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Development of pastilles from flesh and rind of watermelon

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Abstract

A study was carried out to create a new product using watermelon flesh (sources of lycopene) and watermelon by-product, which was watermelon rind (sources of citrulline), into pastilles with different percentages of flesh and rind puree. The formulations involved were formulations A (70% flesh puree: 30% rind puree), B (50% flesh puree: 50% rind puree), and C (30% flesh puree: 70% rind puree). A commercial product was used as a reference in making the pastilles. The physical analyses that were carried out were pH, total soluble solids, water activity, colour analysis, and texture profile analysis (TPA). Chemical analysis that focused on lycopene determination, as well as sensory analyses, was also conducted. The pastilles produced had total soluble solids ranging from 41.44±0.68 to 49.03±1.49°Bx, and pH values measured at 2.52±0.09 to 2.54±0.17, which indicated an acidic aftertaste. Water activity was evaluated to be between 0.72±0.01 to 0.73±0.03, which signified the pastilles were safe to consume. The colour analysis for the L* value, a* value, and b* value was 36.84±1.48, 13.07±2.70, and 11.89±1.61, respectively, which indicated the yellowish-red colour of the pastilles. Formulation A had the highest lycopene value (0.197±0.01) as compared to the other formulations. The pastilles were successfully developed in seashell shapes with diameters of 2.74–2.76 cm and about 2.52–2.80 g in weight. The sensory evaluation showed that the pastilles from formulation B were more acceptable in terms of taste, appearance, and overall acceptability, followed by formulation A, and the least preferred was formulation C.

1. Introduction

Watermelon (*Citrullus lanatus*), which originates from the group of cucumber (*Cucurbitacea*), is a vast, oval, round or elongated tropical fruit (Koocheki *et al*., 2007). The skin is smooth with a dim green surface and light green stripes that turn yellowish-green when ripe. Watermelon is an extremely rich source of vitamins and other bioactive phytochemicals. Various studies have reported a high level of antioxidant activity in watermelons that is attributed to the phytochemical compounds (Choudhary *et al.,* 2015; Ijah *et al.,* 2015).

According to Romdhane *et al*. (2017), the watermelon fruit has nutrients and minerals such as vitamin A, B, C, E and also calcium, magnesium, iron and phosphorus. The major nutritious parts of the fruit are starch (6.4 g/100 g), vitamin A (590 IU), and lycopene (4,100 µg/100 g, in ranges of 2,300–7,200), an anti-carcinogenic compound found in red tissue watermelon. Lycopene substance of red-fleshed watermelon is nearly 40% higher than tomato with 4.81 and 3.03 mg/100 g, individually which may diminish the danger of specific malignancies such as prostate, pancreas, and stomach (Jaskani *et al*., 2006; Choudhary *et al.*, 2009). In addition, Tadmor *et al.* (2005) found that the amount of lycopene and beta-carotene in plants with orange-coloured tissue is slightly less than in red-coloured tissue. The carotenoid in the human body consists of almost 90% beta-carotene, alpha-carotene, and lycopene. Diverse carotenoid examples are found in red-fleshed and yellow-fleshed watermelons. Red-fleshed watermelon contains elevated amounts of lycopene and a shifting measure of β-carotene (Tadmor *et al.*, 2005). The health benefits of fruits are potentially enhanced by the synergistic effects of various phytochemicals such as lycopene, polyphenols, and carotenoids in fruits (Pinto *et al*., 2011), such as in watermelon.

The internal rind, which is generally light green or white, contains numerous shrouded supplements, is consumable, and is an alternative form of food

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preservative (Kistriyani *et al*., 2019). Most times, however, it is discarded because of its unappealing flavour. Although watermelon rind is regarded as a fruit by-product, it contains a valuable amount of total phenolic content, which is higher than that of the flesh (458 vs 389 mg chlorogenic acid equivalent kg^{-1} f.w.) and a higher content of the amino acid citrulline (3.34 vs 2.33 g kg^{-1} f.w.) (Tarazona-Díaz *et al.*, 2011). In addition, watermelon rind has hydroxyl radical scavenging and strong antioxidant activities as reported by Fang *et al*. (2002). Extracted rind citrulline also helps to remove nitrogen from the blood for conversion into the urine (Pons, 2003; Perkins, 2004). According to Rimando and Perkins-Veazie (2005), the citrulline in watermelon rinds provides an antioxidant activity that helps combat oxidative stress related to the development of various diseases. Citrulline has been reported to reduce risk factors for cardiovascular diseases (Hong *et al.*, 2015) and is also fundamental to circulatory and immune systems (Rimando and Perkins-Veazie, 2005). Approximately 30% of the total mass of watermelon comprises rinds (Bhattacharjee *et al*., 2020), and nearly 36 million tonnes of this fruit by-product are discarded (Al-Sayed and Ahmed, 2013). The utilisation of fruit by-products with high antioxidant values such as the watermelon rind is useful for producing valuable food products apart from having a potential for positive environmental impact.

Pastille, which is a soft confectionery product, is widely accepted due to its texture, shape, and delicious taste (Kia *et al.*, 2020). The composition of pastilles is accomplished by utilising different gelling operators, namely gelatine, starch, and pectin. The most essential, such as sucrose, glucose, and corn syrups (as glucose replacer), are commonly utilised as a part of sugar confectionery. Fortification of the pastille with natural antioxidants from plants sources is beneficial in delivering bioactive ingredients for potential health benefits (Amjadi *et al.*, 2018) and has been explored in many previous studies (Charoen *et al*., 2015; Yee *et al*., 2017; Azimi and Mortazavi, 2019; Kia *et al*., 2020). Food products utilising natural health-promoting properties from sources such as watermelon flesh and rind are therefore valuable and of great interest. However, limited studies have been carried out on the use of watermelon flesh and rind in pastille manufacturing. The aim of this work is therefore to develop and determine the best formulation of pastilles produced from watermelon flesh and rind puree. This study also evaluates the acceptability of pastilles produced from watermelon flesh and rind puree.

2. Materials and methods

2.1 Formulations and production of watermelon-based pastilles

Watermelon fruits and rinds were obtained from Batu Enam Market, Kuala Nerus, Terengganu, Malaysia. The rind and flesh puree were blended in a Panasonic MK-5087M mechanical food processor after undergoing washing, peeling, and blanching processes. The product developments were carried out in the Food Technology Laboratory, Faculty of Fisheries and Food Science, Universiti Malaysia Terengganu (UMT). Physical and chemical analyses were conducted in the Food Science Laboratory. The sensory tests were held in the Food Science Restaurant.

In general, the materials used to produce pastilles with watermelon fruits comprised watermelon rind puree, watermelon flesh puree, gelatine, pectin, glucose syrup, sorbitol, sugar, citric acid, and cornflour. The coating of pastilles was made from cornflour using silicone moulds. A commercial product was selected as a reference in this study (referred to as D) and three formulations (A, B, and C), whereby the percentages of each formulation were different from each other.

The development of pastilles produced from the flesh and rind of watermelon has been listed as a copyrighted work by the Intellectual Property Corporation of Malaysia (MyIPO). The ripe watermelon fruits were cleaned from debris or impurities before the washing process with tap water. After that, the watermelon fruits were cut and their flesh and rinds were separated using a peeler. Then, the flesh and rinds were washed and blanched in boiling water for 5 mins and left to dry and cool at room temperature for a while. The rinds and flesh were then proceeded to the blending process using a blender to obtain a puree. The flesh puree and rind puree of the watermelons were stored in a chest freezer (REMI/RCF-300, Malaysia) for future use.

In making the watermelon flesh and rind puree pastilles, the gelatine was mixed with cold water and left aside. Pectin was mixed with 40 g of water. Corn starch was diluted with 30 g of water. Citric acid was diluted with 7 g of water. Glucose syrup mixed with sorbitol was heated and boiled until it reached a temperature of 120°C (softball stage). Watermelon flesh and rind puree were added to the glucose syrup and sugar mixture. The gelatine and pectin mixtures were added and mixed well. Next, corn starch was added gradually and stirred. The mixture was cooked for 15 mins before citric acid was added. Silicone moulds were coated with corn starch to ease the removal of the pastilles. The mixture was then poured into the silicone moulds. The °Bx value was checked using a refractometer. At the temperature of 55°

C, the formed pastilles were dried by a drying cabinet. Afterwards, the pastilles were coated with sugar. Three formulations were prepared based on the ratios of each different formulation (Table 1).

2.2 Physicochemical and sensory analysis of pastilles

All analyses were carried out in triplicate.

2.2.1 pH

The pH of pastilles was measured by using a pH metre (CyberScanpH300, EutechInstrument, United States). The pH metre was calibrated prior to utilisation by immersing the electrode in deionised water and standard solutions of pH 4 and pH 7 by using a calibrated handle. The pH values of the samples were recorded.

2.2.2 Total soluble solids

A refractometer (Pal-alpha, Atago, Japan) was used to determine the total content of soluble solids (TSS) or sugar in the product. The refractometer measured TSS as degree Brix (°Bx) in 0.1% graduation (AOAC, 2000).

2.2.3. Water activity

Water activity is defined as the ratio of the partial pressure of water above a product to that of pure water at the same temperature. Water activity was measured by using METER Aqualab, 4TE, by placing the sample into a closed chamber, equilibrating the liquid-phase water in the sample with the vapour-phase water in the headspace, and measuring the relative humidity of the headspace (Aqualab, 2015).

2.2.4 Colour analysis

To determine the colour of the pastilles, Minolta Chroma Meter CR 300 (Japan) was used. The Minolta Chroma Meter was calibrated with a white calibration plate before the process began. The minced pastilles were put onto a measuring plate until they covered the whole plate. After that, the reading was obtained. This action was taken as a precautionary step to avoid errors while taking the reading. The procedures were repeated with other samples. The samples were done in triplicate (Choudhury, 2014).

2.2.5 Texture analysis

A Texture Analyser Machine (TA.XT Plus, USA) was used to analyse the texture of the pastilles. The products were measured in terms of hardness, springiness, cohesiveness, gumminess, chewiness, and resilience.

2.2.6 Determination of lycopene

The lycopene determination analysis was performed to check the availability of lycopene after the processing. UV-VIS spectrophotometers were used to determine lycopene in the product at the absorbance of 417nm (Sharma and Le Maguer, 1996).

2.2.7 Sensory evaluation

Appearance, colour, odour, texture (chewiness), taste, sweetness, and overall acceptability of the watermelon rind pastilles were evaluated (Table 2). The sensory evaluation session was performed based on a 7-point hedonic scale (a higher score indicates better quality attributes) (Hasmadi *et al*., 2018). All the attributes were independently evaluated by 30 untrained panellists based on their likeness. The sample was coded with a 3-digit code. The mean score for each attribute was reported.

2.3 Statistical analysis

All the results from the chemical analysis, physical analysis, and sensory evaluation were analysed by using

Table 1. Ingredients in watermelon flesh and rind pastille.

Ingredients (%)	A (70% flesh puree:	B (50% flesh puree:	C (30% flesh puree:
Watermelon rind puree	9.09	15.15	21.21
Watermelon flesh puree	21.21	15.15	9.09
Gelatine	4.55	4.55	4.55
Pectin	1.52	1.52	1.52
Glucose syrup	18.79	18.79	18.79
Sorbitol	12.73	12.73	12.73
Citric acid	0.61	0.61	0.61
Corn flour	1.81	1.81	1.81
Water	30.30	30.30	30.30
Total	100.00	100.00	100.00
Yields (g)	330.00	330.00	330.00
Brix value	41.44	49.03	46.58

Table 2. Information about sensory evaluation

Test	Acceptance test
Scale	7-point hedonic scale (1 – Extremely dislike; 7 – Extremely like)
Attributes measured	Appearance; colour; odour; texture (chewiness); taste; sweetness; and overall acceptability
Panellist	30 untrained panellists
Statistical method	One-way ANOVA and Fisher's Least Significant Difference (LSD) multiple comparison test

MINITAB Version 14 Software and all data obtained were presented at mean±standard deviation (Wasnin *et al*., 2012). The statistical methods used were One-way ANOVA and Fisher's Least Significant Difference (LSD) multiple comparison test in order to determine the significant difference ($p<0.05$) between the formulations and commercial products.

3. Results and discussion

3.1 Development of pastilles

Watermelon flesh and rind puree pastilles were successfully developed. Generally, the pastilles were in seashell shapes with diameters of 2.74–2.76 cm and weighed about 2.52–2.80 g. Figure 1 reveals the three formulations of pastilles and one from the commercial product, which acted as a reference in making the pastilles.

Figure 1. Three formulations of watermelon flesh and rind puree pastilles, where A: (70% flesh puree: 30% rind puree); B: (50% flesh puree: 50% rind puree); C: (30% flesh puree: 70% rind puree); and D is the commercial product.

A combination of glucose syrup and sorbitol was used as a sweetener for the pastilles. Since the °Bx values for the watermelon flesh and rind puree pastilles were quite low (less than 20°Bx), this might affect the final texture of pastilles. In addition to providing sweetness, sorbitol acted as a texturising agent and excellent humectant. Sorbitol was utilised as a humectant as part of numerous sorts of items for insurance against loss of moisture substance. Its moisture-stabilising action shielded these items from drying and maintained their underlying freshness amid capacity (Dwivedi, 1991). Zainol *et al*. (2020) demonstrated that the high value of moisture content in belimbing buluh fruit pastilles in formulation 1 might be due to a higher concentration of gelatine.

For gelling properties of a pastille, a combination of gelatine and pectin was used to produce the best texture of pastilles since pectin helped the gellification in the proper concentration of pH and sugar (Mahattanatawee *et al*., 2006).

3.2 pH

Table 3 illustrates the data concerning pH, water activity, and TSS for the different formulations of the pastilles and commercial products. The differences in terms of pH value obtained for all the watermelon flesh and rind puree pastilles' formulations and commercial product were similar since there was no significant difference ($p>0.05$) observed from 2.52±0.09 to 2.69±0.07, which indicated an acidic aftertaste. This occurred because the amount of citric acid used in all formulations was the same, which was 2 g. Due to the small amount of citric acid inserted in each of the formulations, the acidic taste could be discerned after the pastille was swallowed. This is known as an acidic aftertaste and it excellently masks the bitter aftertaste that is commonly related to gummy, gelatine-based confectionery (Sortwell, 2004).

Table 3. Data related to the pH, water activity, and total soluble solids

Formulation	pH	Water Activity	Total Soluble Solids (TSS)
A	2.54±0.07^{a}	0.73±0.03^{a}	41.44±0.68^{c}
B	2.54±0.17^{a}	0.72±0.01^{ab}	49.03±1.49^{b}
C	2.52±0.09^{a}	0.74±0.03^{a}	46.58±1.68^{b}
D	2.69±0.07^{a}	0.66±0.01^{b}	54.47±0.84^{a}

Values are presented as mean±SD (n = 3). Values with different superscript within the same column are significantly different ($p<0.05$).

3.3 Total soluble solids

The reading of total soluble solids (TSS) obtained from all the formulations (A–C) gradually increased when the amount of watermelon rind puree increased from 41.44±0.68 to 49.03±1.49°Bx (Table 3). There was a significant difference ($p<0.05$) in the formulations of the pastilles. Formulation B (50% flesh puree: 50% rind puree) was found to be significantly the highest with 49.03±1.49°Bx as compared to formulation A (70% flesh puree: 30% rind puree) with 41.44±0.68°Bx. According to Delgado *et al*. (2015), the final product of the gummy jellies should achieve at least 30–75% TSS to preclude

mould growth. Based on this, the watermelon flesh and rind puree pastilles achieved the condition needed for producing safe-to-be-consumed pastilles.

Meanwhile, the commercial product, D, had the highest °Bx value and was significantly different ($p<0.05$) as compared to the samples (formulations A–C). This could be due to the ingredients added in the commercial product, which had a higher amount of sweetener and added artificial colouring such as Allura red (E129) in contrast to the formulations that did not use artificial colouring and other preservatives.

3.4 Water activity

Table 3 illustrates that there was a significant difference ($p<0.05$) in water activity between the formulations and commercial products. However, there was no significant difference ($p>0.05$) among the formulations (A–C). The values of water activity in formulations (A–C) were similar, which was from 0.72±0.01 to 0.74±0.03. When the formulations were compared with the commercial product, the water activity in the commercial product was more stable than the formulations with 0.66±0.01. This could be due to the high amount of sugar and glucose added to the commercial product. Sugar is an excellent humectant and is used to reduce water activity for microbial control. The addition of monosaccharides to sucrose solutions will maximise TSS and lower the water activity, and thus the combination of sugar with glucose syrup makes the commercial product more stable and safe to consume in the market (McCann *et al*., 2007).

The water activity of food must be below 0.95 to prevent the growth of bacteria, yeast, and mould. Confectionery products cover a wide range of water activities from 0.2 to 0.9 a_w. The water activity in gummies and jellies like pastille must be in the range of 0.50–0.75 to make the pastilles shelf-stable (Ergun *et al.*, 2010). From Table 3, the average of watermelon flesh and rind puree pastilles was around 0.72±0.01 to 0.74±0.03, which was still in the safe range. Therefore, the watermelon flesh and rind puree pastilles produced were safe and considered shelf-stable confectionery products.

3.5 Colour analysis

Colour analysis was conducted by using a colourimeter to determine the value of the colour possessed by the different formulations in the watermelon flesh and rind puree pastilles in comparison with the commercial product. All the results were observed and recorded as shown in Table 4.

Generally, the L* value represents light versus dark, where a lower number (0–50) indicates dark and a higher number (51–100) indicates light (Luana *et al*., 2014). The L* value gradually increased when the percentage of rind puree watermelon increased. The L* value among the formulations (A–C) was not significantly different ($p>0.05$) but had a significant difference ($p<0.05$) with the commercial product (D). The highest L* value among the formulations was formulation C (30% flesh puree: 70% rind puree), while formulations A (70% flesh puree: 30% rind puree) and B (50% flesh puree: 50% rind puree) had similar L* values. These might be due to the fact that a lower L* value gave a darker colour. In contrast, a higher L* value gave a lighter colour. A higher percentage of watermelon rind puree gave a lighter colour to the pastilles, which explained the reason why formulation C had a lighter colour as compared to the other formulations.

From Table 4, the a* value decreased gradually with the increase in the amount of rind puree in the pastilles. Formulation A (70% flesh puree: 30% rind puree) showed the highest a* value, which was 19.86±1.97. Formulation C (30% flesh puree: 70% rind puree) gave the lowest a* value with 10.45±1.97. There was a significant difference ($p<0.05$) among the formulations. Luana *et al*. (2014) defined that a* value represents the redness to greenness colour, where a positive number indicates red and a negative number indicates green. A higher a* value indicates a higher intensity of redness in a measured sample. Choudhary *et al*. (2009) found that lycopene, which contained red carotenoid pigments of

Table 4. L* value, a* value, and b* value in different formulations of pastilles and comparison with the commercial product

Sample	A (70% flesh puree: 30% rind puree)	B (50% flesh puree: 50% rind puree)	C (30% flesh puree: 70% rind puree)	D (Commercial product)
L* value	36.29±2.56[b]	36.84±1.48[b]	40.18±2.25[b]	53.43±0.95[a]
a* value	19.86±1.97[a]	13.07±2.70[b]	10.45±1.97[b]	12.33±1.11[b]
b* value	12.62±1.36[a]	11.89±1.61[a]	13.03±2.12[a]	10.69±1.40[a]
Colour	Yellowish-red			

Values are presented as mean±SD (n = 3). Values with different superscript within the same row are significantly different ($p<0.05$). L* value (degree of lightness to darkness), a* value (degree of redness to greenness), and b* value (degree of yellowness to blueness).

red-fleshed watermelon, was nearly 40% higher than tomato with 4.81 and 3.03 mg/100 g, individually. In addition, watermelon contains 60% lycopene more than the lycopene concentration found in tomatoes. Interestingly, the highest bioavailable lycopene makes watermelon the lycopene leader among fresh produce (Oberoi and Sogi, 2017). Therefore, formulation A showed a redder colour to the pastilles as compared to the others since formulation A contained a higher percentage of red flesh puree in the pastilles.

The b* value in different formulations of the pastilles showed no significant difference ($p>0.05$) among the samples and commercial products. The highest b* value was in formulation C (30% flesh puree: 70% rind puree), which was 13.03±2.12, whereas the lowest b* value was formulation B (50% flesh puree: 50% rind puree) with 11.89±1.61. The b* value demonstrates the degree of yellowness to blueness, where a positive number indicates yellow and a negative number indicates blue (Luana *et al*., 2014). A higher b* value in formulation C might indicate a more yellowish colour as compared to a lower value.

3.6 Texture analysis

A Texture Profile Analysis (TPA) test was performed by using Texture Analyser Machine (TA.XT Plus, USA) to analyse the texture of the pastilles. Table 5 shows the data and information related to the different parameters that were observed and analysed.

Hardness is defined as the force required to compress a material by a given amount (Delgado *et al*., 2015). The hardness of pastilles had no significant difference ($p>0.05$) among the formulations. There was a significant difference ($p<0.05$) between the formulations and commercial products. Formulation C (30% flesh puree: 70% rind puree) had the highest value than the other formulations with 991.23±74.24. A higher value gave a harder texture as compared to a lower value that gave a softer texture. It is interesting to note that an increase in hardness might be because of a higher percentage of watermelon rind puree in formulation C. According to Vieira *et al*. (2008), candy hardness values are dependent on the solids' content. The soluble solids content was more closely correlated with textural changes in jellies than with residual moisture or water activity. Formulation A (70% flesh puree: 30% rind puree) had a lower value than formulation C probably because the total soluble solids in formulation A were the lowest and gave a softer texture to the pastilles.

Springiness can be defined as the elastic recovery that occurs when the compressive force is removed. There was no significant difference ($p>0.05$) in the different formulations of pastilles for springiness. The value of springiness among the formulations was within the range of 0.96±0.01 to 0.99±0.01 (Table 5). However, there was a large and significant difference ($p<0.05$) between the formulations and commercial products. According to Delgado *et al*. (2015), jellies have a high moisture level during drying and their elasticity is not fully developed. The samples remained strongly deformed after the first bite, which decreased their cohesiveness and springiness, and the values strongly depended on the mechanical behaviour during the second bite. The commercial product might have well-developed elasticity as compared to the formulations of the watermelon flesh and rind puree. Therefore, it gave a large different value in contrast to the formulations.

The definition of gumminess is the energy required to break down a semi-solid food ready for swallowing and is also related to hardness. There was a significant difference ($p<0.05$) between the commercial product and formulations. However, between the formulations, there was no significant difference ($p>0.05$).

Gumminess is the result of multiplying hardness and cohesiveness. The increase in hardness of the pastilles gave a higher gumminess value. The value of gumminess decreased from the higher percentage of flesh puree used, while the value of gumminess increased when the

Table 5. Data of different parameters used in the texture analysis for different formulations of the pastilles and commercial product.

Sample	A (70% flesh puree: 30% rind puree)	B (50% flesh puree: 50% rind puree)	C (30% flesh puree: 70% rind puree)	D (Commercial product)
Hardness	849.70±93.63[a]	807.03±131.40[a]	991.23±74.24[a]	246.08±8.75[b]
Springiness	0.96±0.01[a]	0.98±0.06[a]	0.99±0.01[a]	17.19±1.29[b]
Cohesiveness	0.62±0.03[b]	0.56±0.03[b]	0.57±0.01[b]	0.96±0.06[a]
Gumminess	566.58±103.11[a]	486.21 ±81.80[a]	482.63±100.37[a]	230.27±11.69[b]
Chewiness	648.81±45.29[a]	477.43±84.02[a]	560.12±64.08[a]	4068.69±449.35[b]
Resilience	0.67±0.03[a]	0.50±0.06[b]	0.52±0.05[b]	0.54±0.03[b]

Values are presented as mean±SD (n = 3). Values with different superscript within the same row are significantly different ($p<0.05$).

percentage of rind puree decreased. This explained the reasons that the pastilles in formulation A had the highest gumminess value as compared to the other formulations since it used a low percentage of rind puree (30%) and a higher percentage of flesh puree (70%). Meanwhile, the commercial product was softer in terms of texture, which contributed to the lowest value of the gumminess parameter as compared to the formulations. Delgado and Bañón (2015) showed that hardness value could also be dependent on the gelatine, Arabic gum, water, sugar, and dehydration process.

The chewiness is the energy required to chew solid food into a state ready for swallowing (Delgado *et al*., 2015). The commercial product had the highest value of chewiness as compared to the formulations with 4068.70±449.35 (Table 5), indicating that it would need higher energy to chew the pastilles before swallowing. There was no significant difference ($p>0.05$) among the formulations observed. When compared with the commercial product, there was a significant difference ($p<0.05$) between the formulations and commercial product. Chewiness is the result of multiplying hardness, cohesiveness, and springiness (Delgado *et al*., 2015). Since formulation A had a higher value of gumminess, it also affected the chewiness value, which contributed to the higher chewiness value of 648.81±45.28 as compared to the other formulations.

3.7 Determination of lycopene

Watermelon is a rich natural source of lycopene, a carotenoid of great interest due to its antioxidant capacity and potential health benefits. Food with a high concentration of lycopene is referred to as functional food (Soteriou *et al*., 2014). Figure 2 shows the data regarding the lycopene level in raw watermelons and different formulations of the watermelon flesh and rind puree pastilles.

From Figure 2, there was a significant difference ($p<0.05$) between the various formulations. The ranges of the lycopene value increased from formulation C (30% flesh puree: 70% rind puree) to formulation A (70% flesh puree: 30% rind puree) from 0.166±0.00 to 0.197±0.03. This could be because formulation A had the highest percentage of red flesh puree as compared to formulation C. Meanwhile, the commercial product D, which represented the raw watermelon flesh, had the lowest value with 0.071±0.00.

During processing, the temperature and mechanical influence would weaken the strength of the bond between lycopene and tissue matrix, as well as facilitate in the breaking of the cell walls so that the release of lycopene would increase in processed products (Stahl and Sies, 1992). Elumalai *et al*. (2013) also reported that thermal processing triggers the isomerisation of lycopene bioavailability. As a consequence, a heat-processed tomato contains higher bioavailable lycopene than a fresh tomato. The finding supported the result as to why the lycopene value increased when the percentage of red flesh puree was higher in the watermelon flesh and rind puree pastilles.

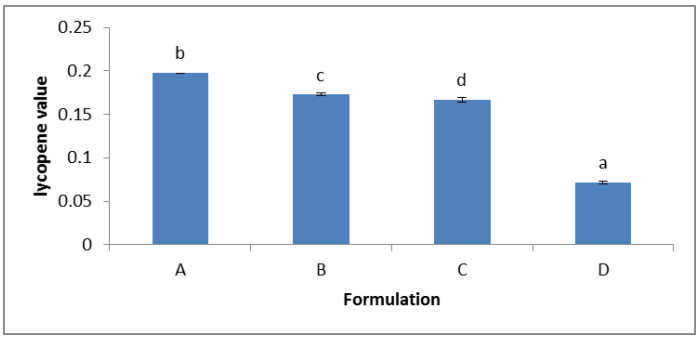

Figure 2. Bar graph for the lycopene value in different formulations of pastilles, where A: (70% flesh puree: 30% rind puree); B: (50% flesh puree: 50% rind puree); C: (30% flesh puree: 70% rind puree); and D is from raw watermelon. Bars with different superscript are significantly different ($p<0.05$).

3.8 Sensory evaluation

According to the Institute of Food Technologists (IFT), sensory evaluation is a scientific method used to evoke, measure, analyse, and interpret those responses to products as perceived through the senses of sight, hearing, touch, smell, and taste (IFT, 2007). Sensory evaluation was conducted to evaluate the acceptance of watermelon flesh and rind puree using untrained panellists. There were 28 female respondents and 2 male respondents, of which 26 of them were Malay and the rest were Chinese. The age range was from 20 to 35 years old. All 30 respondents answered several attributes such as appearance, colour, odour, texture, taste, sweetness, and overall acceptability. Table 6 shows the data of the sensory evaluation for the watermelon flesh and rind puree pastilles.

In terms of colour, there was a significant difference among the samples ($p<0.05$). As seen in Table 6, the highest acceptance of colour was formulation A (70% flesh puree: 30% rind puree) with 5.23±1.25 and the lowest colour acceptance was formulation C (30% flesh puree: 70% rind puree), which was 4.23±1.61. This was clearly shown from Table 6 that most of the untrained panellists accepted and preferred formulation A for colour attribute. Due to the higher amount of red flesh puree in formulation A, it gave a redder colour to the pastilles. Furthermore, from the colour analysis using a colourimeter, formulation A recorded the highest amount of a* value with 19.86±1.97 as compared to the other

formulations.

Next, the acceptance of odour in the different formulations showed no significant difference ($p>0.05$). Based on the result in Table 6, the range for the odour was between 4.27±1.41 and 4.43±1.68. Table 6 shows that most of the untrained panellists preferred and accepted the odour in formulation A (70% flesh puree: 30% rind puree).

The sensory data for texture attribute (Table 6) demonstrated that there was no significant difference ($p>0.05$) among the formulations, which was in the range of 4.57±1.38 to 4.90±1.37. Based on Table 6, the acceptance of the untrained panellists decreased across the formulations (from formulations A to C). This could be due to the different formulations among the samples. The lower amount of red flesh puree and the higher amount of rind puree of watermelon pastilles, the less favourable to the untrained panellists. In addition, the texture analysis using TPA showed that the overall parameters observed demonstrated no significant difference ($p>0.05$) except for resilience. From both analyses (instrumentation analysis and human sensory panels), it was shown that the texture of the watermelon flesh and rind puree pastilles still needed to be modified until the pastilles reached an acceptable level in both instrumentation and consumer acceptance.

The taste of the watermelon flesh and rind puree pastilles was an important indicator for consumers to make a repeat purchase or not. Table 6 shows no significant difference ($p>0.05$) among the samples. The range of the taste attribute was from 4.70±1.29 to 5.07±1.31. The result from the sweetness attribute with a range of 4.87±1.46 to 5.00±1.11 also revealed the same result, where there was no significant difference ($p>0.05$) among the samples. This indicated that most of the untrained panellists agreed that there was not much difference in terms of taste and sweetness among the formulations. Since the mean score ranges of both attributes were in the middle (4–5), it showed that the taste and sweetness attributes were acceptable to the untrained panellists in all formulations.

The overall acceptance for the watermelon flesh and rind puree pastilles is presented in Table 6. It is obvious that formulation B (50% flesh puree: 50% rind puree) had the highest likeness in terms of overall acceptance with 5.30±1.18. Conversely, formulation C (30% flesh puree: 70% rind puree) had the lowest likeness in terms of overall acceptance with 4.87±1.28. It can be seen that most of the untrained panellists accepted and preferred formulation B for overall acceptance. The reason might be due to the fact that the taste attribute was the most acceptable to them. The other attributes for formulation B had a middle value mean score, making formulation B the most acceptable to the untrained panellists.

4. Conclusion

The watermelon flesh and rind puree pastilles were successfully developed with a yellowish red colour, seashell shapes with diameters of 2.74–2.76 cm and weights of about 2.52–2.80 g. When compared between the formulations, the results of the physical, chemical and sensory analyses revealed significant differences ($p<0.05$). When comparing the formulations with the commercial product, there was a significant difference ($p<0.05$) in all analyses, except for parameter resilience in the texture analysis and taste attribute in the sensory analysis. The physical analyses that were conducted included pH, total soluble solids, water activity, colour analysis, and texture profile analysis (TPA). The pH value was similar with a range of 2.52±0.09 to 2.54±0.17, which gave off an acidic aftertaste to the pastilles. For water activity, the pastilles were in the range of 0.72±0.01 to 0.74±0.03, which was safe to consume. TSS showed that formulation B (49.03±1.49) was the highest and formulation A was the lowest (41.44±0.68), which is still in the recommended range of TSS for pastilles. Lycopene determination was the test performed for the chemical analysis. Formulation A showed the highest value in lycopene content since it has

Table 6. Data for sensory analysis in different formulations of pastilles

Sample	A (70% flesh puree: 30% rind puree)	B (50% flesh puree: 50% rind puree)	C (30% flesh puree: 70% rind puree)
Appearance	4.80±1.37[a]	4.83±1.23[a]	4.30±1.49[a]
Colour	5.23±1.25[a]	5.10±1.24[a]	4.23±1.61[b]
Odour	4.43±1.68[a]	4.27±1.41[a]	4.27±1.72[a]
Texture	4.90±1.37[a]	4.67±1.27[a]	4.57±1.38[a]
Taste	4.70±1.29[a]	5.07±1.31[a]	4.97±1.22[a]
Sweetness	5.00±1.11[a]	4.97±1.33[a]	4.87±1.46[a]
Overall acceptability	4.93±1.08[a]	5.30±1.18[a]	4.87±1.28[a]

Values are presented as mean±SD (n = 3). Values with different superscript within the same row are significantly different ($p<0.05$).

a higher amount of watermelon flesh puree (70%) and a low amount of watermelon rind puree (30%) in the pastilles. The sensory evaluation demonstrated that the pastilles from formulation B (50% flesh puree: 50% rind puree) were more acceptable in terms of taste, appearance, and overall acceptability among the untrained panellists. This was followed by formulation A (70% flesh puree: 30% rind puree) and the least preferred was formulation C (30% flesh puree: 70% rind puree). The panellists preferred formulation B because the taste was the most acceptable to them. The mean score for other attributes of formulation B was in the middle value, making formulation B the most acceptable among the untrained panellists. There is a great potential usage of watermelon flesh and rind in the production of pastille products because the flesh and rind can be utilised in value-added products. Reused rind helps greatly to manage the by-product of this fruit. Adding rind, which is rich in citrulline, into the product will increase the nutrient value in the pastilles since rind offers attractive sources of natural antioxidants and dietary fibre. Therefore, the flesh and rind puree of watermelon pastilles have a great potential to be commercial in the industry. Shelf-life study and microbial test should be assessed on the developed watermelon-based pastilles to confirm their safety.

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