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ORIGINAL ARTICLE

Instrumental Measurement, Sensory Descriptive Analysis and Consumer Acceptability of "Kaya" Supplemented with Pumpkin Puree

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Abstract

Kaya toast is a common choice for traditional Malaysian home breakfasts. Kaya, a spread made from eggs, sugar, coconut milk, and sometimes edible starch, is notable for its elevated levels of fat and sugar, contributing to its calorie content. In order to improve its nutritional content, pumpkin puree was supplemented into the kaya formulations. The objectives of the present study were to determine the sensory descriptive profile and consumer acceptability of kaya supplemented with different percentages of pumpkin puree (control: 0%, F1: 20%, F2: 40% and F3: 60%), as well as to evaluate the relationship between the instruments, descriptive and consumer acceptability data. The quality of kaya was evaluated by 10 trained (quantitative descriptive analysis) and 40 untrained (consumer testing) panelists. For instrumental measurements, the kaya was evaluated for its colour, texture and observed under optical microscope. The instrumental data of colour and texture were in good agreement to the one evaluated by the trained panelists. The colour of the kaya became more orangey (decreasing L* values and increasing a* values) with an increase in the amount of pumpkin puree. A higher amount of pumpkin puree resulted in a rougher, firmer, less sticky and less spreadable kaya. The kaya made with 60% pumpkin puree exhibited the softest texture due to the absence of eggs. Among the formulations, kaya supplemented with 20% pumpkin puree was rated the highest acceptance by consumer, thus indicates that consumer prefer kaya that quite similar to control. Data obtained from this study could offer valuable insights into the potential of producing a nutritious kaya using pumpkin puree, which could serve as a guideline for future research and the recipe can be employed by both manufacturers and home cooks.

Keywords: Pumpkin puree; kaya; quantitative descriptive analysis; consumer acceptability

Introduction

Pumpkins, fruits of many species of the genus Cucurbita, are grown all over the world for their pulp and seeds (Provesi et al., 2011). They are used to make syrups, jellies, jams, and purees, as well as for human nutrition. Pumpkin pulp is high in β-carotene pigments, precursors to vitamin A, have been linked to lower risk of cardiovascular disease and several cancers (Arifin et al., 2019).

Their high nutritional value opens possibility of their incorporation into the development of functional food products. Moreover, pumpkins can be considered as a raw source for the production of low-calorie food products (Rodionova et al., 2022). Pumpkin puree is a cooked pumpkin that has been blended or mashed to form smooth pulp. It is a thermally processed intermediate product used to make jam, jelly, sweets, and beverages. There is a risk of microbial contamination in pumpkin puree due to nutrient content and physicochemical parameters (Santos et al., 2017). Colour, flavour, and viscosity retention during heat processing are some of the factors that influence a pureed product's performance (Dutta et al., 2006).

Kaya, known as coconut jam, is a favourite Malaysian spread made from coconut, egg and sugar as a sweetener. It tastes sweet and somewhat creamy and available in either green or brown depending on pandan added (Khong et al., 2015). According to Zhang et al. (2020), heating to a high temperature can improve the variety of aroma compounds in coconut jam products and create a unique flavour. In terms of food chemistry, kaya is a water-in-oil emulsion distributed in a matrix of fine particles of protein and soluble solids (Phang & Chan, 2009). Thus, it has jam-like consistency. Kaya possesses a notable calorie content due to its significant level of fat and sugar (Phang & Chan, 2009). To enhance its nutritional composition, formulations were supplemented with pumpkin puree as it is low in calories and rich in β-carotene (Yadav et a., 2010). However, the texture, appearance, flavour, and aroma of those kaya may differ from the original kaya and thus may affect the overall acceptance by consumers. Therefore, this study was carried out to better understand the relationship between the levels of pumpkin puree supplemented into kaya formulations and several measurable quality characteristics as determined by instruments, sensory descriptive analysis and consumer acceptability.

In this study, the instrumental measurements included determination of texture, colour and microscopic image of the kaya. Food texture is an important sensory attribute that influences consumer acceptance (Ghorbel et al., 2016). Typically, a texture analyser is employed to evaluate attributes such as hardness, stickiness, work of shear and work of adhesion, which serve as prevalent parameters for characterising the texture and spreadability of jams and spreads (Basu & Shivhare, 2010). The orangey colour of pumpkin puree might induce a colour change in the kaya, consequently affecting consumer perception. Consumers desire a smooth kaya but adding pumpkin puree could potentially introduce a granularity to the texture. The resulted kaya was observed under a light microscope to determine its microstructure. The use of instrumental and sensory analysis to evaluate texture is critical in creating new products. Physical measurements are unable to predict customer response or preference due to psychological or sensory responses are difficult to mimic (Dubost et al., 2003). Sensory evaluation of quantitative descriptive analysis is be used to describe the key attributes of a food product. According to Santa Cruz et al. (2002), 8-10 panels that have been screened and given extensive sensory training in accordance with the Standard IS0 8586-1 (International Standard, 2012) are enough to assess product profile. The attributes investigated by the descriptive panelists are further evaluated by consumers for the acceptance levels based on the nine-point hedonic scale (1=dislike extremely, 5 = neither like nor dislike, 9 = like extremely). Maximo and Sheri (2006) recommended that a minimum of 40 panels are required for the consumer sensory test.

The objectives of this study were to: (1) characterise the physical properties of kaya supplemented with pumpkin puree using instrumental measurements, (2) determine the sensory descriptive profile and consumer acceptability of these kaya, and (3) evaluate the relationship between instrumental, descriptive and acceptability data. This study also aimed to develop eggless kaya using pumpkin puree in response to the growing demand for vegan dietary options.

Materials and Methods

Raw Materials

Fresh Japanese pumpkin (*Cucurbita maxima*), coconut milk (Kara, Denis Freres Group, Puchong, Malaysia), medium size eggs (Nutri Plus, Lay Hong Berhad, Klang, Malaysia) and sugar (Gula Prai, MSM Group, Kuala Lumpur, Malaysia), was purchased from a local market in Besut, Terengganu, Malaysia.

Preparation of Pumpkin Puree

Ripe pumpkins were washed under tap water to remove dirt. It was peeled and sliced into small cubes (approximate size of 3 cm x 3 cm). The seeds and string were removed. Then, it was steamed in a steamer for 20 minutes to soften the tissue. After steaming, the pumpkin was rapidly chilled in a cold ice bath to remove heat. Once cold down, the cubes were mashed using a food processor (MK-F300, Panasonic Manufacturing Malaysia Berhad, Malaysia) to turn them into puree.

Preparation of Kaya

The kaya was prepared by following a procedure described by Phang & Chan (2009). There were four levels of pumpkin puree supplemented into kaya formulations: 0% (control), 20% (F1), 40% (F2) and 60% (F3). Kaya without pumpkin puree is the control. The formulations for making the kaya are listed in Table 1. Kaya was prepared by mixing beaten egg, coconut milk, pumpkin puree, and sugar (portion A) into a bread maker pan. Mode 12 was selected to begin the program and it took about 1 hour and 20 minutes to cook the kaya. The mixture became thicker as the temperature rose over time and the creamy egg-white colour was gradually turned to pale brown.

Table 1. Formulation of kaya with different percentages of pumpkin puree.

Ingredients	Formulation (%)			
	Control	F1	F2	F3
Coconut milk	50	40	30	25.6
Egg	22	17.6	13.2	-
Sugar as sweetener	24	19.2	14.4	12.3
Sugar for caramel colour	4	3.2	2.4	2.1
Pumpkin puree	-	20	40	60
Total	100	100	100	100

The mixture was stirred using a spatula every 15 minutes to avoid the mixture burnt on the side. When the process completed, the pan was removed from the bread maker. The kaya mixture was poured into a food processor and blended until smooth. The sugar (Portion B) was heated separately in a non-stick pan. The caramelised sugar was subsequently added into the mixture and blended again until well mixed and obtained an appealing golden-brown colour. The total soluble solid (TSS) was measured using a refractometer. Double boiling was needed if TSS of the

kaya not reached 53° Brix. The kaya was hot-filled into jars that had been pre-sterilised and left a headspace of approximately 1-2 cm before being sealed with fitted lids. It was cooled and kept in a chiller at 4°C for storage. The chilled kaya was thawed to room temperature prior to measurement.

Instrumental Measurements

The instrumental measurements include determination of colour, spreadability parameters and microscopy. These analyses were performed at room temperature (25 ± 2 ºC) after 24 h of preparation, when the kaya was fully set.

Colour

Colour of the samples were analysed using colorimeter (Chroma Meter CR-400, Kinoca Minolta Sensing,Inc, Tokyo, Japan). For each sample, value of L* (lightness), a* (redness) and b* (yellowness) was measured five times and the average values were presented.

Texture

The spreadability parameters of kaya that were assessed using a texture analyser (TA-XTPlus, Stable Microsystems, Surrey, UK), including measurement of hardness, stickiness, work of shear and work of adhesion values. Basu & Shivhare (2010) define these spreadability parameters as following: spreadability is the ease with which a product can be spread; hardness (g force) is the maximum force on a product that displays substantial resistance to deformation; stickiness (g force) is the maximum force necessary to overcome the attractive forces between the surface of the food and the surface of the probe with which the food comes in contact; work of shear (g s) is the total amount of force required to carry out the shearing process, which a measure of ease of spreadability; work of adhesion (g s) is the total amount of the force involved in the withdrawal of probe from the sample.

The measurement of spreadability of kaya was performed according to the method proposed by Basu & Shivhare (2010). Approximately 10 g of sample was analysed using a spreadability probe (Perspex conical) with 45 angles at room temperature (25 ± 2°C C). The kaya sample were filled into the lower female cone with a spatula and the surface were levelled with a flat knife. The instrument was operated at test speed = 3 mm/s, post-test speed = 10 mm/s, distance = 30 mm, trigger type button with a 5 kg load cell. Prior to the test, the male cone probe moves down to ensure it was fitted into the female cone sample holder. The textural data (force versus. time) were analysed by the instrument software and spreadability parameters (hardness, stickiness, work of shear and work of adhesion) were recorded. For each sample, the tests were performed in triplicate.

Microscopy

Samples observed under an optical microscope (BX53M, Olympus, Tokyo, Japan) with a magnification of 40x. Three images were captured for each representative sample.

Sensory Evaluation

The present work was granted the ethical approval by Universiti Sultan Zainal Abidin Human Research Ethnics Committee (UHREC) committee (approval no.: UniSZA/UHREC/2021/332).

Quantitative Descriptive Analysis

Prospective members of the descriptive panel were recruited among a pool of students in Besut Campus, Universiti Sultan Zainal Abidin. Pre-screening questionnaires were distributed to them prior to the screening process. Prospective panelists then subjected to a series of screening tests and then trained on quantitative descriptive analysis (QDA) techniques. The QDA test were conducted in the Sensory Laboratory at the Faculty of Bioresources and Food Industry. An overview of QDA was given during the first training session. Subsequently, the process involved terminology development, wherein the panelists were asked to develop a list of terms (descriptors) describing the sensory attributes of kaya based on the provided commercial samples. Following a group discussion, a consensus was reached and key attributes a selected are for evaluation. Reference standards for each attribute were then defined.

In the next two training sessions, panelists were introduced to the evaluation techniques and provided with written and verbal descriptions of how to rate intensity of the sensory attributes using 150-mm unstructured line scales with anchor points at 12.5 mm from each end. For actual product testing, each sample was prepared: 5 g in 1-oz cups with lids to evaluate the spreadability and 15 g in 2-oz cups to evaluate other attributes such as colour, sweetness intensity, smoothness, firmness and adhesiveness. Samples were coded with 3-digit random numbers and served to panelists at room temperature. Panelists can either swallow or expectorate the samples during the test. To minimise any carry-over effect, panelists were instructed to cleanse their palates by chewing a small piece of unsalted crackers and rinsing with water between samples. The trained descriptive panelists were given a score card and rated each attribute for each sample for a total of three times.

Consumer Acceptance Testing

Approximately 40 untrained consumers were randomly chosen among the students to participate. All participants were 18 to 25 years old. The test was carried out in the Sensory Laboratory at the Faculty of Bioresources and Food Industry, Besut Campus. The new products were compared to control kaya without the addition of pumpkin puree. A total of four samples (control, F1, F2 and F3) were presented simultaneously for evaluation. The samples of approximately 10 g were placed in lidded transparent small cups, accompanied with white bread (onto which the product was spread by the panelists) and room temperature water for palate cleansing purpose between sample tasting. Consumers were provided with a score card and they rated the appearance, odour/aroma, spreadability, taste and overall liking of the products based on the 9-point hedonic scale (1 = dislike extremely, 5 = neither like nor dislike, 9 = like extremely).

Statistical Analysis

The significant differences among data were analysed using one-way analysis of variance (ANOVA) and Duncan's Multiple Range Tests at $p<0.05$. All analyses were performed using the Statistical Package for the Social Sciences (SPSS) software, version 20.0 (SPSS, IBM, Illinois, USA).

Results and Discussion

Instrumental Measurements of Kaya Supplemented with Pumpkin Puree

Colours is one of important attributes used to describe the appearance of kaya besides other attributes such as firmness, spreadability, smoothness and adhesiveness (Phang & Chan, 2009). The L*, a* and b* values for kaya supplemented with pumpkin puree which measured by colorimeter were listed in Table 2. Measuring colour of food using L* a* b* is the most commonly used due to its uniform colour distribution and it is very close to human perception of colour (León et al., 2006). As can be seen in Figure 1, an increase in the pumpkin puree addition caused the colour of kaya became more orangey (decreasing L* values and increasing a* values). The control kaya had light brown colour because of sugar caramelization and Maillard reaction, a non-enzymatic browning reaction between amino acid and reducing sugar under heat treatment (Phang & Chan, 2009). Caramel colour is the most common colour utilized in kaya production, however, green kaya also available in the market due to addition of pandan extract.

Table 2. Colour of kaya supplemented with different percentages of pumpkin puree.

Colour Measurement	Control	F1	F2	F3
L*	54.41±0.74^{a}	37.73±0.68^{b}	36.81±1.59^{b}	29.40±3.01^{c}
a*	-0.31±0.09^{d}	7.00±0.27^{c}	10.46±0.14^{b}	11.88±0.67^{a}
b*	21.67±0.43^{d}	37.75±2.75^{b}	45.45±2.23^{a}	27.58±3.40^{c}

Different letters in the same row show statistically significant different ($p<0.05$).
Values are means ± SD.

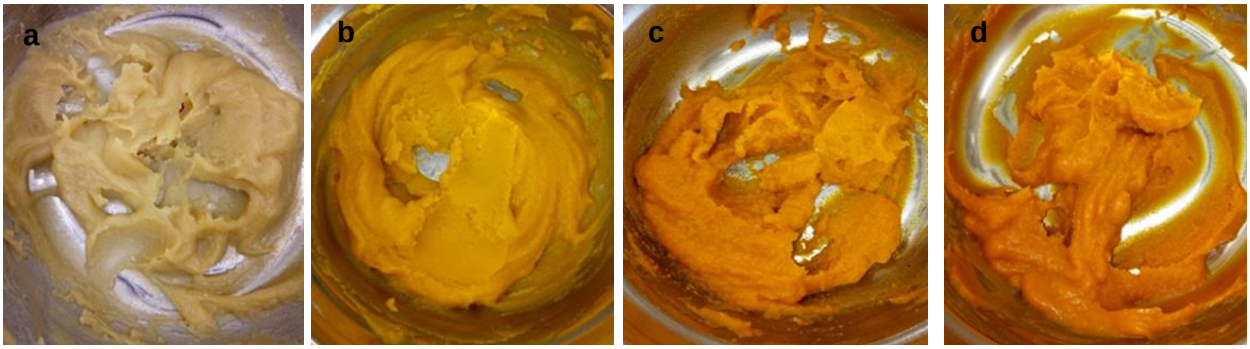

Figure 1. Appearance of kaya supplemented with different percentages of pumpkin puree: a) 0% (control), b) 20% (F1), c) 40% (F2) and d) 60% (F3).

Control kaya had the highest L* value, implying that the colour of kaya became darker with an increase in the amount of pumpkin puree. For a* value, the addition of pumpkin puree resulted in more redness to the kaya. The b* value that indicates the yellowness also increased with the increasing amount of pumpkin puree, except for F3. F3 had lower yellowness than F1 and F2 because this formulation did not contain egg. As compared to control, kaya F3 exhibited the biggest difference in the colour. The distribution of pumpkin puree in the kaya matrix can be seen under light microscope, as shown in Figure 2. Pumpkin that high in β-carotene contributes to its vibrant orange (Arifin et al., 2019), thus the product became more orangey when more pumpkin was added. The pumpkin puree was found to well distributed throughout the kaya matrix.

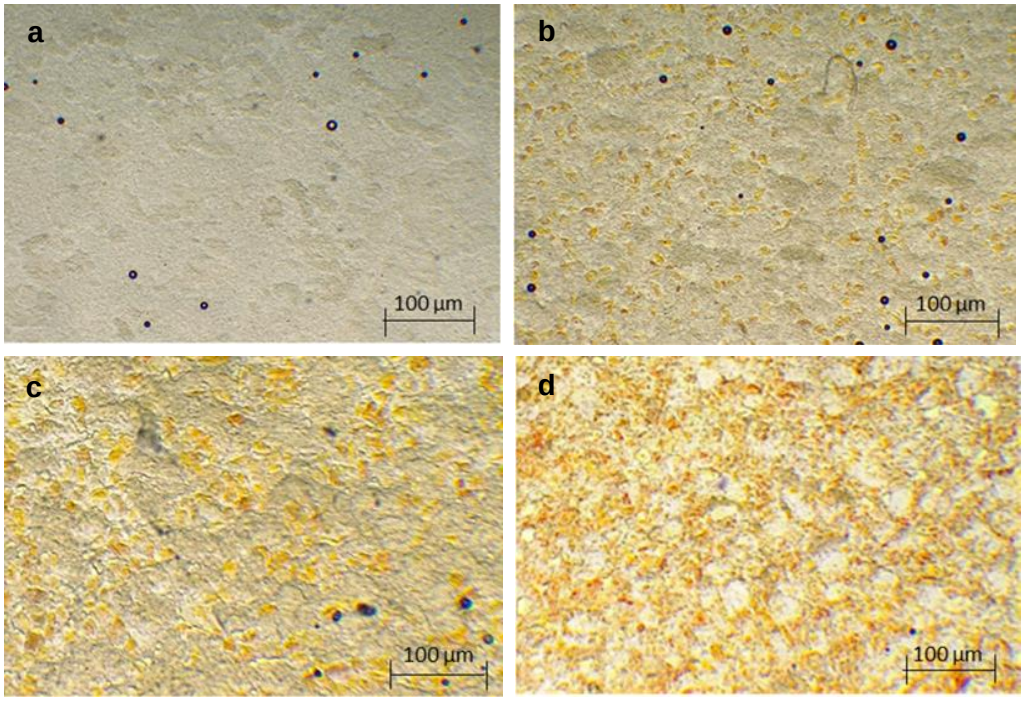

Figure 2. Microscopic image of kaya supplemented with different percentages of pumpkin puree at 40x magnification: a) Control, b) F1, c) F2 and d) F3.

Textural properties (firmness, stickiness, work of shear and work of adhesion) of kaya supplemented with different percentage of pumpkin puree is summarized in Table 3. The firmness of kaya did not vary systematically with pumpkin puree concentration. Among the samples, kaya F3 was the softest as this formulation had no egg. Egg would give structure to the products and thus firmer, for example in bread (Dhiman et al., 2009), mayonnaise (Santa Cruz et al., 2002) and muffin (Hidayah et al., 2019). Kaya F1 and F1 had comparable stickiness to control kaya, while F3 was the least sticky. Therefore, kaya F3 was the easiest to spread and kaya F1 and F2 had similar spreadability to control. In term of adhesiveness, kaya with pumpkin puree was less adhesive than the control.

Table 3. Effect of the addition of pumpkin puree on textural properties of kaya.

Parameter	Control	F1	F2	F3
Firmness (g.force)	6.01 ± 0.35^{b}	7.75 ± 0.42^{a}	6.39 ± 0.41^{b}	4.13 ± 0.63^{c}
Stickiness (g.force)	4.76 ± 0.33^{a}	4.71 ± 0.46^{ab}	4.40 ± 0.76^{ab}	3.78 ± 0.19^{b}
Work of shear (g.sec)	1115.31 ± 38.83^{b}	1086.76 ± 16.24^{b}	1051.01 ± 37.26^{b}	1198.92 ± 21.58^{a}
Work of adhesion (g.sec)	341.03 ± 9.89^{a}	287.31 ± 23.64^{b}	285.23 ± 7.78^{b}	272.59 ± 19.95^{b}

Different letters in the same row show statistically significant different ($p<0.05$).
Values are means ± SD.

Sensory Evaluation of Kaya Supplemented with Pumpkin Puree

Quantitative Descriptive Analysis

Mean intensity rating of descriptive attributes is profiled in Figure 3. It was assumed that the differences were due to variations in percentage of pumpkin puree as all samples were produced under the same conditions. The addition of pumpkin puree gave a significant effect on the colour of kaya. An increase in the pumpkin puree resulted in more orangey kaya. Trained panelists could differentiate the colour difference between samples, which is in-line with the colour measurement by colorimeter. The sweetness of kaya decreased increasing amount of pumpkin puree in the formulations. This happens due to decreasing amount of sugar with an increasing concentration of pumpkin puree.

In term of textural properties, the supplementation of pumpkin puree caused the kaya to become rougher, firmer, less sticky and less spreadable, except for F3 that had no egg. The formulation F3 was quite watery as compared to control. The coagulation of egg during heating may result in firmer texture of products (Woodward & Cotterill, 2012). The observation by the trained panelists was in good agreement with data from the texture analyser. Both trained panelists and texture analyser detected kaya F3 had the softest texture and the easiest to spread. Kia and Hosseini Ghaboos (2018) also found that the texture of cookies became softer when pumpkin puree was added. For adhesiveness, kaya F3 was less sticky than the control, similar to data obtained from texture analyser. Based on instrumental measurement, kaya F1 and F2 were quite similar in their texture, however panelists could detect the differences between the samples. The trained panelists found that kaya F2 was firmer, less sticky and difficult to spread than kaya F1.

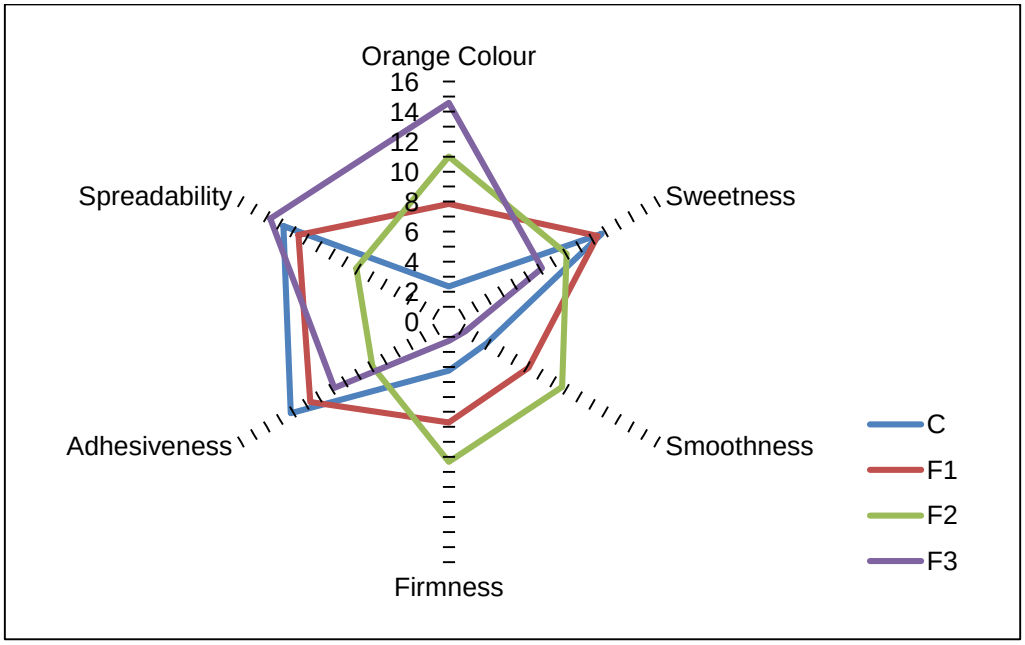

Figure 3. Spider diagram of the mean intensity ratings for the sensory attributes of the kaya supplemented with pumpkin puree.

*Each spoke of the diagram represents an individual sensory attribute. The intensity scales each go from lower values at the centre point to higher values at the outer end of the spoke. The intensity of an attribute in a specific product is represented by the point on the spoke at which the connecting line for that product cross.

Consumer Acceptability

Mean consumer ratings of "liking" for appearance, aroma, flavour, sweetness, spreadability, texture and overall acceptability are presented in Table 5. All the attributes evaluated showed significant differences ($p<0.05$) between control kaya and kaya formulated with pumpkin puree. Overall, consumers liked kaya F1 the most as this formulation received the highest ratings for all attributes. All kaya samples except F3 were rated higher than 6 on a hedonic 9-point scale, indicating that the consumers liked the products at least slightly. The high acceptability of the products by consumers was an interesting result considering that this type of product is not currently available in the market. Thus, kaya supplemented with pumpkin puree has a great potential for commercialisation.

Table 4. Mean of hedonic ratings for consumer's acceptance of kaya supplemented with pumpkin puree.

Attributes	Control	F1	F2	F3
Appearance	5.28±2.16^{b}	7.00±1.73^{a}	6.50±2.00^{a}	7.08±1.79^{a}
Aroma	6.63±1.53^{a}	7.03±1.44^{a}	6.73±1.57^{a}	5.20±2.09^{b}
Spreadability	7.98±0.83^{a}	7.90±1.17^{ab}	7.33±1.76^{ab}	7.28±1.70^{b}
Sweetness	7.60±1.15^{a}	7.13±1.38^{a}	6.98±1.61^{a}	5.58±2.04^{b}
Flavour	7.35±1.46^{a}	7.50±1.45^{a}	7.00±1.68^{a}	5.30±2.02^{b}
Texture	7.78±1.17^{a}	7.63±1.60^{ab}	6.70±1.76^{c}	7.03±1.70b^{c}
Overall acceptance	7.40±1.30^{a}	7.60±1.22^{a}	7.13±1.52^{a}	5.95±1.91^{b}

Values represent means ± standard deviation; n = 40.
Hedonic ratings based on 9-point hedonic scales with the descriptors: 9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, and 1 = dislike extremely.
$^{a-c}$ Different letters in same row indicate a significance difference ($p < 0.05$).

The F1 showed similar acceptance to the control sample, except for the appearance where most consumers gave F1 higher ratings. Consumers commented that F1 need further improvement in sweetness and aroma as this sample was too sweet and lacked in pumpkin aroma. Therefore, future work is required to improve the consumer acceptance. As previously discussed, the texture of F1 and F2 were the same based on texture analyser data, but trained panelists perceived F2 as firmer, less sticky and difficult to spread than kaya F1. As a result, kaya F2 was less preferred by consumers as compared to F1.

Kaya F3 that contained 60% pumpkin puree received the lowest overall scores due to the strong pumpkin aroma and flavour. Moreover, consumers did not like the sweetness of the kaya. Although some customers loved the additional features and gave the sample a good rating, other customers would not accept a product that was different from what they were used to. Texture is a significant aspect of food quality and a lower texture rating might reduce the overall acceptability (Basu & Shivhare, 2010). A strong flavour and aroma of pumpkin in the juices had reduced the sensory quality and led to a dislike of the products by consumers, especially children and the elderly (AlJahani & Cheikhousman, 2017).

Conclusion

The impact of addition of pumpkin puree (at 0, 20, 40 and 60% w/w) on the physicochemical properties (colour and textural properties) was investigated by instrumental measurements and

trained panelists (quantitative descriptive analysis). The data obtained by both instrumental measurements and trained panelists showed a good agreement in which an increase in the pumpkin puree resulted in darker and more orangey kaya (decreasing L* values and increasing a* values). A higher amount of pumpkin puree in the formulation caused a rougher, firmer, less sticky and less spreadable kaya, except for kaya containing 60% puree that contained no egg. Therefore, kaya with 60% puree was the least favoured by consumer as it was quite watery. The consumer liked the kaya containing 20% puree the most as it colours and texture was closest to the control kaya. However, the formulation of kaya supplemented with pumpkin puree should be further improved and finely tailored in order to enhance consumer acceptance and consequently boost its marketability.

For future study, it is essential to determine nutritional content for kaya supplemented with pumpkin puree. Moreover, a storage study should be undertaken to evaluate the shelf life of the kaya.

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