is perceived that commercial availability of this crop will concomitantly experience an inflated demand. As such, food technologist creating food recipe formulations incorporating this ingredient should seek fresh coconut milk substitutes and determine the modifications required that would result in a sensory profile similar to the original recipe.

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