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Utilization of Gum Arabic as a Gelatine Substitute in Halal Watermelon (*Citrullus lanatus*) Pastille

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Abstract

Gelatine is widely used in pharmaceutical and food ingredient that is crucial in most Halal research. Non-halal gelatine accounts for 90% of the world's supply, which is typically taken from animals (bovine and porcine). The expanding and profitable halal, kosher and vegetarian markets (including Hindu) represent a substantial interest in gelatine substitution. Gelatine (G), a versatile hydrocolloid, is a significant ingredient in the confectionary industry due to its gel formation, high water-binding capacity, thickening, colloidal function, and adhesion/cohesion. Gum arabic (GA), a key hydrocolloid used in pastille manufacture, works as a stabilizer and fat emulsifier. The main objective of this study was to ascertain the effect of gum arabic and gelatine substitution on the physicochemical properties, antioxidant activity and sensory acceptability of halal watermelon (Citrullus lanatus) pastille. pH analysis, total soluble solid (TSS), texture profile analysis (TPA), colour, water activity (a_w), melting point, calorie content, antioxidant activity by 2,2-diphenyl-2-picrylhydrazyl (DPPH), mineral content, proximate composition as well as sensory acceptability test were conducted on five different samples {A (0%GA:16%G); B (4%GA:12%G); C (8%GA:8%G); D (12%GA:4%G); and E (16%GA:0%G), respectively. The ideal formulation in terms of physicochemical qualities, antioxidant activity, and sensory acceptance was a sample with 12% gum arabic and 4% gelatine. Also, high antioxidant activity (44.72±3.76), low fat content (0.44 ± 0.27%) and calories (3054.23 ± 6.55cal/g) compared to other samples. The crude fibre and carbohydrate, which were (1.14 ± 0.08%) and (70.68%) were an advantage of this sample as both nutrients are essential in food due to their role to absorb water, assist in intestinal transit and provide roughage for the bowel. The sensory test that the 12% gum arabic and 4% of gelatine sample was most accepted compared to other samples. Gum arabic is a halal substance that can be recommended to produce gelatine alternatives in the pharmaceutical and food industries.

Keyword: *Antioxidant; Citrullus lanatus; Gelatine alternative; Gum Arabic; Pastille*

Introduction

Consumers' demands for functional foods can be fulfilled by creating products that have outstanding sensory and nutritional qualities as well as useful compounds (Jafari *et al*., 2017). Food industry are looking for an alternative method of producing convenient and functional foods, for example, confectionery products such as soft candy, hard candy, toffee, jelly, gum, caramel toffees, pastilles, and gummy products to fulfil consumers' needs. Pastille that has transparent characteristics uses bases such as gelatine, gum, sucrose or glycerogelatin (Makinen, 2011). Certain

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consumer groups may be prohibited from consuming products that contain the animal-based component gelatine due to religious beliefs and vegetarian lifestyle preferences. Using a multiplex quantitative polymerase chain reaction (qPCR) assay that can distinguish between bovine, porcine, and fish gelatine species, Sultana et al. (2020) revealed that two out of 35 halal-branded processed food and dietary items on the market tested positive for pig species.

Gelatin is utilised extensively in the food business because of its beneficial and distinctive functional qualities. Gelatin is typically employed as a stabilising, thickening, and gelling ingredient. Texturization, emulsification, and adhesiveness are other gelatin functional qualities. Gelatin is used by food manufacturers in a wide range of products, including marshmallows, jellies, milk desserts, and gummy sweets (Wang and Hartel, 2022). Gelatin is a type of product with an animal origin and derived from the collagen of leather or bones. The role of gelatin in gummy jelly was to form a gelling network by their junction zones. The proportions of global production in recent years have roughly been as follows: 46 percent from pigskin, 29.4 percent from cow skins, 23.1% percent from cow bones, and 1.5 percent from other sources. Gelatin ranked 726th in terms of global trade in 2019 with $2.01 billion in trade. Gelatin exports increased by 6.76% between 2018 and 2019, from $1.88 billion to $2.01 billion (Velasco-Bejarano et al., 2022).

Due to its widespread use in food and pharmaceutical goods, gelatine is one of the halal ingredients that has received the most research. Gelatine substitutes with most or all of the special functional features of mammalian gelatine have been the subject of years of research (Mohd Zin *et al*., 2020). Morrison *et al.* (1999), stated that the approach to develop gelatine alternatives for food industry should be specific. Many polysaccharides that have been offered as gelatine substitutes for the food industry often have less flexible molecular backbones than gelatin, which results in higher viscosities than gelatin (Morrison *et al.*, 1999). The addition of gum arabic is recommended as it is a stabilizer and viscosity-controlling agent in food (Singh *et al*., 2017). Gum arabic was obtained from *Acacia senegal* or *Acacia seyal* that is halal and possesses both hydrophilic and hydrophobic affinities (Sowntharya *et al*., 2017). Based on its dried, rich, and edible gum feature, it is also recognised as a superb source of soluble dietary fibre that dissolves readily in water (Mariod, 2018; Mohammed, 2015; Hadi *et al*., 2010).

Watermelon (*Citrullus lanatus*) composition is predominantly water with 92% along with vitamins, minerals, amino acids, lipids and sterols (Tlili *et al*., 2011), and lycopene, which helps to overcome many problems in human health, including heart disease, atherosclerosis and cancer (Szalay, 2017). The only utilized part of the watermelon is the flesh or juice which can be consumed right away while the rind and seed were usually disposed of as waste. As a result, relevant studies must be undertaken to increase watermelon utilization and preservation to prolong its shelf life. The idea of creating a halal confectionary product based on watermelon pastille is therefore crucial. As a result, the creation of halal watermelon pastilles increases consumer choice in the confectionery market and offers extra nutritional advantages without sacrificing the gummy-textured pastilles' original physical characteristics. The objective of this study was to determine the effect of gum arabic and gelatine substitution on the physicochemical properties, antioxidant activity and sensory acceptability of halal watermelon pastille.

Materials and methods

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2.1 Raw materials

Raw materials were purchased from Pasar Batu Enam, Kuala Nerus, Terengganu. Gum Arabic provided by Natural Prebiotic (M) Sdn. Bhd.

2.2 Sample preparation

Watermelon was peeled, cut into smaller pieces and grind by using a food processor (Kenwood, UK) to obtain the juice. The clear juice was obtained by sieving the crushed watermelon through 2 layers of muslin cloth 3 times. Once the clear fruit juice was obtained, it was pasteurized at 71^{o}C for 2 min and then rapidly cooled with ice water for 7 min. A quarter of the juice was then dissolved with glucose syrup and sorbitol. The mixture was then heated to 121^{o}C (Zainol *et al*., 2020). Gelatine was dissolved in another portion of watermelon juice before adding the mixture into corn flour and GA that had also been dissolved in the same portion of watermelon juice (Minifie, 1989). A total of 5 formulations were developed that were composed of glucose syrup, watermelon juice, GA, gelatine, sorbitol, cornflour and citric acid, as presented in Table 1. The dissolved hydrocolloid was then added to the cooled solution and thoroughly stirred. The mixture was allowed to cook until it reached a temperature of 70-80°C. The mixture was cooled to 60^{o}C before adding citric acid (Grenby, 1996). The mixture was then poured into a corn flour-lined mould and dried in a dehydrator at 46^{o}C for 16 h. The prepared pastille was then removed from the mould and coated with castor sugar (Zainol *et al*., 2020).

Table 1. Formulations of watermelon pastille

Ingredients	Formulation (%)				
	A	B	C	D	E
Glucose Syrup	20	20	20	20	20
Watermelon Juice	50	50	50	50	50
Gum Arabic	**0**	**4**	**8**	**12**	**16**
Sorbitol	10	10	10	10	10
Corn flour	3	3	3	3	3
Gelatine	**16**	**12**	**8**	**4**	**0**
Citric Acid	1	1	1	1	1
Total	100	100	100	100	100

2.3 Physical analysis

2.3.1 pH determination

Determination of pH was done using a Eutech pH 700 Meter, pH meter (Thermo Fisher Scientific, MA USA). Briefly, 10 g sample was crushed, weighed, and placed in a dry container. Then, 10 ml of distilled water was added to the sample before the container was sealed and shaken until the sample disperses into a semi-liquid mixture (Ramlan *et al*., 2021).

2.3.2 Determination of total soluble solids

Determination of total soluble solid was conducted by using a hand-held refractometer (Mwoukee MA871:0-85% Brix, USA). A small drop of the pureed sample was dropped onto the glass plate of the refractometer, and it was spread as a thin film between two glass plates, which is the movable one, and the other is fixed (Hashim *et al*., 2021).

2.3.3 Colour analysis

The colour of the pastille was being measured using the Minolta colorimeter (Konica Minolta CR300, Japan). The probe was evenly covered with the pastille sample to get the most accurate reading and the analysis was repeated three times to obtain the average values of L* a* and b* (Chew *et al*., 2020).

2.3.4 Texture profile analysis

Samples hardness, adhesiveness, cohesiveness, springiness, gumminess and chewiness were determined using a Texture Analyzer (Stable Micro System, TA.XT.Plus, Surrey, UK) with a P36/R probe. Three measurements were recorded for each sample (Azuan *et al*., 2020).

2.3.5 Determination of melting point (DSC)

Determination of melting point was conducted using a Differential Scanning Calorimetry (DSC) (Mettler Toledo, USA). A sample of 5-10 mg was weighed into a pre-weighed pan. Sample and reference pan was then placed in DSC cell and measured (Reinheimer *et al*., 2010).

2.3.6 Water activity

Two grams of the sample were crushed into little pieces, placed in a disposable cup, and analyzed using the water activity meter (Aqualab Pre Water Activity Meter, UK) sample chamber. An infrared beam focused on a tiny mirror was used to determine the dew point, and the water activity value was recorded (Hashim *et al*., 2021).

2.4 Chemical analysis

2.4.1 Proximate analysis

The proximate analysis was performed to determine the values of moisture, ash, crude fibre, crude protein, crude fat, and carbohydrates based on the Association of Official Analytical Chemist's procedure (AOAC, 2002).

2.4.2 Determination of calorie content

The pastilles samples were dried in the oven (40°C, 24 h) to remove all the moisture. The crucible containing the sample was placed into the sample holder. After drying, approximately 1 g of sample was weighed and placed in the pan. A bucket containing exactly 2 L of water was placed into the bomb bucket calorimeter's well. A 10 cm of wire were inserted into the bomb slot. The calorie content of the wire left after the pre-fire, fire, and post-fire sessions were measured (Azuan *et al*., 2020).

2.4.3 Determination of antioxidant activity using 2, 2-diphenyl-2-picrylhydrazyl (DPPH) assay

1.9 mg of 2, 2-diphenyl-2-picrylhydrazyl (DPPH) was dissolved in 100 mL of methanol to create a 0.1 mM solution, and the reaction was then carried out in the absence of light. 10 mL of diluted extracts (50 mg sample in 100 mL of distilled water), 10 mL of distilled water (control), and 10 mL of standard ascorbic acid, -tocopherol, and butylated hydroxytoluene (BHT) were each combined with an aliquot of 4 mL of this solution. Following that, the mixture was incubated for 60 minutes at room temperature in the dark. A UV-Vis spectrophotometer was used to read the absorbance at 517 nm (Looi *et al*. 2020) and calculated using the equation given.

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

2.4.4 Determination of mineral content

Two grams of sample was weighed in a pre-dried crucible prior to heating at 450-550°C in a muffle furnace for 12 h and cooled in desiccators. The sample was treated with two millilitres of concentrated HNO3, which was then dried out on a heated hot plate. To obtain clear carbon, the sample was then heated to 500°C in a muffle furnace for one hour. Ten millilitres of 1N HCl was added and heated continuously on the hot plate to dissolve the ash. Ten millilitres of the prepared sample were analysed using ICP-OES (Agilent, USA).

2.5 Sensory evaluation

Sensory evaluation of watermelon pastille with different percentages of GA and gelatine was evaluated by 30 untrained panellists. A 7-point hedonic scale of acceptance test with score 1 referred to dislike extremely and score 7 for like extremely was used to evaluate the sensory attributes of watermelon pastille in term of colour, hardness, chewiness, sweetness, sourness, and overall acceptability according to modified method of Wan Mohamad Din *et al*., 2020). Five samples labelled with 3-digits random numbers and randomly permutated were presented to each panellist.

2.6 Statistical analysis

The statistical analysis was carried out using Minitab software (version 18) (Minitab Inc., United State) and all data were analyzed by One-way Analysis of Variance (ANOVA) and followed by post hoc test of Fisher Least Significant Different (LSD) at $p<0.05$.

Results and discussion

3.1 Physical properties of watermelon pastille

The physical properties in terms of pH, total soluble solid, texture (hardness, springiness, cohesiveness, gumminess, chewiness), colour profile (L*, a*, b* values), water activity (a_w) and melting point of watermelon pastille are presented in Table 2.

Table 2. Physical properties of watermelon pastille

Analysis		A	B	C	D	E
pH		3.94 ± 0. 08^{a}	3.85 ± 0.05^{a}	3.67 ± 0.06^{b}	3.46 ± 0.06^{c}	3.30 ± 0.03^{d}
Total soluble solid		63.27 ± 0.32^{b}	64.13 ±0.64^{b}	64.43 ± 1.12^{b}	66.87 ± 0.93^{a}	65.50 ± 0.52^{ab}
Texture	Hardness (g)	22194.94 ± 326.67^{a}	21947.10 ± 557.67^{a}	16550.53 ± 835.10^{b}	13608.52 ± 119.14^{b}	4472.25 ± 540.51^{c}
	Springiness (mm)	0.66 ± 0.01^{c}	0.87 ± 0.01^{a}	0.88 ± 0.01^{a}	0.71 ± 0.02^{b}	0.16 ± 0.02^{d}
	Cohesiveness	0.92 ± 0.02^{a}	0.91 ± 0.01^{a}	0.88 ± 0.03^{ab}	0.84 ± 0.01^{b}	0.30 ± 0.04^{c}
	Gumminess	16891.42 ± 227.16^{b}	20801.44 ± 979.08^{a}	14720.58 ± 110.83^{c}	10499.82 ± 628.10^{e}	12199.29 ± 832.26^{d}
	Chewiness (g)	11606.59 ± 500.11^{c}	17482.90 ± 659.12^{a}	12875.19 ± 213.21^{b}	7151.59 ± 106.99^{d}	283.24 ± 104.95^{e}
Colour	*L	37.79 ± 0.70^{e}	44.02 ±0.78^{d}	46.33 ± 0.53^{c}	49.90 ± 0.25^{b}	51.84 ± 0.89^{a}
	*a	6.47 ± 0.28^{c}	6.70 ± 0.28^{bc}	7.71 ± 0.25^{b}	8.99 ± 0.24^{a}	9.86 ± 0.96^{a}

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*b	7.78 ± 0.45 [c]	10.65 ±0.65 [b]	11.07 ± 0.14 [b]	11.28 ± 0.45 [b]	13.31 ± 0.34 [a]
Water activity	0.63 ± 0.02 [c]	0.67 ± 0.01 [b]	0.71 ± 0.01 [a]	0.71 ± 0.01 [a]	0.73 ± 0.01 [a]
Melting point (°C)	68.02± 1.05 [a]	64.55 ±1.29[ab]	61.66± 2.40[ab]	58.10± 4.67[ab]	55.10± 5.18 [b]

Values are expressed in mean ± standard deviation of triplicate (n=3). Mean values with different superscript letter in the same row are significantly different (p<0.05). A = (0% gum Arabic:16% gelatine), B = (4% gum Arabic:12% gelatine), C = (8% gum Arabic:8% gelatine), D = (12% gum Arabic:4% gelatine), E = (16% gum Arabic:0% gelatine)

3.1.1 pH

Samples A (0 % GA and 16 % gelatine) and B (4 % GA and 12 % gelatine) were significantly different ($p<0.05$) from the other samples (Table 2). Sample E (highest amount of GA, 16% and no gelatine) was significantly the lowest in pH value (3.46 ± 0.06) compared to other samples. Williams and Phillips (2009) stated that GA is slightly acidic (~4.5) and found as mixed calcium, magnesium, and potassium salt of a polysaccharide acid. According to Harris *et al*. (2003), gelatine is not acidic, with a pH range of 6.5 to 9.0, so contributes to the high pH of sample A, which contains 16 % gelatine. The low pH value in the watermelon pastille sample indicated a high amount of acid present. Presence of acid influence the nutritive value as it can affect the brightness of colour, flavour, consistency, stability and keeping quality (Offia-Olua and Ekwunife, 2015).

3.1.2 Total soluble solid

Table 2 also exhibited an increasing value of total soluble solids (TSS) for different watermelon pastille with an increase in GA percentage except for sample E with the highest GA value (16% GA, 0% gelatine) where a slight decrease was observed. Sample D (12% GA, 4% gelatine) had a significantly ($p<0.05$) higher TSS value (66.87 ± 0.93) than samples A, B and C while no significant ($p>0.05$) difference was observed for samples D and E. GA could play a significant role in contributing to TSS value as compared to gelatine for all sample thus, sample E that has no gelatine showed no difference to other samples. Total soluble carbohydrates, including fructose, glucose, and sucrose, are said to have a considerable impact on the TSS (Soteriou *et al*. 2014). Only a small proportion of carbohydrates can be found in gelatine (1-1.5%) in the form of glucose and galactose (Harris *et al*., 2003) as compared to GA, which has a high carbohydrate content (83.05%) (Williams and Phillips, 2009). Soluble solid content could also be influenced by the amount of glucose syrup, sorbitol, or sugars in watermelon juice (Offia-Olua and Ekwunife, 2015). According to Soteriou et al. (2014), the TSS in watermelon juice is predominantly made up of soluble mono- and disaccharides, and hence it contributes to sweetness.

3.1.3 Colour profile (L*, a*, b*)

The L* value increased somewhat from sample A to sample E (Table 2). The data exhibited a slight increase in a* value from samples A to E. The b* value slightly increased from sample A to E. Samples B, C, and D did not substantially differ from one another (p>0.05), however they did significantly differ from samples A and E ($p<0.05$). Increasing value of L*, a*, b* may be due to increasing amount of GA from 0% to 16% in all sample. According to Chung et al. (2016), GA offered more glycoprotein fractions for the anthocyanin to bind with, leading to enhanced stability so the pigment could be preserved during high heat processing of food components. Colour has been reported to be associated with a_w where intermediate level

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contributes to high rates of Maillard browning and ascorbic acid oxidation reaction that lead to dark pigmentation (Ruiz *et al*., 2017). Dark pigmentation can be observed in sample C, D and E as result for water activity was higher in sample C, D and E. Colour is associated with pH as reduction of pH lead to increase of L*, a*, b* value.

3.1.4 Texture profile analysis

Higher hardness values were found in samples with more gelatine, and lower hardness values were found in samples with high GA, therefore it's reasonable to believe that samples with more gelatine rank higher for hardness value than those with more GA (Table 2). The value of hardness varied according to the addition of different types of hydrocolloids. High hardness was contributed by the high amount of gelatine and minimum hardness is contributed by the high amount of GA. These results are in line with the findings by Patil *et al*. (2017) who reported that hardness of date leathers varied accordingly to hydrocolloid used where the observations rank the highest hardness is in date leathers containing gelatine followed by pectin, guar gum, starch and least in dextrin.

Sample A showed the highest value as compared to other samples while sample E had the lowest value of cohesiveness. The difference in value may be due to the level of GA and gelatine where a high level of cohesiveness was observed with the high percentage of gelatine while a high percentage of GA resulted in low cohesiveness (Table 2). Low cohesiveness is suggested to be the best as the food can be easily chewed (Patil *et al*., 2017). However, some other desirable properties like springiness may not be suitable within the range of cohesiveness.

Table 2 also demonstrates that samples A, B, and C have slightly higher springiness values than samples D and E, whereas samples D and E have lower springiness values. With relation to springiness value, Sample A was discovered to be substantially different from the other samples ($p<0.05$). Sample B was not significantly different ($p>0.05$) from sample C, which had a greater springiness rating, possibly because the GA and gelatine compositions were similar. Samples B and C were significantly different ($p<0.05$) to sample A, D and E in terms of springiness value.

Sample E significantly showed the lowest springiness value (0.16 ± 0.02 mm). Combinations of polysaccharides can produce synergistic behaviours, which allow expansion of the range of material or textural properties (Chen and Rosenthal, 2015). Phillips and Williams (2014) reported that mixtures of hydrocolloids are commonly used to improve rheological characteristics such as the elasticity of food products. This can explain the low elasticity value among samples A and E that were only composed of a single type of hydrocolloid except for corn starch. Sample B, C and D was high in springiness value as they were composed of a mixture of both GA and gelatine as well as corn starch as the basic ingredients.

Sample B showed a high gumminess value while sample D had a low gumminess value which may be due to the high composition of gelatine in sample B compared to D and low composition of GA in sample B compared to D. Shaddel *et al*. (2018), reported that significant cross-linking activity via the main amino group of gelatine resulted in a dense structure. This suggests that sample B, which contains more gelatine, is denser than sample D, contributing to a high gumminess rating, indicating high energy is required to break down the sample into a ‘ready to swallow' state (Patil *et al*., 2017).

As the percentage of GA increased and the percentage of gelatine decreased, the

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chewiness value increased somewhat from samples A to B but decreased considerably in other samples (Table 2). Sample B has the highest chewiness value, whereas sample E has the lowest. There was a significant difference in chewiness ($p<0.05$) across the different watermelon pastille samples. The chewiness is connected to cohesion, according to Patil *et al*. (2017), who say that low cohesiveness suggests easier chewing. This explains the low chewiness score in sample E, which also has a low cohesion value. All the properties might render the use of gum Arabic as the potential substitute for gelatine in halal pastille.

3.1.5 **Melting point**

A slight decrease in melting point values from sample A (68.02 1.05°C) to sample E (55.10 5.18°C) were observed in pastille samples (Table 2). This is probably due to the higher gelatine composition in sample A as compared to sample E as gelatine has a higher melting point than GA. Shaddel *et al*. (2018), expressed that the endothermic peak for the melting point of GA is at 63.31°C while gelatine is at 108 °C. Other ingredients such as sorbitol and glucose syrup, which also required high heat, may also influence the melting point. The melting point and gelatinization process are crucial for gel formation and gel formation occurs as the cooling process of hot (>65^{o}C) gelatine solution is take place (Williams and Phillips, 2009; Harris *et al*., 2003).

3.1.6 **Water activity**

Water activities (a_w) for the pastille samples were ranged from 0.6 to 0.75 which could be considered safe for storage at ambient temperature (Table 2). Low water activity in sample A may be due to the highest gelatine content and the lowest amount of GA. As water activity is related to moisture content, 8.19% moisture in gelatine results in low water activity as compared to GA with 10.7% moisture (Rafieian *et al*., 2015; Williams and Phillips, 2009).

3.2 **Chemical properties of watermelon pastille**

Table 3 demonstrate the chemical characteristics of watermelon pastille, including its proximate composition (moisture, ash, crude fibre, crude protein, crude fat, and carbohydrate), calorie count, and antioxidant activity.

Table 3. Chemical properties of watermelon pastille

Analysis	A	B	C	D	E	toco	BHT
Moisture content	18.13±0.11	18.72±0.49[c]	19.17±0.23[c]	20.10±0.48[b]	23.62±0.73[a]		
Ash	0.41± 0.01[a]	0.41±0.03[a]	0.50±0.34[a]	0.55±0.14[a]	0.80±0.04[a]		
Crude fibre	1.40±0.24[a]	0.75±0.38[b]	1.10±0.38[b]	1.14±0.08[ab]	1.56±0.09[a]		
Crude protein	28.88±3.69[a]	20.42±0.38[b]	16.90±1.11[b]	7.10±0.26[c]	0.38±0.05[d]		
Crude fat	1.83±0.81[a]	1.88±0.19[a]	1.16±0.07[ab]	0.44±0.27[b]	0.40±0.07[b]		
Carbohydrate	49.36±3.33[d]	57.83±4.59[c]	61.16±5.32[b]	70.68±6.61[a]	73.25±5.14[a]		

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Calorie Content (cal/g)	3352.03 ± 48.86[b]	3266.76 ± 34.44[c]	3159.37 ± 39.17[d]	3054.96 ± 47.85[e]	3576.49 ± 38.11[a]		
Antioxidant Activity (DPPH)	23.10 ± 1.41[d]	11.56 ± 1.05[e]	22.86 ± 2.19[d]	44.72 ± 3.76[c]	6.83 ± 4.52[e]	50.45 ± 4.97[b]	91.57 ± 8.83[a]

Values are expressed in mean ± standard deviation of triplicate (n=3). Mean values with different superscript letter in the same row are significantly different ($p<0.05$). A = (0% gum Arabic:16% gelatine), B = (4% gum Arabic:12% gelatine), C = (8% gum Arabic:8% gelatine), D = (12% gum Arabic:4% gelatine), E = (16% gum Arabic:0% gelatine)

3.3.1 Proximate composition

Due to its higher GA concentration compared to the other samples, Sample E had the highest moisture content (Table 3).William and Phillips (2009) stated that the moisture content of watermelon pastille was 10.70% thus it can be assumed that GA is the major contributor to the percentage of moisture in watermelon pastille. As compared to gelatine, Rafieian *et al*. (2015) reported that only 8.19% of moisture composition was analysed. The moisture content of the watermelon pastille samples for all formulations ranges from 18.13 – 23.62% which were within the recommended values of lower than 24% for this type of product (Rafieian *et al*., 2015). Moisture content can be related to the texture of the product as the reduction in hardness occurred and chewier pastille was produced with the increase in moisture content (Subramaniam, 2016). Meanwhile there is a slight increase in ash content from watermelon pastille sample A (0.41%±0.01) to E (0.80%± 0.04). Results also show that sample E showed a higher ash content probably due to high GA composition. Rafieian *et al*. (2015) reported that ash composition in GA was 3.3%. Offia-Olua and Ekwunife (2015) reported the influence of ash on mineral amounts where the high level of ash shows a high component of minerals. This can support the result of this study as the number of minerals which were calcium, potassium and magnesium were higher for sample E that was among the best in the amount of ash.

Sample A depicts the highest protein content (28.88 ± 3.69) compared to other samples. This is probably due to the highest gelatine composition in sample A while sample E has the lowest protein content (0.38 ± 0.05). Gelatine contributes more to protein content as compared to GA as reported by William and Phillips (2009) whereby only 2.2% of protein was recorded in GA while the protein content in gelatine is about 86.20% which is very high (Rafieian *et al*., 2015). Gelatine is made from collagen found in animal skin and bones and is a source of nutrient-rich protein that includes important amino acids (Harris, et al., 2003). Meanwhile fat content was found to be low in sample E (0.40 ± 0.07) which is probably due to the high content of GA and no gelatine used while fat content in sample B is high (1.88 ± 0.19) probably due to the high percentage of gelatine used. GA has a lower fat content compared to gelatine, which was 0.32% and 0.72%, respectively (William and Phillps, 2009; Rafieian *et al*., 2015). The amount of fat in all samples can be assumed as low and the fat content detected in the samples may be originated from glucose and sorbitol as the level of fat in GA and gelatine are low.

It is interesting to note that, crude fibre composition was high in sample E (1.56 ± 0.09). The result could be due to the highest GA content as compared to other samples.

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According to William and Phillips (2009), crude fibre composition in GA was 1.58%. Sample E also had the highest carbohydrate content (73.25%) followed by sample D (70.68%) and the lowest amount was found in sample A (49.36%). The high amount of carbohydrate in sample E was probably due to the high GA content in its formulation. William and Phillips (2009) reported that carbohydrate content in GA was 83.05% while only 1-1.5% of carbohydrate can be found in gelatine (Harris *et al*., 2003). The low carbohydrate content of gelatine could be attributed to the low carbohydrate composition of sample A, which is made up entirely of gelatine and contains no GA.

3.3.2 Calorie content

Table 3 also demonstrates that the calorie content of watermelon pastille decreases somewhat from sample A to sample D, but increases dramatically in sample E. Sample E, which is made up entirely of GA, had the most calories, which could be attributed to its high sugar content when compared to the other samples. All the samples were significantly different ($p<0.05$) within each other regarding calorie content which may be due to the different compositions of GA and gelatine used. Calorie value may be correlated to fat content as the reduction in fat causes a reduction in calories. The use of sorbitol and glucose may provide calories to the pastilles as both GA and gelatine have low calorific value. The calorie values of GA and gelatine are 1.7 kcal/g and 3.5 kcal/g and thus considered as low calorie (William and Phillips, 2009; Harris *et al*., 2003).

3.3.3 Antioxidant activity of 2, 2-diphenyl-2-picrylhydrazyl (DPPH) assay

Result showed that sample D has the highest value of antioxidant activity (44.17%), while sample E was among the lower in antioxidant activity value (6.83%). All samples were significantly different ($P < 0.05$) with the standards (α-tocopherol and BHT) regarding the antioxidant activity. The data showed a significant difference ($p<0.05$) in terms of antioxidant activity between samples, yet samples A and C, as well as B and E, showed no significant difference ($p>0.05$) between each other. The sample that has high antioxidant activity has a high composition of GA. Recent studies proved that GA has antioxidant properties as it plays role in the metabolism of lipids and gives a positive result in kidney failure and cardiovascular treatment (William and Phillips, 2009).

3.3.4 Mineral content

The mineral content in terms of calcium, potassium, magnesium and phosphorus of watermelon pastille are presented in Table 4.

Table 4. Mineral content of watermelon pastille

Mineral (mg/kg)	A	B	C	D	E
Calcium	1349.15±112.18[a]	1451.11 ±99.37[a]	1624.05 ±100.14[a]	1502.80 ±200.57[a]	1927.45 ±61.29[a]
Potassium	722.20±61.14[a]	622.47±64.11[a]	842.02±90.14[a]	772.51±80.16[a]	908.12± 55.59[a]
Magnesium	298.62±27.24[a]	287.07±31.65[a]	386.66±33.38[a]	319.75±52.11[a]	412.57±20.21[a]
Phosphorus	183.02±19.74[b]	150.56±14.26[b]	269.09±19.85[a]	139.37±14.31[b]	199.75±18.14[ab]

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Values are expressed in mean ± standard deviation of triplicate (n=3). Mean values with different superscript letter in the same row are significantly different (p<0.05). A = (0% gum Arabic:16% gelatine), B = (4% gum Arabic:12% gelatine), C = (8% gum Arabic:8% gelatine), D = (12% gum Arabic:4% gelatine), E = (16% gum Arabic:0% gelatine)

Result exhibited that the calcium content in sample E which contain the highest composition of GA exhibited a higher amount of calcium (1918.25 mg/kg) while sample D has a lower amount of calcium (1451.10 mg/kg). The composition of calcium is considerably high in GA which is 480 mg/kg (Ellinwa and Umar, 2017). Gelatine does not contribute to high mineral composition as commercial gelatine consist of gelatine protein in a high state of purity (Harris *et al*., 2003). Thus, the sample that has high gelatine may have low calcium content as it is assumed that no calcium is provided by gelatine that is used for watermelon pastille production. According to Offia-Olua and Ekwunife (2015), the value of ash content influences the amount of mineral where high ash content indicated high mineral constituent. This relates to the amount of calcium which was high for sample E that was among the best in the amount of ash.

Sample E also depicted high amount of potassium (832.47 mg/kg) while sample B has the lowest amount of potassium (722.12 mg/kg). The composition of potassium is considerably high in GA which is 510 mg/kg (Ellinwa and Umar, 2017). Value of ash content influences the amount of mineral where high ash content indicated high mineral constituent (Offia-Olua and Ekwunife, 2015). This can be correlated to the amount of potassium which was high for sample E that was among the best in the amount of ash. It is interesting to note that, magnesium also high in sample E, which was among the best in ash amount. This result is in line with research by Offia-Olua and Ekwunife (2015), which stated that high mineral constituents are the result of high ash value. Sample E has a high amount of magnesium (387.54 mg/kg) while sample B has a low amount of magnesium (287.08 mg/kg. Minerals such as calcium, potassium, and magnesium were not significantly influenced by changes in GA and gelatine composition, and they were associated with each other, with a high GA % implying a high composition. Sample C has the highest amount of phosphorus (260.09 mg/kg) while sample D has a low amount of phosphorus (139.37 mg/kg). Sample A, B and D were not significantly different (P > 0.05) from each other yet were significantly different ($p<0.05$) with sample C for phosphorus content. Harris *et al.* (2003) claimed that the composition of commercial gelatine, consist of gelatine protein in a high state of purity. Thus, the phosphorus content may come from other ingredients such as sorbitol, glucose, corn starch and watermelon juice. Phosphorus in watermelon is 109.74 mg/kg, which is considerably high (Watermelon, raw Nutrition Facts and Calories. n. d).

3.4 **Sensory acceptability of watermelon pastille**

Mean score of all sensory acceptability included colour, hardness, chewiness, sweetness, sourness, and overall acceptability of watermelon pastille is showed in Table 5.

Table 5. Mean score (n=30) of sensory acceptability of watermelon pastille

Attributes	A	B	C	D	E
Colour	3.57 ± 1.68^{b}	5.27 ± 1.31^{a}	5.17 ± 1.18^{a}	5.70 ± 0.92^{a}	4.90 ± 1.21^{a}

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Hardness	2.20±1.19[c]	2.47±1.43[c]	3.50±1.72[b]	5.43±1.10[a]	4.03± 1.52[b]
Chewiness	1.77±1.0[d]	1.83±1.18[d]	2.87±1.48[c]	5.50±1.04[a]	3.70±1.76[b]
Sweetness	2.40±1.43[c]	2.70±1.53[bc]	3.43±1.63[b]	4.77±1.33[a]	4.47±1.48[a]
Sourness	2.63±1.62 [b]	2.73±1.68[b]	3.30±1.60[b]	5.10±1.12[a]	4.63±1.38[a]
Overall Acceptability	2.17±1.18[d]	2.50±1.25[cd]	3.17±1.37[c]	5.40±1.10[a]	4.27±1.53[b]

Values are expressed in mean ± standard deviation of triplicate (n=3). Mean values with different superscript letter in the same row are significantly different (p<0.05). A = (0% gum Arabic:16% gelatine), B = (4% gum Arabic:12% gelatine), C = (8% gum Arabic:8% gelatine), D = (12% gum Arabic:4% gelatine), E = (16% gum Arabic:0% gelatine)

It is interesting to note that there was no significant difference ($p>0.05$) between samples B, C, D and E yet they were significantly different ($p<0.05$) to sample A in terms of colour acceptance. Sample D had higher colour acceptability (5.70±0.92) when compared to the other samples, whereas Sample A had the lowest score (3.57±1.68). The results show that the panel prefers samples that are bright red yellowish over those that are pale reddish in colour. Gum arabic contains a significant amount of acid, which influence the nutritive value as it can affect the brightness of the colour (Offia-Olua and Ekwunife, 2015).

Results also demonstrates that sample D has the highest hardness acceptance (5.43 ±1.10) compared to the other samples, whereas sample A has the lowest score (2.20 ±1.19). The use of GA and gelatine affects the textural and sensory qualities of the sample, and the panellists prefer samples that have a mixture of both compositions with a high level of GA and a low amount of gelatine (12:4). According to Dong, Hua (2018), the soft texture on pastille was found to be the result of a starch-continuous structure containing inclusions of protein (gelatine). The presence of a high amount of GA affects the moisture content, which in turn affects the texture of the product whereby an increase in moisture content leads to a reduction in hardness, producing chewier pastille (Subramaniam, 2016).

Acceptance of chewiness is high for samples with a chewiness value of (7151.59 ±106.99), whereas acceptance of chewiness is low for samples with a g value of (11606.59 ± 500.11) (Table 5). Sample D is the most preferred (5.50±1.04) whereas sample A has the lowest score (1.77±1.0). Sample A contains a high gelatine content with no GA added, which contributes to the toughness of the watermelon pastille samples. According to Dong and Hua (2018), gelatine was discovered to be responsible for the chewing roughness of pastille as the chewing texture of pastilles may be connected to their microstructure. In the case of sample D, the GA may be dispersed well in a syrupy matrix and the protein in the form of discrete pockets within the matrix, thus it is easier to break down during chewing.

The acceptance of sweetness is high for the sample that has the highest TSS value (66.87 ± 0.93) ie sample D (4.77±1.33) while sample A which has lowest TSS value (63.27 ± 0.64) also exhibited lowest acceptability score the panelist (2.40±1.43). A high TSS value indicates a high amount of sugar content, and this indicates that TSS can be correlated to sweetness. This also

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indicates that the rate of sweetness acceptance by the panellists was based on the high intensity of sweetness. Bolhuis *et al*. (2018) stated that the taste of pastille is contributed by the amounts of sugar content in the fresh pulp. An increase in the amount of sugar beyond optimum amounts may, however, reduce the taste ratings thus, requiring optimization. This explains the reduction in acceptance in sample E (4.47 ± 1.48) as compared to sample D. Sweetness rating may also depend on the type of the fruit and may also vary during storage (Bolhuis *et al*., 2018). TSS of watermelon juice adds to sweetness since it is predominantly made up of soluble monosaccharides and disaccharides, according to Soteriou et al. (2014). Sample D also exhibited higher acceptability score (5.10 ± 1.12) in sourness compared to other samples while sample A was the lowest score (2.63 ± 1.62). Sample A was not preferred because of its high gelatine content, which might cause tartness to fade. Because it has a pH range of 6.5 to 9.0, this is the case (Harris *et al*., 2003). Panellists prefer samples with an intermediate sourness rating that are neither too high nor too low in acidic value. Acceptance of sourness and sweetness are connected, as high acceptance of sweetness leads to high acceptance of sourness (Torres et al., 2015).

Table 5 also demonstrates that Sample D was found to have the significantly ($p<0.05$) highest score for overall acceptability (5.40 ± 1.10) when compared to the other samples, whereas Sample A had the lowest score (2.17 ± 1.18). Panellist rate sample D as the highest overall acceptability as all other attributes which are colour, hardness, chewiness, sweetness, and sourness is mostly preferred for sample D. Results of the overall acceptability were positively correlated with the entire sensory attribute tasted (Offia-Olua, and Ekwunife, 2015).

Conclusion

Watermelon pastille (D) with 12% of gum Arabic and 4% of gelatine is the best formulation in terms of physicochemical properties and sensory acceptability score. The physicochemical and organoleptic characteristics of the finished goods were significantly impacted by the inclusion of gum Arabic and gelatine. Therefore, gum Arabic could be a potential gelatine alternative, act as a gelling coagent for confectionary production. Moreover, the usage of the Gum Arabic in variety of product may increase the utilization and its quality of confectionary product. Besides that, the benefits will definitely increase the commercial potential demand of consumer as it gains its trust to purchase halal product.

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