FOOD

RESEARCH

Development of Kaya Slice (coconut jam slice): evaluation of physicochemical, sensory evaluation and macronutrients composition when cooperated with gelatin

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Abstract

Kaya Slice is a nutritious traditional breakfast-on-the-go that was innovated from the traditional kaya. In this study, the traditional kaya was transformed into square shape gelatin to make it a more convenient and ready-to-eat breakfast. A total of six formulations were developed by using commercial and fresh coconut milk together with different percentages of gelatin (2%, 4%, and 6%). This insight was investigated by sensory evaluation using a 9-point hedonic and scoring test in descriptive data set. The best formulation obtained from the evaluation of 35 panellists was then characterized in terms of physicochemical properties (Texture Profile Analysis (firmness), Brix, Protein, Fat, Fiber, and Calories). From the descriptive data, all formulations were accepted by the panellist. Nevertheless, ANOVA analysis indicated that C2 (commercial coconut milk + 4% of gelatin) is the best formulation. In macronutrient analysis, Kaya Slice was found to have good dietary fibre content (0.11 g/100 g), high-fat content (0.49 g/100 g), protein content (0.32 g/100 g) compare to the commercial kaya (0.00 g/100 g), (1.00 g/100 g), and (0.00 g/100 g) respectively. Low-calorie content in Kaya Slice with 45 % of °Brix value is the minimal degree of Brix and the texture was softer (hardness) (significantly different ($p<0.05$)) to commercially processed cheese slice as standard. Overall, Kaya Slice has a great potential in becoming new emergent of traditional nutritious breakfast on the go.

1. Introduction

Traditionally known as kaya a sweet coconut custard is made from three basic ingredients, eggs, sugar, and coconut milk (Phang and Chan, 2009) that are commonly eaten with steamed or toasted bread. It is spreadable and prepared with laborious and continuous stir until it forms a custard-like texture. Kaya covers the important macronutrients such as carbohydrates, protein, and fat that aligned with World Health Organization (WHO) recommendation. According to Foscolou *et al.* (2019), carbohydrate and protein have been shown to play an important role in health and diseases. According to Harianis and Sari (2018), the intake of kaya (protein and fat-rich) in the nutrition improvement intervention programme had successfully increased the weight of a group of malnourished people. In this study, the nutritious traditional Southeast Asia breakfast 'Kaya' is converted into a new breakfast-on-the-go named Kaya Slice. The development of Kaya Slice as breakfast-on-the-go involved the addition of a different percentage of gelatins. Gelatin functions as a crystallization inhibitor of lactose sugar during cold storage and at the same time, its gelling ability (Al-Teinaz, 2020) provides chewy attributes and forms stabilization. The stabilization character holds the Kaya body to form the intended shape. At the same time, the addition of gelatin in food is recommended for diabetic patients to enhance protein intake and reduce carbohydrate intake. In Kaya Slice formulations, brown sugar was used as a white sugar replacement. Brown sugar has a great nutritive value and high micronutrients contents which influence people to choose them instead of white sugar (Jaffe, 2012; Ducat *et al.*, 2015). It helps in build-up immunity, reduces diabetic risk, and hypertension (Jaffe, 2015). Fat in Kaya Slice was mainly from coconut milk. Coconut milk is an

emulsion obtained from the soaking, squeezing, and extraction of coconut flesh (Chiewchan *et al.*, 2006) which is known as 'Santan'. Zhu *et al.* (2014) revealed that coconut milk was healthier as it consists of medium-chain triglycerides (saturated fat) which support the function of the digestive organ. Protein, fat, and moisture were the main constituents of Kaya Slice. It consists of 80 per cent of the mass of the product and influences the textural and functional properties of kaya. Accordingly, this has led to the main objective in determining the best formulation for 'Kaya Slice' via sensory evaluation (hedonic). The best formulation was then evaluated in terms of texture profile (firmness) in comparison with cheese slice. Macronutrient content was determined and compared with commercial kaya.

2. Materials and methods

2.1 Raw materials

Fresh coconut (*Cocus nucifera*) milk and UHT coconut milk were obtained from Tunas Manja Mart Kuantan, Malaysia. Other ingredients included; CP brand Size B hygienic eggs, PRAI soft brown sugar, pandan leave (*Pandanus amaryllifoliuss*), HALAGEL gelatin, and potassium sorbate were received from suppliers SSMJ Enterprise.

2.2 Kaya Slice formulations

Kaya Slice formulation was adapted from traditional kaya formulation and modified with the addition of gelatin, replacing white sugar with brown sugar and reducing the amount used. A total of six formulations with different percentage of gelatin (2.0%, 4.0%, and 6.0%), brown sugar (10.0%, 12.0% and 14.0%) and types of coconut milk were presented as variables were shown in Table 3. The first three formulations were prepared by using fresh coconut milk. Represented as F1, F2, and F3 while another three formulations were represented as C1, C2, and C3 that were prepared using commercial coconut milk.

2.3 Kaya Slice preparations

Kaya Slice was developed by blending the main ingredients that are pandan leaves, fresh coconut milk, and brown sugar until a fine texture was obtained. The mixture was sieved with 120×120 cm cotton blended muslin cloth (32 yarn counts) and using a double-boiler cook with the starting temperature of 60°C. The water was filled up in the pot at least a quarter of the level of the kaya mixture inside the container. The mixture of Kaya Slice was stirred continuously to avoid egg protein coagulation below 90°C temperature. The mixture was stirred and monitored via a refractometer until it reached 55° Brix, before adding the gelatin and potassium

sorbate. As the gelatin and potassium sorbate were dissolved and the temperature reached 70°C, the mixture was filled in the Kaya Slice (7×7 cm), as in Figure 1, it was moulded and placed in a chiller at 4°C for 1 hr to allow the Kaya Slice to take shape. These processes were repeated for commercial coconut milk with different percentages of gelatin and brown sugar. The chilled Kaya Slice was removed from the 7×7 cm mould and wrapped in 10×10 cm Polypropylene plastics (0.04 mm) before being placed in the Kaya Slice box.
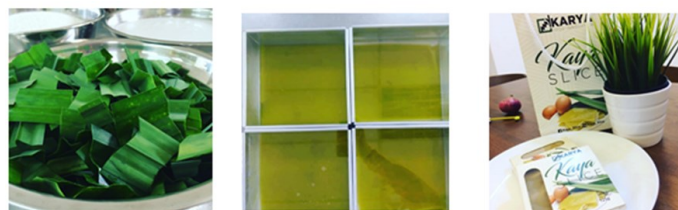

Figure 1. Kaya Slice development

2.4 Quality characteristics of kaya slice

2.4.1 Sensory evaluation

Sensory evaluations are vital in evaluating new products developed which provide a quality measure, product improvement, storage stability, optimization, and acceptance (Stone *et al.*, 2020). In this study, 35 trained panellists were selected to determine the best formulations of Kaya Slice based on a 9-point hedonic scale from 1 = Like extremely to 9 = Dislike extremely. Kaya Slice was prepared in a bite-sized; 1.0×1.0 cm. Samples were placed into the white and clean plate at room temperature during evaluation. Plain water was prepared in a 1.5 oz sampling paper cup to the panellists for rinsing purposes.

2.4.2 Texture profile analysis

In Texture profile analysis (TPA), the kaya slice was analysed by using Brookfield CT3 Analyzer USA. The method is referred to Szczesniak (1996) with modification. The sample was placed on the fixture base table of the texture analyser. 12.7 mm cylindrical plane surface TA7 probe was used to test the hardness by positioning the probe 10 mm above the test sample. The test commences once 1 kg of load cell was attached to the texture analyser. The probe approaches the test sample at a pre-test speed of 1 mm/s. Once the probe makes contact and detects a trigger force of 50 gm force, the data of textural parameters were generated.

2.4.3 Total soluble solid

All samples were measured in triplicates by using Atago Pocket Refractometer, Japan during the cooking process (Periche *et al.*, 2015). The refractometer plate was rinsed using distilled water and calibrated to zero reading. A few drops of kaya slurry were placed on the plate and the °Brix value was recorded.

2.5 Macronutrients

Protein, fat, and fibre were analysed by implementing the standard of the Association of Official Analytical Chemist (AOAC) method of analytical analysis. Total protein and fat contents in Kaya Slice were measured by the Kjeldahl method (AOAC, 2000) and the Gerber method (Rahimi *et al*., 2007) respectively. Fibre analysis was determined using Prosky 985.29 methods (AOAC, 2000). All macronutrients determination was carried out in triplicate. Total carbohydrate was determined based on FAO and the World Health Organization (Nantel, 1998). Total calories were calculated based on the following formula:

$$Total\ Energy = (\%\ protein \times 4) + (\%\ fat \times 9) + (\%\ Carbohydrate \times 4)$$

3. Results and discussion

3.1 Sensory evaluation for kaya slice

3.1.1 Hedonic test of Kaya Slice

In descriptive Table 1, six (6) formulations (F1, F2, F3, C1, C2, and C3) were analysed using SPSS Version 17.0. Based on the result in Table 2, for colour attributes, panellist preference was on the scale 2 = "like very much" and scale 3 = "like moderately". Colour plays important role in consumer acceptance. In Formulation F1 and C1, the percentage of brown sugar was the highest; 14% which contributed to the dark green colour. During the cooking process, the light green colour of F1 and C1 were transformed into dark green due to the replacement of refined sugar with brown sugar. The effect of dark colour does not involve the caramelization or Maillard reaction since the cooking process involved low temperature cooking at 70°C. Maillard reaction occurred at the medium temperature between 90°C to 130°C (Kchaou *et al*., 2019). Colours attribute for formulation F2, F3, C2, and C3 are more preferable by panellists compared to formulation F1 and F2 due to less percentage amount of brown sugar that leads to light green. F1 and C1; F2 and C2; F3 and C3 resulted in no significant difference (p<0.05). Therefore, different types of coconut milk do not affect the colour of Kaya Slice. However, different percentages of brown sugar give a significant difference (p<0.05) towards F1, F2, and F3 and C1, C2, and C3.

Food texture significantly contributes to consumer preference (Foegeding *et al*., 2011) and one of the aspects of consumer quality assurance (Melton *et al*., 2019). It is part of the human sense when they taste the food in their mouth. The translucent appearance was due to gelatin ability as clarifying agent (Sunday, 2018). In Kaya Slice formulations, F1 and C1 were evaluated on scale 4 = "like slightly" compared to F2 and C2 is on the scale 2 = "like very much" and F3 and C3 on the scale 3 = "like moderately". Different percentages of gelatin give significant difference (p<0.05) towards F1, F2, and F3 and C1, C2, and C3. The low amount of gelatin (2%) added in the formulation F1 and C1 makes the Kaya Slice texture too soft and fragile. It can be observed that panels preferred formulations F2 and C2 due to the average amount of gelatin (4%) that result in perfect square shape and firm. However, there was no significant

Table 1. Kaya Slice formulations

Ingredients	Formulation					
	Fresh Coconut Milk			Commercial Coconut Milk		
	F1	F2	F3	C1	C2	C3
Coconut Milk (%)	37	37	37	37	37	37
Eggs (%)	43	43	43	43	43	43
Brown Sugar (%)	14	12	10	14	12	10
Extract Pandan Leaves (%)	3	3	3	3	3	3
Gelatin (%)	2	4	6	2	4	6
Potassium Sorbate (%)	1	1	1	1	1	1
Total (%)	100	100	100	100	100	100

F1, F2, F3 indicate Fresh Coconut Milk while C1, C2, C3 indicate Commercial Coconut Milk
Adapted and modified from (DMT 5083 Plant Product Technology, 2017)

Table 2. Hedonic scale for kaya slice with different percentage of gelatin and types of coconut milk

Attributes	Fresh coconut milk			Commercial coconut milk		
	F1	F2	F3	C1	C2	C3
Colour	3.03±1.35[a]	2.97±1.56[b]	2.10±1.37[c]	3.23±1.63[a]	2.40±1.40[b]	2.07±1.41[ab]
Texture	4.37±1.59[a]	2.53±1.89[c]	3.50±1.94[ab]	4.53±1.87[a]	2.02±1.31[c]	4.30±1.91[ab]
Taste	3.50±1.68[b]	2.20±1.58[ab]	3.87±1.68[a]	3.23±1.61[ab]	2.17±1.50[c]	3.93±1.78[a]
Aroma	3.43±1.14[a]	3.00±1.14[a]	3.83±1.32[a]	3.77±1.50[a]	3.37±1.54[a]	3.47±1.19[a]
Overall acceptance	3.57±1.25[a]	2.80±1.98[c]	3.30±1.64[b]	3.10±1.84[bc]	2.17±1.47[d]	3.57±1.83[a]

Values represent means ± standard deviation with number of samples, n = 35, Different alphabet a-c in the same row indicate a significant difference at p < 0.05

difference (p<0.05) for the texture of Kaya Slice when comparing to F1 and C1; F2 and C2; F3 and C3. Therefore, it can be concluded that types of coconut milk do not affect the texture of Kaya Slice.

The taste attribute is very vital in determining the acceptance of consumers towards new food development. In the Kaya Slice formulation, C2 was preferable compared to FI, F2, C1, F3, and C3 since a significant difference (p<0.05) is observed in the C2 formulation. C2 is using the commercial (UHT) coconut milk that undergoes the sterilization process. Sterilization is a treatment that inhibited microorganisms or enzymes in coconut milk. For the safety of consumers and at the same time prolong the shelf life of coconut milk (Umme *et al*., 2001). Wang *et al*. (2020) reveal that the sterilization process does not affect the taste of coconut milk. Remarkably, the coconut milk becomes sweeter and justifies the choice of panellists towards C2 rather than F2. However, the aroma for Kaya Slice in both types of coconut milk has no significant difference (p<0.05). The pandan aroma fragrance obtained from pandan leaves was more dominant compared to coconut milk. Resmi and Ana (2016) reveal that fresh pandan leaves produce a high intensity of fragrance and consist of chemical compounds that can act as a food preservative.

Overall, C2 formulation was in the scale 2 = "like very much" give significant difference (p<0.05) compare to other formulations (C1, C3, F1, F2, and F3). Therefore, panellists choose Formulation 2 as the best formulation for Kaya Slice.

3.1.2 Texture profile analysis of Kaya Slice

Texture measurement via instrument resembles the sensory evaluation made by panellists (Kohyama, 2020). Firmness was described as the force applied during compression to the penetration surface area which is most significant for TPA analysis (Garrido *et al*., 2015). Table 3 shows the firmness of Kaya Slice from C2 formulation (best formulation selected by trained panellist) in comparison with commercial sliced cheese. The firmness of commercial slice cheese was selected as a benchmark towards Kaya Slice. Kaya Slice (C2) has significantly lower firmness than Cheese Slice (p<0.05, Table 3). This is due to the different products being compared and each product used different ingredients and formulations. However, Taj and Ebrahimi (2020) revealed that hardness or firmness attributes were influenced by fat content, gelatin percentage (Garrido *et al*., 2015), types of sugar (Curi, Carvalho, Salgado *et al*., 2017), and storage temperature (Bubelova *et al*., 2017). Higher mineral content in brown sugar might increase the hardness, rigidity, and elasticity (Curi, Nogueira, de

Almeida *et al*., 2017) of Kaya Slice.

3.1.3 Total soluble solid

Total soluble solids (TSS) measure the sugar content in food in the degree of Brix (Curi, Carvalho, Salgado *et al*., 2017). It is vital for food quality determination (Zhengya *et al*., 2016). A high degree of Brix indicates a high percentage of sugar (Yusof *et al*., 2018). However, sugar plays an important role as natural food preservative which is one of the reasons many traditional foods were high in sugar. However, Kaya Slice was developed by reducing the sugar content and replacing refined sugar with brown sugar. At the same time, Kaya Slice formulation was utilizing pandan leaves as natural preservatives (Resmi and Ana, 2016). Therefore, it can be seen that the TSS for Kaya Slice was reduced by 33% from 67° to 68°Bx (commercial kaya) to 45°Bx.

3.1.4 Moisture content

Moisture content contributed to the texture of processed food. Higher moisture resulted in elasticity and hardness deficiency which resulted in poor palatability (Delgado and Banon, 2015). High moisture content in processed food will also lead to spoilage. From the study, moisture content for Kaya Slice has a significant difference (p<0.05, Table 3) from the other two commercial products. Kaya Slice has the lowest (32.9%) moisture content compared to commercial cheese slice (37.5%) and commercial kaya (42.2%). Therefore, there was a tendency that Kaya Slice can be stored for a longer time and increased this breakfast on-the-go shelf life.

Table 3. Physical and chemical properties of Kaya Slice the breakfast on-the-go for the best formulation

Properties	Best formulation (C2)	Commercial cheese slice	Commercial kaya spread
Texture profile analysis (TPA) at room temperature	895±39	1114±73	-
Total soluble solid (TSS) (°Brix)	45	-	67
Moisture (%)	32.9±1.04	37.5±2.01	42.2±0.07

3.2 Macronutrients of Kaya Slice

3.2.1 Protein

Protein helps in immunity, antimicrobial activity, and protecting the body against cancer and hypertension. It also contributed to the maintenance of skeletal muscle and protecting malnutrition in children, decrease glycaemic index, and effective weight control (Wu *et al.,* 2019). One of the main ingredients for Kaya Slice was eggs. Eggs provide a wide variety of nutrients, acting as an excellent source of protein and delivering a rich diversity of vitamins, minerals, and fats. Protein in Kaya

Slice was higher 0.32 g/100 g compare to the commercial kaya spread that was 0.00 g/100 g. A previous study shows that an egg-based breakfast provides satiety to consumers compared to a bagel breakfast. Besides, this study also found that the egg-based breakfast group had a greater BMI reduction and consume less energy during lunch (Wu *et al.,* 2019). Therefore, the protein-based breakfast helps individuals in making their energy intake through increased satiation.

3.2.2 Fat

Kaya Slice contains high-fat content which mainly comes from coconut milk. According to (Hauy *et al.*, 2020) coconut milk is beneficial for weight loss and the combination of high protein food with coconut milk is able to reduce the cholesterol level. In this study, Kaya Slice consist of 0.49 g/100 g fat compared to commercial kaya 0.00 g/100 g. Previous studies revealed that coconut consists of medium-chain triglycerides that are absorbed efficiently into the human body. It is more beneficial compared to other high saturated acid food (Zhu *et al.*, 2014). The medium-chain fatty acids also consist of antimicrobial properties that inhibit microbial growth (Parfene *et al.*, 2013). Therefore, fat content in Kaya Slice has the potential to reduce the cholesterol level and improved the shelf life of a product.

3.2.3 Carbohydrate

High carbohydrates diets consist of 55 to 65% of total energy (Lee *et al.,* 2018). Overconsumption will lead to obesity. In this study, the total carbohydrate for Kaya Slice has a significant difference ($p < 0.05$, Table 4) with commercial kaya. The commercial kaya reveals high carbohydrate content of 12.00 g/100 g compared to Kaya Slice 2.65 g/100 g. WHO recommendation that simple carbohydrates should not exceed 10% of daily energy intake. Therefore, Kaya Slice which is low in carbohydrate content will help the consumer in controlling their energy intake. Kaya was normally eaten with bread will certainly increase total carbohydrates and calories in a body compared to Kaya Slice.

Table 4. Macronutrient of Kaya Slice and commercial kaya spread

Properties	Amount per Serving	
	Best formulation (C2) (1 slice = 5 g)	Commercial kaya spread (1 tablespoon = 20 g)
Protein (g/100 g)	0.32±0.08	0.00±0.37
Fat (g/100 g)	0.49±1.04	1.00±0.19
Fibre (g/100 g)	0.11±0.35	0.00±0.40
Carbohydrate (g/100 g)	2.65±0.09	12.0±0.20
Calories (J)	16.29	59

3.2.4 Fibre

Dietary fibre is synonym with plant-based carbohydrates which is vital for the digestive system at the same time prevents constipation. It also contributes to other processes, such as stabilizing glucose and cholesterol levels. Kaya slice the breakfast-on-the-go was found to have 0.11 g/100 g of dietary fibre that might be from pandan leaves compared to commercial kaya that is none of the fibre content 0.00 g/100 g. Therefore, dietary fibre in Kaya Slice has the potential in improving appetite and satiety.

3.2.5 Calories

Macronutrients that is carbohydrate, fat, and protein has unique functions that the body needs (Carreiro *et al.*, 2016). It provides energy for growth, physical work, daily activity, and maintaining body temperature. Energy deficiency could be acute since it caused weight loss and deterioration in health. Too high in calories will result in health problems such as obesity, respiratory difficulties, diabetes, cancer, and others. Kaya Slice consists of 16.29 calories compared to commercial kaya that is high in calories. Therefore, it was expected that breakfast-on-the-go with low calories or energy tends to prevent excess energy intake.

4. Conclusion

From this study, Kaya Slice formulation (C2) is preferred for texture, taste, colour, and overall acceptance attributes. The results show a significant difference ($p < 0.05$) in C2 formulation (commercial coconut milk + 4% of gelatin) compare to F1, F2, F3, C1, and C3. Different percentages of brown sugar and gelatin give a significant difference in colour, texture, taste, and overall acceptance attributes. However, the hardness of Kaya Slice is incomparable to cheese slices since each product has a different function, purpose, and uniqueness. The macronutrients obtained have a significant difference ($p < 0.05$) compare to commercial kaya spread where Kaya Slice provides good nutritional values with low-calorie value. In conclusion, Kaya Slice is a promising ready-to-eat traditional food for breakfast-on-the-go.

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