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FULL PAPER

Proximate composition, physicochemical characteristics and sensory evaluation of reduced-calorie belimbi fruit (*Averrhoa belimbi*) jam with maltitol

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Abstract

Consuming of foods high in calories is often associated with higher risks for obesity. This has increased the consumer demand for the food products that promise health benefits. The aim of this study was to evaluate the proximate composition, physicochemical properties, and sensory attributes of reduced-calorie belimbi fruit jam with maltitol. Two formulations of belimbi fruit jams were prepared using sucrose as a reference food (*i.e.* BJSUC) or maltitol (*i.e.* BJMAL). The proximate composition, biochemical analysis, texture profile analysis, and sensory evaluation of the produced fruit jams were conducted. The obtained results of BJSUC and BJMAL were compared using unpaired Student's t-test. The moisture content of BJMAL (76.58%) was significantly ($P<0.05$) higher than the BJSUC (66.41%). There was a reduction in carbohydrate and caloric values for belimbi fruit jam prepared using maltitol (22.19% and 96.43 kcal, respectively) as compared with belimbi fruit jam prepared using sucrose (32.91% and 136.09 kcal, respectively). However, belimbi fruit jam prepared without sucrose (*i.e.* BJMAL) did not affect to the ash (0.27%), crude protein (0.39%), crude fat (0.55%), and crude fiber (1.95%) contents, as well as for pH value (3.05), water activity (0.80), and vitamin C (22.90 mg/100 g) contents. BJMAL showed a significant ($P<0.05$) lower total soluble solids (66°Brix) and total titratable acid (0.09%) than BJSUC. BJMAL had lower firmness value and easy to spread than the BJSUC. The overall acceptability of BJMAL by panellists was comparable to the BJSUC, both fruit jams received scores higher than 5. The reduced-calorie belimbi fruit jam can be prepared by using maltitol.

1. Introduction

Belimbi (*Averrhoa belimbi*) is one of the tropical fruits belongs to genus Averrhoa. It is originated from Malaysia and Indonesia. In Malaysia, this fruit is called as "belimbing buluh" (Anuar and Salleh, 2019). Belimbi fruit has received very low attention as compared with other local fruits, like pineapple, papaya, and guava because of its high concentration of oxalic acid (8.57-10.32 mg/g) which is regarded as too sour for eating raw. The high levels of oxalic acid found in belimbi fruit are responsible for its extremely low pH value (pH2.05-2.27) at their maturity stage (Lima *et al.*, 2001; Bhaskar and Shantaram, 2013). Thus, belimbi fruits become underutilized fruit and go to waste. However, the fresh belimbi fruit was recorded to contain a high amount of crude fibre, minerals, vitamin C, antioxidants, and low in fat (Bhaskar and Shantaram, 2013). In addition, several studies found that it has medicinal values, which are able to cure fever, inflammation and stop rectal bleeding as well as alleviate internal haemorrhoids (Ambili *et al.*, 2009; Orwa *et al.*, 2009; Roy *et al.*, 2010). Moreover, Anuar and Salleh (2019) reported that bilimbi has a short shelf life after harvest. Therefore, belimbi fruit has a high potential to be utilized and processed as a health food product for better options in preserving the fruit.

Jams are made to preserve fruit for consumption during the off-seasons. It is processed from fresh fruits, sugar (*i.e.* sucrose), and additives such as gelling agent (*i.e.* pectin) and acidic agent (*i.e.* citric acid). The fresh fruit used in jam making is preferable to be slightly under-ripe fruit which is rich in pectin along with the ripe fruit in order to secure the desirable gelling effect in the jam (Vibhakara and Bawa, 2012). Sucrose derived from sugar beets or sugar cane is added to jams for sweet taste and acts as a natural preservative in inhibition of microbial growth by binding the water in the jam (Alsuhaibani and Al-kuraieef, 2018). Pectin always added in jam making for gelling purpose in proper pH

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and sugar, thus help in facilitating the establishment of pectin-pectin linkages (Makena, 2015; Anuar and Salleh, 2019). Acid performs a variety of functions in jam processing, the primary being acidifier, pH regulator, and preservatives (Vibhakara and Bawa, 2012). The desired texture of fruit jam can be achieved through utilizing a proper balance of sugar and pectin concentration and adjustment of pH, whereby pectin sets best at pH 3.2 (Baker *et al.*, 2005; Makena, 2015). According to the Food Act (Act 281) and Regulation Malaysia (2017), jam shall contain not less than 35% of fruit and has 65% of soluble solids.

High consumption of sugar is often associated with high energy intake that could result in higher risks for obesity, diabetes, and cardiovascular diseases. This has increased the awareness of the consumers because they are more concerned about their health and often look for the food products that are low sugar, sugar-free, reduced-calories, low calories, high protein and dietary fibre (Abdullah and Cheng, 2001; Mamede *et al.,* 2013; Amin *et al.*, 2016). Therefore, the demand for the production of low-calorie foods has increased recently. However, fruit jams sold in the market today are of high in calorie, but the consumers show high interest in reduced-calorie food products especially for those who are on diet management that needs restriction in calorie. Therefore, production of a reduced-calorie jam is gaining market share compared to the conventional jams which are prepared with sucrose. Reduced-calorie or low-calorie fruit jam can be produced from low-calorie sweeteners and other low-calorie raw materials (Alsuhaibani and Al-kuraieef, 2018).

Many natural and artificial sweeteners are developed to replace sugar in food products. Polyols are one of an example of natural sweetener added into food products to reduce total calories and maintain palatability. Maltitol, a disaccharide sugar alcohol derived from starch through the reaction of catalytic hydrogenation of maltose has approximately 75-90% similar sweetness to sucrose, with the relative sweetness of 0.9. (Dobreva *et al.*, 2013). In addition, maltitol also has identical properties such as odourless, white crystalline appearance and texture similar to sucrose (Schiweck *et al.*, 2011). This high sweetness allows it to be used as a table sugar substitute and alternative sweetening agent without being mixed with other sweeteners. It is often used at approximately one-for-one replacement for sucrose in food products. Maltitol is incompletely absorbed and metabolized by the body, and thus it consequently contributes lower calories than most sugars and has a lesser effect on blood glucose level (Kearsley and Boghani, 2016).

Therefore, this present study is aimed to produce a reduced-calorie jam that contains at least 25% less calories than the reference food (*i.e.*, jam prepared using sucrose). To achieve the aims, the belimbi fruit was used as fresh fruit and maltitol as the sweetening agent in preparation of jam. Then, the physic-chemical properties and sensory attributes of the prepared jam were investigated.

2. Materials and methods

2.1 Materials

The mature fresh belimbi fruits were obtained from a local farm in Besut, Terengganu, Malaysia. The greenish -yellow colour skin of fruits was selected for jam processing. The other ingredients such as pectin and sucrose were procured from Bake Well Supplies Sdn. Bhd., Penang, Malaysia and maltitol was purchased from Sim Company Sdn. Bhd., Penang, Malaysia. All reagents used in this present study were of analytical grade.

2.2 Preparation of belimbi fruit jam

Table 1. Formulations of belimbi fruit jam making

Ingredients (g)	BJSUC	BJMAL
Fruit puree	44.5	44.5
Sucrose	55	-
*Maltitol	-	61.11
Pectin	0.5	0.5

BJSUC: Jam prepared using sucrose as a sweetener, BJMAL: Jam prepared using maltitol as a sweetener. *weight was calculated based on the relative sweetness to sucrose, 0.9.

Belimbi fruits were washed thoroughly under running tap water to remove any adhering dirt and cut into small pieces of cube size. Then, the fruits cubes were blended using blender (Panasonic Blender MX-GM1011H, Selangor, Malaysia) to obtain the fruit puree. The pH of the fruit puree was measured using pre-calibrated pH meter (Orion 2 Star pH Benchtop, Singapore) prior cooking to check the acidity of the fruit puree. This is to ensure all the prepared fruit puree has pH approximately 3.0-3.1. The belimbi fruits had pH less than 3.0 were excluded from this study. Two jams formulations were prepared, as shown in Table 1. Belimbi fruit jam formulated with sucrose was served as the control (BJSUC). Sucrose was 100% replaced with Maltitol for the preparation of BJMAL. The belimbi fruit puree was boiled in a pot. Then, pectin-sweetener mixtures (1:5) was added accordingly. The remaining sweetener was added into the pot after dissolving pectin-sweetener. The mixture was boiled vigorously until the desired viscosity was reached. This takes about total cooking time of 10 to 12 mins. The boiling process was stopped as the total soluble solid of the fruit jam reached 65°Brix, checked using a hand-held refractometer (Kern ORA 80BB Series Analogue Refractometer, Kuala

Lumpur, Malaysia). The heat was cut off and the jam was hot-filled into sterilized glass jars. After capping, the jars were pasteurized by placing in a boiling water bath and allowed to cool to room temperature.

2.3 Proximate analysis

The proximate compositions of the different fruit jam formulations were analysed with referring to the standard method of AOAC (2000). The moisture, ash, crude protein, crude fiber, and crude fat contents were estimated by oven drying method, dry ashing method, Kjeldahl's method, gravimetric method, and Soxhlet method, respectively (AOAC Method 977.11, AOAC Method 923.03, AOAC Method 955.04, AOAC Method 991.43, and AOAC Method 960.39, respectively).

2.4 Total carbohydrate estimation

The total carbohydrate of the different jam formulations was calculated by difference, whereby, % total carbohydrate = 100% - % (moisture + ash + crude protein + crude fat) (BeMiller and Low, 1998).

2.5 Caloric value estimation

The calorie of the different jam formulations was calculated according to the equation developed by Nielsen (1998), whereby, Calorie (kcal) = (Crude Protein × 4 kcal) + (Crude Fat × 9 kcal) + (Crude Carbohydrate × 4 kcal).

2.6 pH determination

The pH of the different jam formulations was determined using pre-calibrated pH meter. The pH meter was prior calibrated using buffers at pH 4, pH 7, and pH 10. Approximately, 10 g of sample was suspended in 90 mL of deionized water (Mamede *et al.*, 2013). The electrode of pH meter was immersed in the suspended solution and the result was recorded.

2.7 Total soluble solid determination

The total soluble solid of the different jam formulations was determined using a hand-held refractometer (Kern ORA 80BB Series Analogue Refractometer, Kuala Lumpur, Malaysia), scale ranging from 45 to 82°Brix.

2.8 Total titratable acidity determination

The total titratable acidity of the different jam formulation was determined using the method proposed by Mamede *et al.* (2013). Approximately, 3 g of sample was weighed and suspended in 15 mL of distilled water. The suspended solution was filtered and the filtrate was added with two drops of phenolphthalein indicator. The mixture was titrated with 0.1 N of sodium hydroxide solution until the faint pink endpoint achieved. The obtained results were multiplied with the conversion factor of 63 g oxalic acid.

2.9 Water activity measurement

The water activity of the different jam formulation was analysed using pre-calibrated water activity meter (AquaLab Dew Point Water Activity Meter 4TE, USA) at room temperature. Approximately, 1 g of the jam was placed in the sample plastic cup and inserted into the sealed chamber to read the results.

2.10 Vitamin C determination

The Vitamin C of the different jam formulation was determined by using redox titration method (Shamsul Azrin, 2009). A 10 g of jam sample was suspended in 20 mL of distilled water and the solution was stirred to homogenize the mixture. The mixture was then filtered through a muslin cloth to obtain the filtrate prior adding with 1 mL of the starch indicator. The solution was titrated with 0.005 mol/L iodine solution until the blue endpoint achieved. The vitamin C of the jam sample was expressed as mg of ascorbic acid/ 100 g of sample.

2.11 Texture profile analyses

Texture profile of the different jam formulation was analysed using Texture Analyzer (TA-XT2). The texture analyser was pre-calibrated using a 5 kg load cell. The settings for the texture analyser were return distance of 25 mm, return speed of 10 mm/s, contact force of 1 g, test speed of 3 mm/s and distance of 23 mm. The probe used was TTC Spreadability Rig and the selected test mode was compression. The analysed parameters were hardness and spreadability.

2.12 Sensory evaluation

Sensory evaluation of the different jam formulations was performed using seven scales hedonic test to compare the degree of acceptability of belimbi fruit jams. The seven scales were denoted as '1' = extremely dislike, '2' = slightly dislike, '3' = moderately dislike, '4' = neither like or dislike, '5' = moderately like, '6' = slightly like and '7' = extremely like. A total of 30 panelists consisting of students and staff from the Faculty of Bioresources and Food Industry, Universiti Sultan Zainal Abidin, Besut Campus participated in sensory evaluation. Each panellist received jam samples coded by three-digit random number to avoid bias and a glass of water to rinse the palate before or in the middle of the evaluation. Panelists were asked to evaluate the attributes including colour, aroma, sweetness, sourness, spreadability and overall acceptability of the given samples. Panellists were provided with white bread (2

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cm x 2 cm x 0.5 cm) for spreadability attribute evaluation.

2.13 Statistical analysis

The statistical methods used to analyze the data in this study were unpaired Student's t-test (two-tailed) using MS-Excel 2010 Software program. All analyses were done in triplicate and results were expressed as mean value ± standard deviation. A calculated p-value of <0.05 was considered to be statistically significant.

3. Results and discussion

3.1 Proximate composition

Table 2 presents the proximate composition of the different formulations jam. Moisture content is the most commonly measured properties in food products for the estimation of its shelf life (Mohd Naeem *et al.*, 2017). In addition, moisture content measurement is also important for legal and labelling purpose. Jam prepared using maltitol (BJMAL) (76.58%) showed significant ($p<0.05$) higher moisture than jam prepared using sucrose (BJSUC) (66.41%). The moisture content of each sample was highly affected by the hygroscopicity properties that differ between types of sweeteners. Maltitol belongs to the group of well soluble polyols has crystallized similar to sucrose. However the crystalline maltitol is the least hygroscopic polyols and it begins to absorb moisture in relative atmospheric humidity of 80% (Dobreva *et al.*, 2013; Kearsley and Boghani, 2016). There are many hydroxyl groups in the structure of maltitol that can interact with water molecules via hydrogen bonds. Furthermore, maltitol acts as a humectant that has the property of absorbing water (Charoen *et al.*, 2018). These results were compared with a study done by Muresan *et al.* (2014) on the quality of jam processed from banana and ginger which has a moisture content of 74%. In the other hand, Chacko and Estherlydia (2014) reported that jams made from indigenous fruit peels have a moisture content of 39.1% to 62.6%.

Table 2. Proximate composition of belimbi fruit jams

Parameter	BJSUC	BJMAL
Moisture (%)	66.41±1.04^a	76.58±0.58^b
Ash^{ns} (%)	0.25±0.01^a	0.27±0.03^a
Crude Protein^{ns} (%)	0.40±0.02^a	0.39±0.02^a
Crude Fat^{ns} (%)	0.48±0.06^a	0.55±0.04^a
Crude Fibre^{ns} (%)	1.85±0.13^a	1.95±0.17^a
Total Carbohydrate (%)	32.91±0.99^a	22.19±0.80^b
Calorie (kcal)	136.09±4.40^a	95.24±3.36^b

Presented data are mean value of three triplicates ± standard deviation. Means in the same row with different superscripts are significantly ($p<0.05$) different. ^{ns} – Not statistically significant at level $p<0.05$.

Ash contains in food products can be used to predict the total amount of mineral presence. There was no significant difference in ash content between BJSUC (0.25%) and BJMAL (0.27%). Generally, low ash content indicated that all of the jam samples produced were not a good source of minerals. The ash content does not show significantly different between samples was due to the amount of belimbi fruit puree used in each formulation was similar. In addition, Bhaskar and Shantaram (2013) reported that the ash content in fresh belimbi fruits is 0.33% which is slightly higher than the ash content of jams obtained from this present study. This variation of mineral content was attributed to the losses of minerals during washing and cooking of belimbi fruit. This was agreed by Dandago (2009) whereby, some of the minerals contained in raw materials are not available in prepared foods, due to the leaching of minerals into the water during processing caused the significant reduction. Moreover, these results are comparable with dietetic jam prepared using Umbu-Caja fruit (0.20-0.30%) (Mamede *et al.*, 2013). However, the ash value of belimbi fruit jam processed from this present study is lower than the ash content of belimbi fruit jam (0.37%) studied by Anuar and Salleh (2019). This might be due to the different environmental factors such as climate and soil type (Fabbri and Crosby 2016) in which belimbi fruits are grown as well as the ripening stage of the fruit at harvest.

The crude protein composition in all of the prepared samples were 0.40% and 0.39% for BJSUC and BJMAL, respectively. This indicates that the crude protein composition was not significantly influenced by the types of sweeteners used. In addition, the low protein content of jams found in this study was due to all of the jams were prepared from ingredients such as fresh fruits, sweetener, pectin and acid, which none of the ingredients used is a rich source of protein. The crude protein content of both BJSUC and BJMAL were found similar value to that of apricot jam (0.43%), blueberry jam (0.31%), strawberry jam (0.41%), and belimbi jam (Mohd Naeem *et al.*, 2017; Anuar and Salleh, 2019). Furthermore, Anuar and Salleh (2019) reported that the crude protein content in fresh belimbi fruits is 1.00% which is much higher than the crude protein content of belimbi fruit jams produced from this present study. The variations may due to dissolve and loss of some nitrogen compounds during processing by heating. This has caused to less protein content detected in the Kjeldahl analysis in which non-protein nitrogen is also detected (Ho *et al.*, 2016).

For crude fat content, the replacement of maltitol for sucrose in jam making did not affect the crude fat content of jam (0.48% for BJSUC and 0.55% for

BJMAL). The crude fat value of belimbi jams obtained from this study was higher than the crude fat content of apricot, strawberry, blueberry, and grape jams which have very low fat content (0.01-0.03%) (Mohd Naeem *et al.*, 2017). The higher crude fat content detected in these present processed jams can be explained by the facts that the raw belimbi fruit has higher crude fat (0.27) (Bhaskar and Shantaram, 2013) than apricot, strawberry, blueberry, and grapefruits (0.1%) (Food Standards Australia New Zealand, 2010). Moreover, the average crude fat content (0.44-0.55%) of belimbi fruit jams showed an increase compared to the raw belimbi fruits (0.27%) reported by Bhaskar and Shantaram (2013). Therefore, the belimbi fruit is a major ingredient source of calories in these present processed jams. In the other hand, the crude fat value of belimbi jam obtained from this study was slightly similar to the crude fat content of belimbi jam (0.46%) studied by Anuar and Salleh (2019).

Belimbi fruit jams processed using sucrose (BJSUC) or maltitol (BJMAL) had no significant difference in crude fibre content. The presence of crude fibre in the belimbi fruit jam resulted from the fibre content from belimbi fruits. Bhaskar and Shantaram (2013) reported that belimbi fruit has 0.96% of crude fibre content. The crude fibre recorded in this present study showed a higher amount than the crude fibre of belimbi fruit jam reported by Anuar and Salleh (2019). This can be attributed to the different ripening stages of belimbi fruit used in jam processing as the maturity of fruit influence the fibre content, especially pectin, one of the sources of fibres hydrolysed during ripening.

In terms of total carbohydrate, BJMAL had significantly lower total carbohydrate content (22.19%) than the BJSUC (32.91%). The sweeteners used in the Belimbi fruit jam processing have a high influence on the total carbohydrate content. Higher carbohydrate content in BJSUC was associated with the high amount of sugar (i.e., sucrose) present in belimbi fruit jam. In addition, BJSUC showed a higher amount of total carbohydrate than the belimbi fruit jam reported by Anuar and Salleh (2019). This was attributed to the lower moisture content of belimbi fruit jam (33.58%) produced by Anuar and Salleh (2019) as compared to the belimbi fruit jam produced from this present study (66.41-76.58%), whereby, carbohydrate of fruit jam is more concentrated as their low-water content.

The calculated results for the calorie value showed that the belimbi fruit jam processed using maltitol (BJMAL) (95.24 kcal) had significantly lower calorie value than the belimbi fruit jam processed using 100% of sucrose (BJSUC) (136.09 kcal). This was due to the maltitol (2.1 kcal/g) has a lower caloric value compare with sucrose (Dobreva *et al.*, 2013). According to Food Act (Act 281) and Regulation Malaysia (2017), to claim the food products as reduced-calorie food products, the test food products must contain at least 25% less calories than the reference food. Therefore, from the results, belimbi fruit jam formulated with maltitol (BJMAL) can be considered as reduced-calorie jam as its calorie value was reduced to about 30% as compared with BJSUC (*i.e.*, reference food).

3.2 Biochemical properties

Data pertaining to biochemical properties of the different belimbi fruit jam formulations are tabulated in Table 3. The pH value of the belimbi fruit jam made with sucrose was 3.01 and pH 3.05 for belimbi fruit jam made with maltitol. In the belimbi fruit jam production, there was no addition of acidulant. The acidity of the belimbi jam mainly came from the oxalic acid content of the belimbi fruit itself and not from the citric acid which can be found in jam product sold local market. Therefore, the natural pH of the belimbi fruits is the reason for the low acid value of jam (2.05-2.27) (Bhaskar and Shantaram, 2013). According to Anuar and Salleh (2019), pH value plays a crucial role in determining the gel consistency, pH range of 2.8 to 3.3 is needed for the production of good jelly-like consistency and spreadability. Moreover, the most common cause of gel failure is insufficient acid. Food with a pH below 4.6 is considered as a low acid food. Thus, the belimbi fruit jam can be considered as a low acid food product and it is safe from bacterial or spore-forming pathogens growth. Hence, the shelf –life of the jam products could be prolonged (Food and Drug Administration, 2016). The present findings are close to pH value of 2.92 for dietetic jam made of Umbu-Caja (Mamede *et al.*, 2013).

Table 3. Biochemical properties of belimbi fruit jams

Parameter	BJSUC	BJMAL
pH^{ns}	$3.01±0.02^a$	$3.05±0.04^a$
Total Soluble Solids (°Brix)	$68.00±0.00^a$	$66.00±0.00^b$
Total Titratable Acid (%)	$0.14±0.00^a$	$0.09±0.01^b$
Water Activity^{ns} (a_w)	$0.80±0.00^a$	$0.80±0.00^a$
Vitamin C^{ns} (mg/100 g)	$23.18±2.21^a$	$22.90±3.18^a$

Presented data are mean value of three triplicates ± standard deviation. Means in the same row with different superscripts are significantly ($p<0.05$) different. ^{ns} – Not statistically significant at level $p<0.05$.

The values of total soluble solids showed no significant differences between BJSUC (68ºBrix) and BJMAL (66ºBrix). These results are in agreement with the results of Muresan *et al.* (2014), who observed the total soluble solid of fruit jam made from banana and ginger to contain 66.00-69.30ºBrix. This produced belimbi fruit jams are in complying with Food Act (Act 281) and Regulation Malaysia (2017), whereby, the final jam product shall contain 65% soluble solids (Brix).

The acidity is one of the physicochemical properties that are responsible for a longer shelf-life of the food products as it associates with a certain degree of acidity prevent the food products from microorganisms growth (Tifani *et al.*, 2018). The mean acidity value noted for BJSUC (0.14%) was significantly higher than BJMAL (0.09%). The higher acidity value of BJSUC might be due to sucrose is more hygroscopic than maltitol which tends to hold more water molecules. These water molecules then play an important role in the biochemical reaction, whereby, degradation of polysaccharides and breaking of pectic bodies occurred and forming organic acids (Sutwal *et al.*, 2019). Thus, more acid was found in belimbi fruit jam prepared with sucrose. The results obtained in this present study were not consistent with those of Ajenifujah-Solebo and Aina (2011), who reported that the fruit jam made from black-plum fruit has total titratable acid of 0.34%.

Water activity is one of an important environmental parameter to determine the ability of microorganisms to grow on food (Vilela *et al.*, 2015). There are no significant differences in water activity between the belimbi fruit jam prepared from sucrose and maltitol. Belimbi fruit jam made with sucrose or maltitol were recorded to have water activity values lower 0.80. According to Manitoba Government (2016), jam product should have water activity value ranges from 0.75 to 0.80. Therefore, this present findings showed that the water activity of all the belimbi fruit jams prepared was within the specified range of fruit jam. In addition, the water activity of belimbi fruit jams was lower than water activity reported by Correa *et al.* (2011) for guava jam made without added sugar (0.93). Thus, the belimbi fruit jams prepared in this study are the jam products that can better prevent the growth of microorganisms and subsequent extended of jams' shelf life. However, the water activity value obtained showed contrary to the results of moisture content (Table 2). According to Park (2008), various types of food with the same level of moisture content exhibit differences in perishability and stability that associate with their water activity value. Moisture content solely is not a reliable indicator of the perishability of food products, which is partially due to the differences in intensity of association of water with non-aqueous constituents. This intensity is often indicated by the value of water activity which is a more reliable indicator of perishability or stability of food products.

The results obtained regarding vitamin C are presented in Table 3. The statistical analysis revealed that there was no significant difference in vitamin C value between BJSUC (23.18 mg/100 g) and BJMAL (22.92 mg/100 g). The vitamin C content in Belimbi fruit jam is rather high as compared with jam made of osmotically dehydrated pineapple slices (13.33-18.40mg/ 100 g) (Fasogbon *et al.*, 2013) as well as higher than belimbi fruit jam with sucrose (3.79 mg/100 g) produced by Anuar and Salleh (2019). However, these findings are in line with those of Rafeek *et al.* (2015), who reported that the orange-based formulated low-calorie jams contain vitamin C ranged from 8.94 to 28.77 mg/100 g.

3.3 Physical properties

The results of hardness and spreadability of the different belimbi jam formulations are shown in Table 4. Hardness is measured by the force required to compress a food product (*i.e.*, belimbi fruit jams) between the molar teeth (Anuar and Salleh, 2019). BJMAL showed significant lower hardness value (401.29 g) than the BJSUC (639.63 g). A similar trend was observed for the spreadability parameter, whereby, BJMAL (266.71 g/s) had significantly lower spreadability value than BJSUC (869.28 g/s). According to Tifani *et al.* (2018), hardness is highly correlated with the spreadability parameters of the end food products. The higher the hardness value, the higher the force required for the foods to spread. From the results obtained in this present study, it indicates that BJMAL requires a lower amount of force to spread on the surface of food as compared with BJSUC. However, these findings showed lower hardness values than the dietetic jam made of Umbu-Caja (172.33-329.00 g) (Mamede *et al.*, 2013). In addition, both hardness and spreadability parameters were strongly influenced by acid/ pH, pectin, and type of sweeteners/ sugar content (Mamede *et al.*, 2013; Tifani *et al.*, 2018). These results are in agreement with the results of total soluble solids and total titrable acidity (Table 3), whereby, BJMAL showed lower total soluble solids and less acidic than the BJSUC. Therefore, it requires less force to spread the jam on the surface of the food.

Table 4. Hardness and spreadability of belimbi fruit jams

Parameter	BJSUC	BJMAL
Hardness (g)	639.63±46.41^{a}	401.29±20.07^{b}
Spreadability (g/sec)	869.28±33.46^{a}	266.71±14.66^{b}

Presented data are mean value of three triplicates ± standard deviation. Means in the same row with different superscripts are significantly ($p<0.05$) different. ^{ns} – Not statistically significant at level $p<0.05$.

3.4 Sensory evaluation

Sensory attributes are one of the determinants of a consumer's choice of food (Banaś *et al.*, 2018). The attributes of colour, aroma, sweetness, sourness, spreadability and overall acceptability were evaluated for all of the prepared jam. The results of the sensory evaluation for different belimbi fruit jams are tabulated in Table 5. The results show that the substitution of maltitol for sucrose had no significant impact on the scores for the attributes of colour, aroma, sweetness, spreadability, and overall acceptability. However, the sourness attribute was significantly different when sucrose was substituted with maltitol.

Table 5. Sensory evaluation of belimbi fruit jams

Attribute	BJSUC	BJMAL
Colour^{ns}	5.57±1.14^{a}	5.57±1.01^{a}
Aroma^{ns}	4.73±1.08^{a}	4.57±1.04^{a}
Sweetness^{ns}	5.80±1.00^{a}	5.47±1.20^{a}
Sourness	5.93±0.69^{a}	5.20±1.03^{b}
Spreadability^{ns}	5.40±1.10^{a}	5.67±1.45^{a}
Overall acceptability^{ns}	5.47±0.94^{a}	5.73±1.14^{a}

Presented data are mean value of three triplicates ± standard deviation. Means in the same row with different superscripts are significantly ($p<0.05$) different. ^{ns} – Not statistically significant at level $p<0.05$.

For colour attribute, BJMAL received a similar score (5.57) with BJSUC (5.57). Considering to the scale rated by panellists, panellists rated belimbi fruit jam with sucrose or maltitol (BJMAL or BJSUC) as 'moderately like'. Although maltitol does not react with amino acids (Dobreva *et al.*, 2013), thus may not cause the Maillard reaction, supposedly presented a lighter colour of belimbi fruit jam as compared with belimbi fruit jam with sucrose that caused Maillard reaction and resulting darker end product. Therefore, this can be concluded that panellists preferred belimbi fruit jams with lighter or brownish colour appearance. Similar results were observed in the study reported by Anuar and Salleh (2019) which found that panellists rated belimbi fruit jams prepared with different amount of pectin (1-3 g) as 'moderately like' (5.33-5.90).

Aroma is generally developed from the types of raw material (*i.e.*, fruit) used in the processing of jam. The belimbi fruit jams with sucrose or maltitol exhibited intense aroma and achieved final scores of 4.73 and 4.57 for BJSUC and BJMAL, respectively, which indicated 'neither like or dislike'. In terms of sweetness attribute, panellists scored the belimbi fruit jam with sucrose or maltitol at 5.80 and 5.47, respectively. Considering the total soluble solids results as presented in Table 3, BJMAL had a lower amount of total soluble solids than BJSUC. Therefore, the panellists is assumed to preferred jam that is less sweet to sweet.

During the sensory evaluation, it was observed that the belimbi fruit jam prepared with sucrose (BJSUC) received significantly higher score (5.93) than belimbi fruit jam prepared with maltitol (BJMAL) (5.20). Considering the results of total titratable acidity (Table 3), panellists prefer the belimbi fruit jam which was sourest. The substitution of maltitol for sucrose to belimbi fruit jams resulted in nearly the same spreadability levels and had no effect on the food application. Both BJSUC and BJMAL received the scores of 5.40 and 5.67, respectively. This indicates that the texture of belimbi fruit jams which was neither too soft nor too hard to spread were still acceptable to the panellists. These results are in agreement with those previously reported in Anuar and Salleh (2019). The authors reported that belimbi fruit jams with pectin amount of 1 and 3 g received 5.37 and 5.23 scores, respectively (Anuar and Salleh, 2019). This research concluded that the belimbi fruit jams prepared from sucrose or maltitol do not have any significant differences in overall acceptability. All the prepared belimbi fruit jams were acceptable by panellists as they received score 5.47 and 5.73 ('moderately like') for BJSUC and BJMAL, respectively.

4. Conclusion

The investigated belimbi fruit jam prepared from maltitol (BJMAL) meet the requirement of Food Act (Act 281) and Regulation Malaysia for labelling as 'jam' product as well as 'reduced-calorie jam'. The belimbi fruit jams from sucrose (BJSUC) or maltitol (BJMAL) were prepared from more than 35% of fruit and they had more than 65 ºBrix. In addition, approximately 30% of the calorie value in BJMAL was reduced as compared to the BJSUC. Evaluations of texture parameters and sensory attributes with the aids of instrumental or by untrained panellists make it possible to determine the acceptability of belimbi fruit jams prepared from sucrose or maltitol for consumption.

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