A COMPARATIVE STUDY OF THE EFFECTS OF PROCESSING CONDITIONS AND FORMULATIONS ON THE PHYSICAL AND SENSORY PROPERTIES OF FROZEN *NASI LEMAK* MADE OF PALM-BASED *SANTAN* AND COCONUT *SANTAN*

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ABSTRACT

The objective of the study was to determine the effect of processing conditions on physical characteristics of frozen nasi lemak. *Two types of* santan *that is, palm-based* santan *and coconut* santan *were used in this experiment. They were tested at three* santan *to rice ratios,* i.e. *1:5, 1.5:5 and 2:5 under different freezing rates and thawing processes. The results showed that* nasi lemak *made of palm-based* santan *have lower moisture content compared to that made of coconut* santan *and fast-freezing followed by immediate reheating, was able to retain a higher moisture content in both samples. The water activity of frozen* nasi lemak *samples ranged from 0.994 to 0.998 at 25.0 ± 0.7°C and was not significantly affected by processing conditions and type of* santan*. An increase in the amount of* santan *significantly increased the amount of lipid-amylose complexes formed in frozen* nasi lemak *which resulted in high Complexing Index (CI) values. It simultaneously reduced the hardness and increased the stickiness of the rice kernels for both types of* santan*. The freezing rate influenced the stickiness of rice. At 1:5* santan *to rice ratio,* nasi lemak *made of palm-based* santan *was comparable to that of coconut* santan *in its sensory attributes, except for its colour, odour and overall taste.*

Keywords: lipid-amylose complexes, thawing, frozen, *nasi lemak*, palm-based *santan*.

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INTRODUCTION

Santan is a Malay term for coconut milk and is derived from the flesh of coconut. Due to the increase in demand for *santan*, palm-based *santan* has been developed. Researchers at the Malaysian Palm Oil Board (MPOB) developed a palm-based *trans*-free liquid *santan* in 2008 and it was successfully commercialised in 2010. It has been proven that coconut *santan* contains higher fat and protein content compared to palm-based *santan* (Zaida *et al.*, 2008).

Foods that contain *santan* are always perceived as 'rich'. *Santan* gives a unique flavour and taste to the food. Among the popular local dishes that contain *santan* are *nasi lemak* and curry. *Nasi lemak* is one of the most popular Malaysian dishes for

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breakfast. Two of the main ingredients in *nasi lemak* are *santan* and rice. Recently, instant and frozen *nasi lemak* was introduced to the market as a ready-to-eat meal in order to cater to the busy life-style of the urban community, which requires for meals that can be served fast. Palm-based *santan* has been tested in many foods, including *nasi lemak*. However, the usage of palm-based *santan* in *nasi lemak* has not been scientifically reported in peer-reviewed journal.

In this study, the physical characteristics of frozen *nasi lemak* made of palm-based and coconut *santan* were examined. The objective of the study was to determine the effects of processing conditions on the physical characteristics of frozen *nasi lemak*. Four analyses involved were moisture content, water activity, complexing index and texture analysis.

Water content, or moisture content, is a measurement of the total water contained in a food. On the other hand, water activity is a measurement of the availability of water for biological reactions. It determines the ability of microorganisms to grow. If water activity decreases, microorganisms with the ability to grow will also decrease. Water activity can be reduced by freezing, *e.g.* water is removed in the form of ice. However, Benson *et al.* (1992) had detected increased amounts of malondialdehyde, a breakdown product of lipid peroxides, in frozen/thawed rice cells compared to unfrozen controls. They suggested that freezing injury can promote lipid peroxidation. Later, Yu *et al.* (2010a) found that high quality cooked rice can be produced by combined rapid freezing with frozen storage. They reported that rapid freezing combined with −18°C frozen storage can effectively retard starch retrogradation and maintain the textural properties of cooked rice for at least seven months. Another finding suggested that cooked rice chilled with slower cooling rate retrograded faster than chilled with rapid cooling rate (Yu *et al.*, 2010b).

The texture of a cooked rice is described by the hardness and stickiness values. The textural properties of a cooked rice is affected by the processing conditions and chemical characteristics of the raw kernel (Mestres *et al.*, 2011). These chemical characteristics may include amylose, protein and arabinoxylan contents. Xie *et al*. (2008) discovered the hardness and adhesiveness of cooked rice of non-waxy cultivars were due to protein hydration.

The cooking method applied in this study was based on the common rice cooking method of households in Malaysia which is boiling followed by slow heating. Another method is by stewing. Ghasemi *et al*. (2009) reported that stewing of rice grains by steam after boiling in excess water can be used for cooking rice perfectly. It reduced the hardness and increased the adhesiveness of rice grains significantly, which means that it produced better gelatinisation and more expansion of starch granules compared to non-stewed rice.

MATERIALS AND METHODS

Materials

White rice (Super Special Jasmine, Selangor, Malaysia) was purchased from a shop. Palm-based *santan* (Khalis, Premium Food Corporation Sdn Bhd, Selangor, Malaysia) and coconut *santan* (Ayam Brand, Selangor, Malaysia) were purchased from a nearby supermarket. Ginger, shallots, pandan leaves (screwpine) and salt were bought from a wet market. Filtered tap water was used for cooking.

Methods

***Preparation of frozen* nasi lemak.** Several formulations were tested as listed in *Table 1*. All ingredients were put into an automatic rice cooker (Model 18GXN, 1.8L, 220V, 50Hz, Panasonic, Shah Alam, Selangor, Malaysia) and cooked for about 26 min. Cooked samples of 100 g were transferred into labelled 350 ml square microwavable polypropylene plastic container. Every set has seven containers. These containers were labelled A, B, C, D, E, F and G (*Table 2*). These samples were then subjected to different processing conditions, as specified in *Table 2*.

***Storage of frozen* nasi lemak.** Samples C, F and G from all treatments were stored at -20°C, straight away after cooking. While, samples B, D and E were frozen using a blast freezer (at -40°C for 2 hr) before storage at -20°C. Samples were stored overnight before further analyses were carried out.

***Reheating of frozen* nasi lemak.** On the day of the analysis, samples D and F were directly reheated in the microwave without thawing. Whereas, samples E and G were thawed for 15 min (at room temperature) before they were reheated in the microwave for 5 min. Reheated samples were used for all analyses.

Moisture content. The moisture content was determined according to the AOAC International Method 926.08 (AOAC, 2007). The 3 g sample was put in a crucible before it was left in an oven (Memmert, Schwabach, Germany) overnight at 105°C. Then it was transferred into an electronic dessicator (Eureka, Taipei, Taiwan) for cooling down before weighing. Total moisture content was calculated using the formula:

$$\text{\% Moisture content} = \frac{b - (c - a)}{b} \times 100$$

where, *a* is weight of empty crucible (g);
b is weight of sample (g); and
c is weight of final sample with crucible (g)

TABLE 1. FORMULATIONS FOR ALL LEVELS OF TREATMENTS

Santan to rice ratio	1:5	1.5:5	2:5	1:5	1.5:5	2:5	No *santan*
Ingredients	• Rice (500 g) • Water (1000 ml) • Palm-based *santan* (100 ml) • Ginger (5 g) • Shallots (5 g) • Salt (2 g) • Pandan leaves (2 pcs)	• Rice (500 g) • Water (1000 ml) • Palm-based *santan* (150 ml) • Ginger (5 g) • Shallots (5 g) • Salt (2 g) • Pandan leaves (2 pcs)	• Rice (500 g) • Water (1000 ml) • Palm-based *santan* (200 ml) • Ginger (5 g) • Shallots (5 g) • Salt (2 g) • Pandan leaves (2 pcs)	• Rice (500 g) • Water (1000 ml) • Coconut *santan* (100 ml) • Ginger (5 g) • Shallots (5 g) • Salt (2 g) • Pandan leaves (2 pcs)	• Rice (500 g) • Water (1000 ml) • Coconut *santan* (150 ml) • Ginger (5 g) • Shallots (5 g) • Salt (2 g) • Pandan leaves (2 pcs)	• Rice (500 g) • Water (1000 ml) • Coconut *santan* (200 ml) • Ginger (5 g) • Shallots (5 g) • Salt (2 g) • Pandan leaves (2 pcs)	• Rice (500 g) • Water (1000 ml)

Complexing Index. Complexing Index (CI) was determined using method developed by Gilbert and Spragg (1964). Sample of 2 g was mashed into paste and mixed with 10 ml distilled water in the 12 ml test tube. The sample was then homogenised using a vortex mixer (Barnstead Thermolyne, Dubuque, USA) for 2 min and centrifuged (Model 80-2, Jiangsu, China) for 15 min at 3000 rpm. The supernatant (500 μl) was transferred into a cuvette and iodine solution was added before made up to 2 ml with distilled water. The iodine solution used for this analysis was freshly prepared by dissolving 2 g of potassium iodide (KI) (Systerm, Shah Alam, Malaysia) and 1.3 g iodine (I_2) (Systerm, Shah Alam, Malaysia) in 50 ml of distilled water. This solution was allowed to stand for about 2 hr before the final volume was made up to 100 ml with distilled water. The absorbance was measured using spectrophotometer (Aquamate, Minnesota, USA) at 690 nm. The absorbance represents the portion of starches that formed complexes with iodine. Pure potato starch (98%) was used as control. CI was calculated using the following equation.

$$\text{CI (\%)} = \frac{(\text{Absorbance of control} - \text{absorbance of sample})}{\text{Absorbance of control}} \times 100$$

Water activity. The sample was placed in a water activity (A_w) meter (AquaLab, Pullman, USA). This instrument has selectable internal temperature control which enables temperature-controlled water activity determination under a temperature-stable sampling environment, without the need of an external waterbath. The measurement was taken directly from the instrument.

Textural analysis. The texture of the frozen *nasi lemak* was determined using a Texture Analyser (TA. XT21, Texture Technologies, Corp, UK) with a 36 mm cylinder probe by using a 5 kg load cell. The analyser was linked to a computer that recorded the data by a software program called Texture Expert Excede version 1.0 (Stable Micro Systems Software, Surrey, UK). A compression force *vs.* time program was used to compress the samples till 90% of the original kernel thickness was achieved. A 36 mm cylinder probe was used to compress three kernels, with pre-test speed and test speed of 0.5 mm s^{-1}, and post-test speed 10.0 mm s^{-1}. The texture was expressed as hardness (peak force of the first compression) and stickiness (maximum negative force) of the samples. At least four readings were taken for every sample.

TABLE 2. LABELLING OF *NASI LEMAK* SAMPLES FOR DIFFERENT PROCESSING CONDITIONS

Sample A= freshly prepared *nasi lemak*.
Sample B= freshly prepared *nasi lemak* – fast freezing (-40°C).
Sample C= freshly prepared *nasi lemak* – slow freezing (-20°C).
Sample D= freshly prepared *nasi lemak* – fast freezing – immediately reheated (5 min).
Sample E= freshly prepared *nasi lemak* – fast freezing – thawed (15 min) prior to reheat (5 min).
Sample F= freshly prepared *nasi lemak* – slow freezing – immediately reheated (5 min).
Sample G= freshly prepared *nasi lemak* – slow freezing – thawed (15 min) prior to reheat (5 min).

Sensory evaluation. Sensory evaluation was conducted by 32 untrained panellists. Panellists were randomly selected from the Malaysian Palm Oil Board (MPOB) staff and students, without any specific priority in selection. They were asked to evaluate two samples; 1) *nasi lemak* made from palm-based *santan*; and 2) *nasi lemak* made from coconut *santan*. Evaluation was based on six attributes that included colour, odour, hardness, stickiness, oiliness and overall taste using a nine-point scale. Scale 1 indicates the least acceptable sample while 9 indicated the most acceptable sample. Samples of frozen *nasi lemak* made of palm-based *santan* and coconut *santan* were immediately reheated in a microwave before they were served to the panellists. *Nasi lemak* was served warm with hot savoury. Only *nasi lemak* with 1:5 *santan* to rice ratio was used in the sensory evaluation.

Statistical analysis. Data were evaluated using the analysis of variance (ANOVA) and General Linear Model (Minitab Version 14). Significance was established at a level of $p < 0.05$.

RESULTS AND DISCUSSION

Moisture Content

Moisture content is an important criteria that has a significant effect on the freshness and quality of the food. Rice is considered as fully cooked when the final moisture content is in the range of 58% to 64% (Zheng and Lan, 2007). *Figure 1* shows the significant difference in moisture content of samples between different processing conditions. Samples B and C were not analysed. In sample A, where *nasi lemak* was freshly prepared and did not undergo any freezing treatment, the lowest value of moisture content was recorded, regardless of type or any *santan* to rice ratio, due to moisture loss to the surrounding atmosphere during the process of cooling down.

Sample D, regardless of type or any *santan* to rice ratio, has the highest moisture content. Obviously, fast freezing and immediate reheating have significant effects on the moisture content of the frozen *nasi lemak*. Fast freezing formed very small ice crystals in food structure, which provide less damage to the cellular structure when the frozen product is thawed (Ernest, 1999). Thus, water remains within the kernel after reheating.

Theoretically, slow freezing will result in significant lower moisture content than initial value due to the structural damage of the rice which promotes drip when the product is thawed (Redmond *et al*., 2005). However, in this experiment, samples that went through slow freezing before they were thawed and reheated (sample G) had a higher content of moisture compared to sample that undergone fast freezing (sample E). Most probably the drip loss during thawing was re-absorbed into the kernel during reheating since the packaging was kept intact during thawing.

The moisture content of samples E and F were about the same. Fast freezing followed by thawing and reheating seems not to have much effect compared to slow freezing followed by immediate reheating in these frozen *nasi lemak* samples.

It was generally observed that the moisture content of *nasi lemak* increased as the ratio of *santan* to rice was increased from 1:5 to 1.5:5. An addition of *santan* reduces relative water content because the components in *santan* which are mainly oil would lower the water activity of the cooked rice (El-Bassiouny and Bekheta, 2005). However, at 2:5 *santan* to rice ratio, the moisture content dropped slightly. This applies to both types of *santan* as shown in *Figure 1.*

Overall, *nasi lemak* made of palm-based *santan* has lower moisture content compared to that made of coconut *santan*, due to the fact that moisture content of palm-based *santan* is lower than coconut *santan*. The moisture content for palm-based *santan* is 63.1%, while that for coconut *santan* is 65.3% (Zaida *et al*., 2008).

When the data were analysed using the General Linear Model (GLM), it was observed that the value of R^2 of each single factor was just 51.4% and this gave an indication that the single factors (type of *santan*, *santan* to rice ratio, freezing rate and reheating condition) did not significantly affect the moisture content of frozen *nasi lemak*. But, the R^2 of the interactions of these factors was very high (99.84%). The interactions of these factors significantly influenced the moisture content of samples. The interactions between freezing rate and thawing condition have the highest value of Sequential Sum of Squares (Seq SS) which meant that this interaction highly influenced the moisture content of frozen *nasi lemak*.

Water Activity

It was observed that the range of A_w of *nasi lemak* samples was from 0.994 to 0.998 at 25.0 ± 0.7°C. Water activity is in the range of 0 to 1. The values near to 1 indicated that *nasi lemak* is classified under the perishable food category. Theoretically, the range of A_w that for perishable food is 1.00 to 0.95. Perishable food needs to be handled with extra care since it can easily be spoilt by microbial contamination due to high water availability. A_w is a very useful parameter to determine the possibility for microbial growth (Subramaniam, 2000). As the A_w gets higher, shelf-

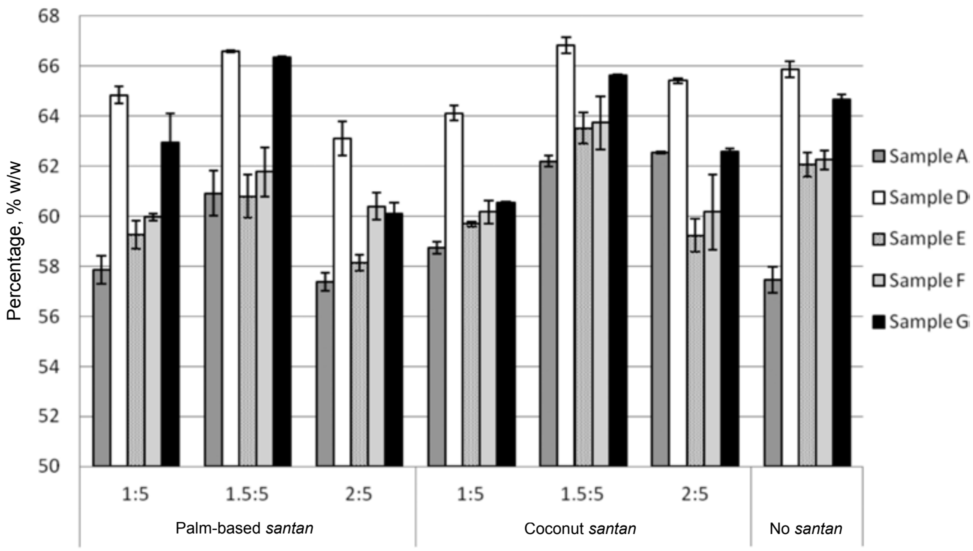

Figure 1. Means ± standard deviation of moisture content of nasi lemak *made of palm-based and coconut* santan *under different processing conditions.*

life would become shorter. Perishable food should be kept hot (>70°C) or cold (<5°C) to ensure it is safe for consumption. Results showed that there were no significant differences in water activity of all samples. Thus, *santan* to rice ratio and the rates of freezing and reheating method do not significantly influence the A_w of frozen *nasi lemak*.

On the other hand, there was a slight difference in A_w of rice cooked without an addition of *santan*, where the A_w was lower compared to other samples. The addition of *santan* increased the A_w of the rice kernel.

Complexing Index

Figure 2 shows the means and standard deviations for CI of samples. CI gives the indication of how much starches (*i.e.* amylose) have formed complexes with lipid in *nasi lemak* samples. In this context, amylose was from rice, while lipid was from *santan* that was added in during the preparation of *nasi lemak*. Amylose helices occupied by lipid reduced its capacity to attach to iodine, and will have a lower absorbance than starch alone when mixed with iodine. Thus, the CI will increase as

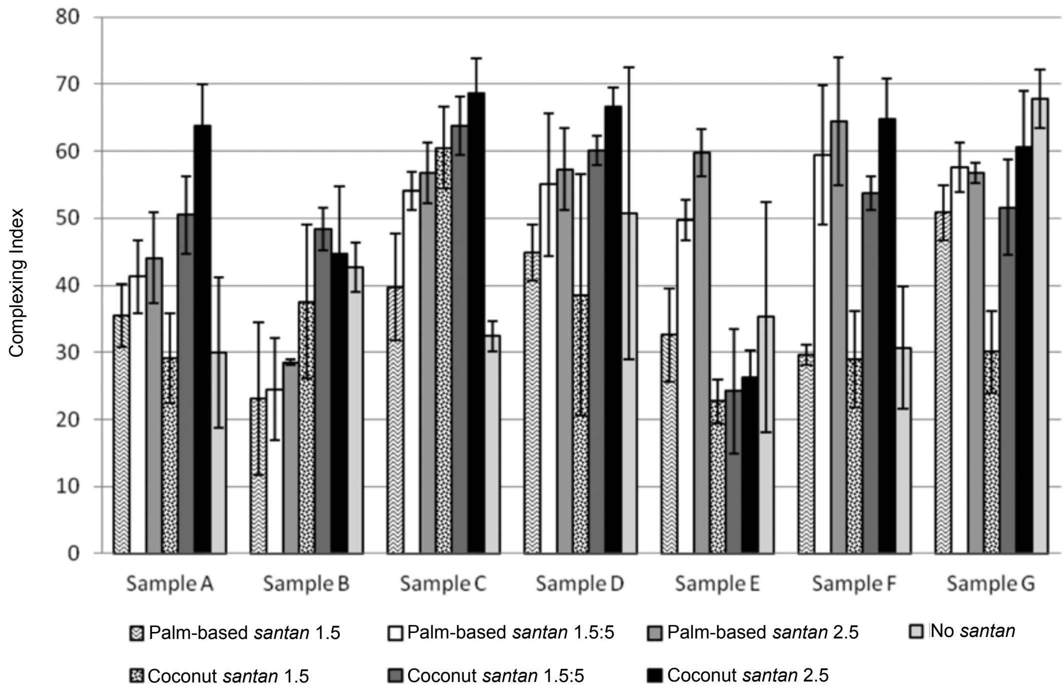

Figure 2. Means ± standard deviation of complexing index of nasi lemak *made of palm-based and coconut* santan *under different processing conditions.*

the iodine binding capacity decreases (Tang and Copeland, 2007). The control starch used in this analysis is the amylose from potato starch (>98%) and its absorbance was determined to be 0.982.

From the results shown in *Figure 2*, the effect of different processing conditions (freezing rate and thawing condition) on CI was negligible. However, there was a clear pattern when the amount of *santan* was increased. The CI progressively increased when the amount of *santan* added was increased. This applies to both palm-based and coconut *santan*. This means that when more *santan* was added, more amylose-lipid complexes were formed leaving only small amount of free amylose helices that could bind with iodine. Thus, the amount of *santan* added influenced the CI value.

A higher CI value indicates that there are more lipid-amylose complexes formed and fewer amylose formed complexes with iodine. Theoretically, rice without the addition of *santan* should have the lowest CI values in all treatments. However, the CI values of sample cooked without *santan* remained relatively low in all treatments except for B, D, E and G. Rate of freezing affects the CI as well. Fast freezing has resulted in lower CI compared to slow freezing, as indicated by samples B, D and E. The effect of rate of freezing on CI is very significant. Immediate reheating resulted in higher CI value compared to thawing prior to reheating as indicated by sample G.

When the data were analysed using the GLM, it was observed that the single factors (type of *santan*, *santan* to rice ratio, freezing rate and reheating condition) did not have a high impact on the CI of *nasi lemak*. The value for R^2 was just 53.88%. However, the interactions between these factors having R^2 of 99.66% really influenced the CI values. The interaction between type of *santan*, freezing rate and thawing condition had given the highest impact on CI of frozen *nasi lemak*.

Hardness

The rice kernels were analysed for its hardness at an ambient temperature and the results are shown in *Figure 3*. Hardness is related to the hydration process which takes place in starch granules. During cooking, rice granules absorb moisture and swell which provide the increase in volume of cooked rice. While the granule expands, cells will rupture and cause amylose leaching. This may affect the rice texture.

Cameron and Wang (2005) reported that the cooked rice texture has strong correlation with the amount of insoluble amylose than did the apparent amylose or leached amylose. They concluded that the higher the amount of leached amylose, the harder the final cooked rice texture. This could explain why rice cooked without *santan* (sample G) that has undergone slow freezing has higher hardness values compared to that of fast freezing. Slow freezing caused more rupture to cells and more leaching components is released. But this situation could only be noticed easily in rice cooked without *santan*. When *santan* was added during cooking and cooked samples were freezed and reheated at different conditions, this theory could not be applied. The effect of different freezing rates and thawing conditions were not very clear in frozen *nasi lemak* regardless of the type of *santan* used.

Hardness is generally related to the level of the amylose content. Generally, high amylose rice has high hardness and tensile values (Lu *et al*., 2009). In this experiment, the same type of rice is used in all samples. Therefore, the difference in hardness values is not due to the difference in amylose content. The addition of *santan* may contributed to the changes in hardness. According to Kaur and Singh (2000), the addition of fatty acids into food that contains starch will alter the physical and chemical properties of food since starchy food will tend to form complexes between amylose and lipids. These complexes affect the hardness value. Cameron and Wang (2005) reported that protein and crude lipid contents have a negative correlation with hardness of cooked rice. Generally, results in *Figure 3* indicate that as the amount of *santan* increased, the hardness of rice gradually decreased.

It is observed that type and amount of *santan* added affected the hardness of *nasi lemak*. However, the effect of using different types of *santan* only had a smaller impact on the hardness of the samples.

Data analysis using the GLM showed that type of *santan*, amount of *santan*, the interaction between the rate of freezing and thawing condition, and the interaction between type, amount and rate of freezing have a significant effect on the hardness of frozen *nasi lemak*.

Stickiness

Stickiness is another important criteria when it comes to cooked rice. Amylose content is not directly related to the stickiness but when the amylose content was high, the stickiness will be low (Ayabe *et al*., 2009). *Figure 4* shows the mean and standard deviation of stickiness of samples. Negative (-ve) sign indicates the stickiness, as measured by the Texture Analyser (TA.XT21, Texture Technologies, Corp, UK). Rice without *santan* has the lowest stickiness value followed by frozen *nasi lemak* made of palm-based *santan* and frozen *nasi lemak* made of coconut *santan*. The stickiness of rice was increased as more *santan* was added. The amount of *santan*

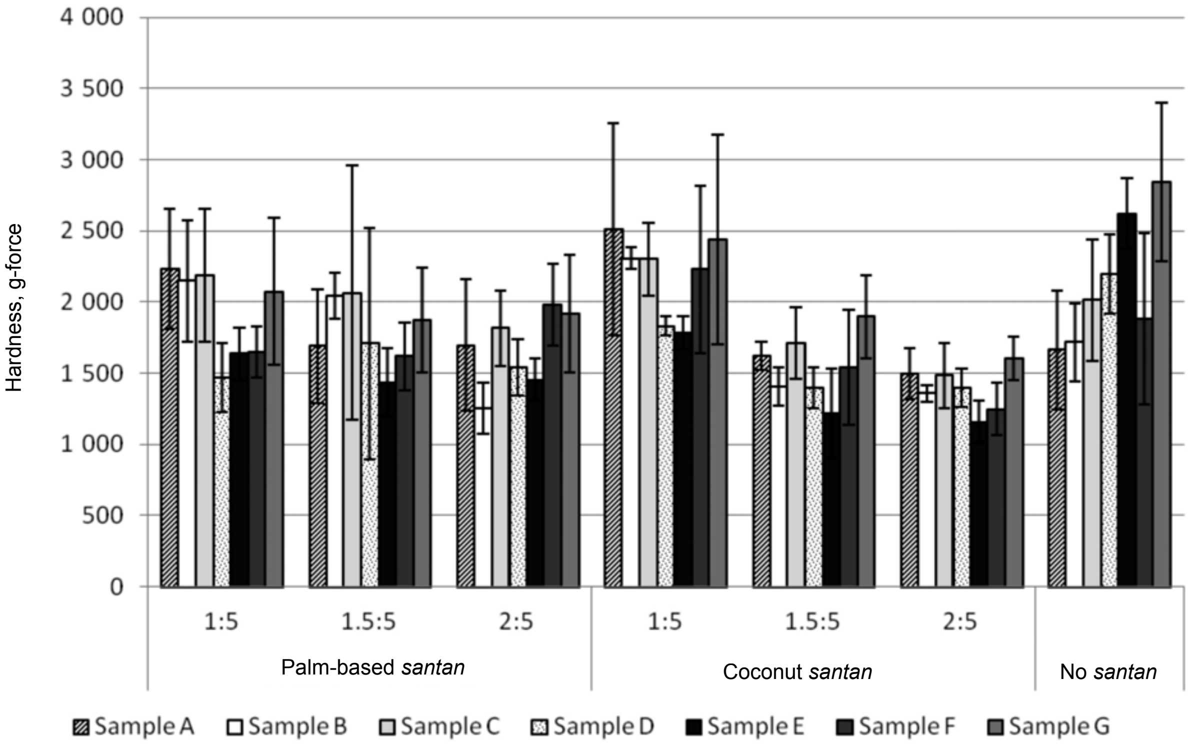

Figure 3. Means ± standard deviation of hardness of nasi lemak *made of palm-based and coconut* santan *under different processing conditions.*

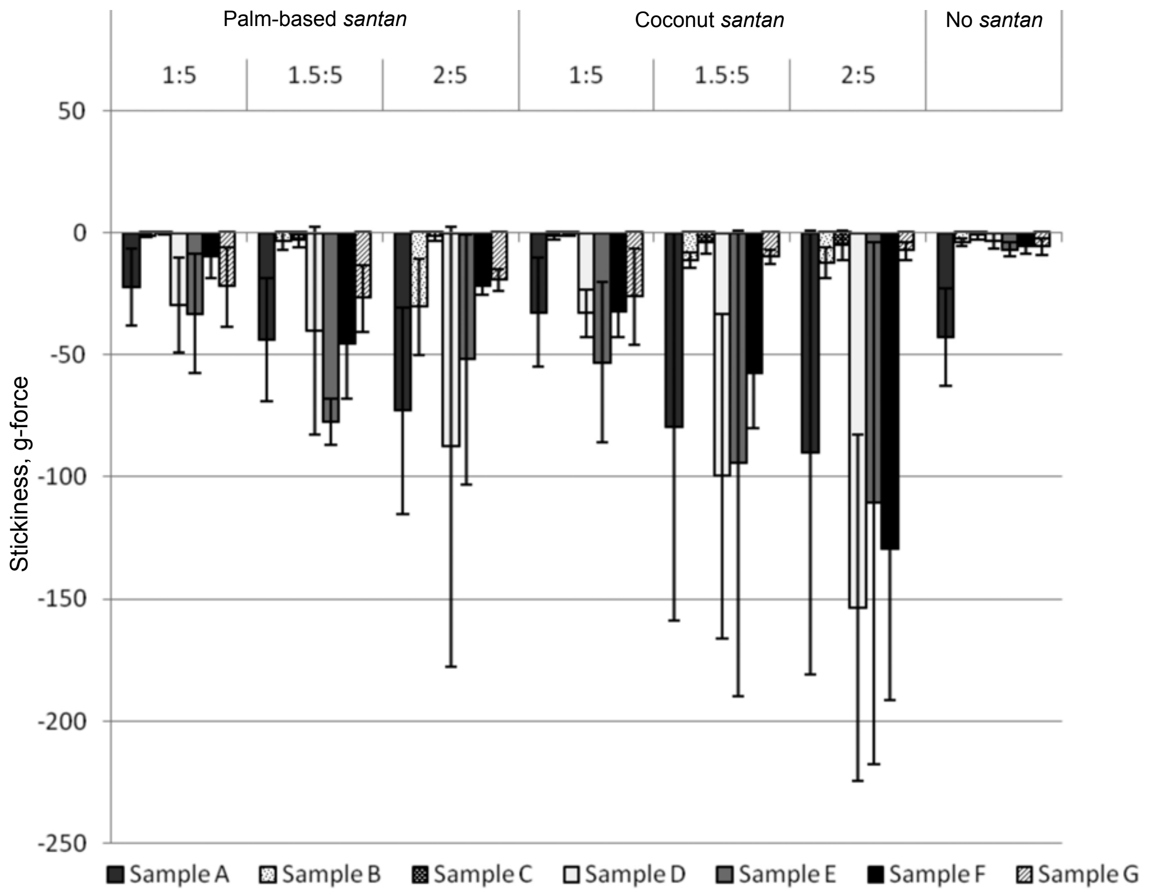

Figure 4. Means ± standard deviation of nasi lemak *made of palm-based and coconut* santan *under different processing conditions.*

significantly influenced the stickiness. This applied to both types of *santan*.

The rate of freezing also has significant effect on the stickiness of samples. Slow freezing resulted in samples which were less sticky compared to fast freezing and unfrozen rice. Immediate reheating resulted in stickier samples compared to thawing prior to reheating.

The stickiness of the rice was not greatly affected by the processing conditions as shown in *Figure 4*. The trend was not very clear. According to Syamsir *et al.* (2011), the deformation of the grain and exposed endosperm after the grain splitting sharply changed stickiness values. The addition of *santan* during cooking and the processing conditions (freezing and thawing) caused some deformations to the rice kernels that vary its stickiness values. However, frozen samples (B and C) had low stickiness values in all formulations. The stickiness value was the highest in samples formulated with 2:5 *santan* to rice ratio that had undergone fast freezing followed by immediate reheating.

The R^2 value for the single factor analysis was 64.53%, whereas, in the interactions analysis the R^2 value was higher (98.87%). This indicates that interactions between factors (type of *santan*, *santan* to rice ratio, freezing rate and reheating condition) has a significant effect on the stickiness of *nasi lemak*. The type and amount of *santan* have the highest value of sequential Seq SS, thus indicating that these two factors have very significant impact in the stickiness of *nasi lemak*.

Sensory Evaluation

Nasi lemak is a common food among Malaysians especially for breakfast. Therefore, the use of untrained panellists in this sensory study was sufficient to meet the purpose. Only *nasi lemak* with 1:5 *santan* to rice ratio was used in the sensory evaluation because results from the previous physical analyses of this experiment showed that 1:5 *santan* to rice ratio is sufficient to cook a *nasi lemak*, and it applies to both types of *santan*.

Results from the sensory evaluation shows that frozen *nasi lemak* made of coconut *santan* had higher scores compared to frozen *nasi lemak* made of palm-based *santan* for all attributes except for oiliness, hardness and stickiness, where they are not significantly different, as shown in *Table 3*. Significant differences were observed for colour, odour and overall taste between the samples. Only eight out of 32 panellists prefered the frozen *nasi lemak* made of palm-based *santan*. The majority of the panellists prefered frozen *nasi lemak* made of coconut *santan*.

Figure 5 further illustrates the values showed in *Table 4*. From the results, it can be concluded that some efforts could be made to improve the colour, odour and overall taste of *nasi lemak* made of palm-based *santan*. The performance of palm-based *santan* should be improved so that it is comparable or better than coconut *santan* in frozen *nasi lemak*. By

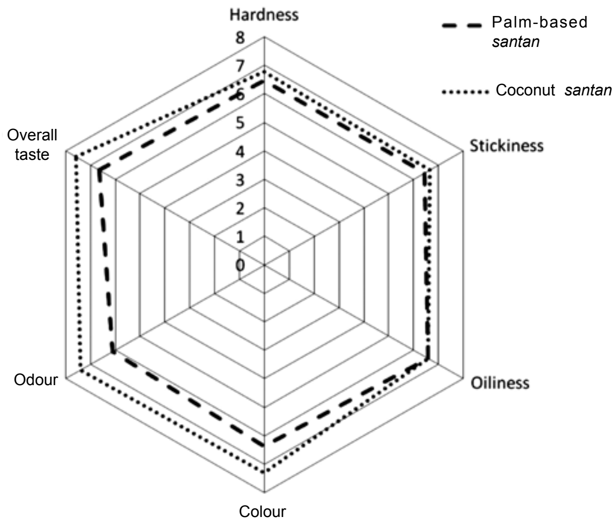

Figure 5. Mean values of hardness, stickiness, oiliness, colour, odour and overall taste of frozen nasi lemak *made of palm-based and coconut* santan.

TABLE 3. MEAN ± STANDARD DEVIATION OF SENSORY ATTRIBUTES OF *NASI LEMAK* MADE OF PALM-BASED AND COCONUT *SANTAN*

	Hardness	Stickiness	Oiliness	Colour	Odour	Overall taste	Preference
Coconut *santan*	6.7813 ± 1.3616[a]	6.6563 ± 1.3102[b]	6.5625 ± 1.2165[c]	7.2813 ± 0.9583[d]	7.4063 ± 1.1876[f]	7.5937 ± 0.9108[h]	24
Palm-based *santan*	6.4688 ± 1.7410[a]	6.4375 ± 1.2936[b]	6.5625 ± 1.1622[c]	6.3438 ± 1.4505[e]	6.0938 ± 1.6136[g]	6.6563 ± 1.4505[i]	8

Note: Mean values in the same column with different letters are differ significantly (p<0.05).

doing this, consumer demand and preferences for palm-based *santan* can be increased.

CONCLUSION

The ratio of palm-based *santan* to rice of 1:5 is sufficient in providing the texture to a frozen *nasi lemak*. However, *nasi lemak* made of palm-based *santan* has a lower moisture content compared to one made of coconut *santan*. The rate of the freezing and thawing process influences the moisture content and texture properties of frozen *nasi lemak*. Fast freezing followed by immediate reheating without thawing resulted in less sticky, firm texture. The water activity of frozen *nasi lemak* was very high (0.994 to 0.998 at 25.0 ± 0.7°C) and was not significantly affected by processing conditions and type of *santan*. The formation of lipid-amylose complexes was enhanced by increasing the amount of *santan* and this applies to both types of *santan*. Increasing of *santan* to rice ratio led to the reduction of hardness but an increase in the stickiness of the rice kernels, regardless of the type of *santan*. *Nasi lemak* made of palm-based *santan* was comparable to that of coconut *santan* in its sensory attributes except for colour, odour and overall taste when tested at 1:5 *santan* to rice ratio.

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