Development of Gummy Containing Honey and Habbatussauda (*Nigella sativa*) Oil and its Characterisation

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Abstract. Tremendous interest in sugary confectioneries is rapidly expanding, and adding healthier ingredients to gummy jellies enhances the health attributes of a typically nutritionally deficient product. However, consuming these products can pose various health risks. The aim of the study was to develop and characterize sugar-substituted gummies and gummy ingredients were honey, habbatussauda seeds and oil, citric acid, and water. In this study, sugar was 100% substituted with honey. Formulations were selected based on texture and aw criteria, and sensory evaluation was conducted for appearance, color, texture, taste, and overall acceptability. Honey and sugar were found to affect the development of the gummy in terms of moisture, water activity, color, and structure. The finalised formulation of the gummy exhibited acceptable texture properties and color, while also showing low pH, water activity, and moisture content, which helps prolong the shelf life of the product. Sensory evaluation showed that the developed gummy was appreciated and comparable to commercial gummies, as it received scores almost equal to those in the market. The finalised gummy formulation showed reliable analysis results, complementing the sensory evaluation conducted through random food testing to develop the most accepted gummy.

Keywords: gummy, *Nigella sativa*, honey, sugar substitution, habbatussauda oil, habbatussauda seeds.

1 Introduction

1.1 Background of Study

Gummy supplement that's referred to as a confectionery gel, consist of sucrose or syrup mixed with a gelling agent including gelatin, gum, or pectin. Other excipients may be added to this system, along with coloring agent, flavor, and acidulant [28]. Nowadays, gummy complement has been developed as nutraceutical products in view that those are simpler to swallow or chunk in comparison to other dosage forms like capsules or

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capsules. Therefore, they're extensively used in pediatric, geriatric, and sufferers with swallowing troubles [12]. Gummy complement is formulated the use of a gelling agent as the vehicle of this product. Several hydrocolloid substances serve as gelling agents, which includes gelatin, pectin, sodium alginate, and gum. The choice of a gelling agent is a pivotal part of gummy supplement formulation as it considerably impacts the physicochemical houses of these products [8].

Nowadays, tremendous interest is more on the development of foodstuffs from natural source. Gummy confectionary is widely known to consist high amount of sugar which can cause health problem such as obesity, tooth decay, hyperglycemia due to their high glycemic index or high in calories [15]. As times goes by, more people are depending on modern medicine while leaving traditional medicine behind. The significance of this study is to develop a supplement gummy which does not contain any added table sugar while replacing it with Yemeni Sidr Honey that contains high health benefit. Besides honey, habbatussauda is also added due to its beneficial properties and also both ingredient honey and habbatussauda are used in this gummy supplement development to make awareness regarding the sunnah food of the Prophet of Islam. Thus, the main objective of this study is to development a Gummy containing Honey and Habbatussauda (*Nigella sativa*) oil.

Confections, a term encompassing candies and sweets, are foods primarily defined by their delightful, sugary taste and typically, candy refers to a small, specific type of food item. Confectionery products are generally categorized into two main groups: sugar confections and chocolate confections. Sugar confectionary is mainly consisted of sugar and chocolate confectionary consist chocolate as the characterizing ingredient, either as entirely make up of chocolate or as a coating or inclusion [14]. Sugar confectionery, as the name implies, is rich in sugar of various types. There are two main types of sugar confections: boiled sweets and fondant. Boiled sweets are made by boiling sugar and water at such a high temperature that almost no water remains, forming a glassy mass upon cooling. Fondant, on the other hand, consists of tiny sugar crystals in a saturated sugar syrup and is used as a creamy filling in chocolates and biscuits and for decorating cakes. It is made by boiling a sugar solution with added glucose syrup or an inverting agent and then rapidly cooling it while stirring [3] [37].

Gummy jelly is a sort of sugar confectionery based on a hydrocolloid, which forms a network that keeps sugar syrup with noticeably excessive moisture content material. Typically, gummy jelly comprises hydrocolloids as gelling retailers, together with sweeteners, acids, flavorings, and coloring sellers. Hydrocolloids are big molecules that disperse in water and form a gel with a 3-dimensional community that absorbs water and particles below the proper conditions [16]. Although gelatin is usually used as the hydrocolloid gelling agent in gummy jelly formulations, other hydrocolloids may be used on my own or in combination with gelatin to decorate the houses of the gummy jelly. Pectin, as an example, is another hydrocolloid taken into consideration a gelling agent [23] [27]. Children tend to prefer soft confectionery items such as pastilles, edible jelly, and gummy candies over other types of sweets, due to their ease of consumption,

appealing aesthetics, and delicious flavors, as supported by various studies in child psychology and nutrition (Kostecka, *et al.,* 2021, [17], Kia *et al.,* 2020). Gummy is known to consist mainly sucrose or syrup combined with a gelling agent such as gelatin, gum or pectin. Other ingredients that can help with the taste and appearance of the gummy are coloring agent, flavor and acidulant [22].

1.2 Formulation of Gummy

Gummies contain various kind of active ingredient for the purpose to enhance its health properties also to give better taste and appearance. Previous studies use Moringa oleifera in the development of its chewable-gummy tablets. From this study, chewable gummy tablets containing Moringa oleifera develop using 10% gelatin and 1.5% pectin are considered optimal because these fulfil all the physical characteristics requirement, show no syneresis, and provide the best texture [22]. Study done by Moghaddas [17] uses red beet extract as colouring agent and Salix aegyptiaca as a flavouring agent for the development of gummy candy. The results showed that the amount of red beet extract directly influenced the antioxidative properties, redness, and chroma of the gummy candies.

The development of gummy supplement with natural honey and herbal ingredient is promising. The honey used for this development of gummy supplement was Yemeni Sidr Honey. At present, studies regarding Yemeni Sidr Honey shows significant natural source of antioxidants and has potential therapeutic value in the treatment of cancer, heart disease, cataracts, and several inflammatory diseases [29]. Besides honey, Habbatussauda (*Nigella sativa*) is another beneficial ingredient added in this mixture. It contains Habbatussauda in two different forms: oil and powder. *Nigella sativa* (Habbatussauda) black seeds belonging to the family Ranunculaceae; have been long-established used for medicinal purposes since time. The black seeds (habbatussauda) of the *Nigella sativa* plant that belongs to the Ranunculaceae plant family have an extensive history of medicinal use that dates back thousands of years as a spice and food preservative. The black seeds and oil have shown potential medicinal properties in traditional medicine and was used by physicians to treat an assortment of illnesses, however Prophet of Islam; Muhammad (SAW) once stated the black seed can heal every disease except death [19]. Contemporary naturopathic medicine around the world has used NS and its major component Thymoquinone (TQ) as a diuretic, carminative, treatment for asthma, bronchospasm, coughs, back pain, hypertension and obesity [19].

Gelatin is a protein derived from collagen, which is found in the skin, bones, and connective tissues of animals [25]. It is made by breaking collagen down to smaller parts and is commonly added as a gel agent to foodstuff, medicine or cosmetics. When put into cold water they form these transparent but elastic substances we call gelatins, otherwise known as gels. This ingredient acts differently depending on what anyone wants to achieve with it; maybe thickening, making it stronger so that things do not fall apart easily among other things. The properties include floor concord, film-forming capabil-

ity, functioning as a colloidal stabilizer, gel-forming traits, texture enhancement, thickening, and water-binding capability. Pectin's are complex polysaccharides located within the cell wall of plant, serving as a hydrating agent and strengthening the cell network. They make contributions to the firmness and shape of plant tissue, acting as a part of the primary cellular wall and the principal factor of the middle lamella, that is concerned in intercellular adhesion, just like the intercellular substance in animal tissue [18][30]. Citric acid ($C_6H_8O_7$) is a weak organic tricarboxylic acid naturally found in citrus fruits (APA, 2024). It is commonly used as a preservative and is known for its acidic taste. It is used in flavoring agent and increases stability of the fruit [11]. Honey is a complex product which is sweet, flavorful, viscous, liquid food that is produced from the nectar due to action of bee enzymes. It used to replace the function of sugar and to provide high health benefit from it [1] and habbatussauda (*Nigella sativa*) oil & powder form able to provide medicinal properties [19].

2 MATERIALS AND METHOD

2.1 Development of Gummy Formulation

Throughout the development of gummy containing honey and habbatussauda oil, 28 formulations had been formulated. The first formulation started with using sugar, glucose syrup, honey, citric acid and gelatin. Slowly sugar and glucose syrup were removed and replaced with honey. The removal of sugar and glucose syrup were supported with the addition of honey and also the adjustment of gelatin and water ratio. Gelatin and water ratio need to be adjusted due to honey containing moisture content that differs with sugar and glucose syrup. After obtaining a suitable taste and structure of gummy when all sugar is replaced with honey, habbatussauda oil and powder are incorporated. Various formulation had been done for the percentage of habbatussauda added into the gummy. The last touch in improving the gummy was by combining gelatin and pectin to get a more suitable gummy structure. After obtaining the finalized gummy, coating of gummy was also being done by using sugar coating method. Sugar coating method is the usedness of sugar and corn starch to 1:1 ratio. Gummy coated with sugar coating was also compared with corn starch coating and corn starch coating shows good effect to prevent the stickiness of the gummy.

For the adjustment being done throughout all the formulation, personal preference and also sensory evaluation done by random panel tasting was conducted. This helps to give a better understanding of the ingredient used and also how consumer react to the combination of ingredient in developing the gummy. This also leads to the formation of finalized gummy.

2.2 Preparation of Honey-Habbatussauda Gummy and its Limitations

During this process of combining gelatin and pectin as a thickening agent in developing gummy, several formulations had been done to obtain the most preferred gummy structure. From this process, I manage to properly identify the function of both thickening

agent which gelatin gives the elasticity and stretchiness to the gummy while pectin gives body to gummy which makes it firmer. Several formulations were conducted to get the best structure by also evaluating it with panels via sensory evaluation. The aroma of Habbatussauda oil and powder in the gummy really gave slight negative feedback from panels who tried it due to not being familiar with it taste. This issue was overcome by adjusting the amount of honey and citric acid which camouflage the aroma of Habbatussauda.

2.3 Physicochemical properties of Honey-Habbatussauda Gummy

Moisture content

The moisture of honey samples was presented as TSS content and was analysed according to method describe by Bogdanov [4] and Yegge [38]. A hand-held refractometer (Model TI-RBX4582 / TI-RBX5890) that can determine the soluble solid content in the range of 0–95 ◦Brix was used. The samples of Kelulut honey were directly measured with the refractometer and each honey sample was measured twice and the average value was taken.

Water activity (a_w)

Water activity was determined using [2] method and was carried out at 24–26 °C using an electronic dew-point water activity meter Aqualab CX2 (Decagon Devices, Pullman, WA). The equipment was calibrated using saturated salt solutions within the relevant water activity range. For each measurement, three replicates were taken, and the average value was reported.

pH

The pH of the gummy samples was measured using a HANNA HI 2211 pH meter. A 6g sample of gummy was homogenized in 30 mL of distilled water, and the pH value was directly read from the meter [39].

Colour

The colour analysis of honey samples were determined by using a Chroma meter (CR-400, Konica Minolta, Japan) and was expressed by L (lightness), a (redness), and b (yellowness) parameters in CIE Lab system. The chroma meter was set at D65 illuminant and 10o standard observer and calibrated before each measurement against a standard white tile (Y = 93.8; x = 0.313; y = 0.319) [26]. The samples were measured by placing it into a petri dish and placed on the sample's holder parallel to its base.

Texture Profile Analysis (TPA)

Texture profile analysis of gummy samples was conducted using a TA-XT 2 Texture meter (Texture Pro CT3 V1.2, Brookfield, Middleboro, USA) as described by Yuan and Chang (2007). Force-time deformation curves were obtained by applying a 5 kg

load cell at a crosshead speed of 1 mm/s. The following texture attributes were calculated: hardness cycle 1 (g), adhesive force (g), resilience, fracturability (g), hardness cycle 2 (g), and springiness (mm).

3 RESULT AND DISCUSSION

3.1 Characterisation of Honey-Habbatussauda Gummy

Water activity (aw), moisture content and pH

The result on the water activity and pH showed no significant difference ($p > 0.05$) with the values in the range of 0.62 – 0.78 and 3.71-3.77 respectively between formulation. Meanwhile, result obtained for moisture content in Table 1 showed significant difference ($p < 0.05$) between formulations. Periche (2014) stated in his study, water activity of a gummy jelly was in the range of 0.7-0.8 and its moisture content need to be less than 20 % [20]. Romo-Zamarrón [24] also stated in his study, gummy candies range of water activity and pH are 0.54-0.66 and 3.50-3.92 respectively since higher value may favor microbiological growth. Therefore, it was established that the finalised gummy formulation was not significantly affect the physicochemical and microbiological stability of the product since it contains low pH, low moisture and reduced water activity [35].

Table 1 Analysis of pH Value, Water Activity (a_w)and Moisture Content of Gummy Profile with Different Sugar and Honey Composition

Colour	Finalized Formulation	Sugar	Honey-sugar	Honey-maltitol	Commercial
Moisture (%)	22.11 ± 0.41^{a}	8.61 ± 0.01^{d}	14.59 ± 0.40^{c}	14.70 ± 0.11^{c}	16.82 ± 0.92^{b}
Water activity (a_W)	0.69 ± 0.00^{b}	0.78 ± 0.00^{a}	0.62 ± 0.00^{d}	0.64 ± 0.00^{c}	0.62 ± 0.00^{d}
pH	3.75 ± 0.00^{b}	3.77 ± 0.00^{a}	3.75 ± 0.00^{b}	3.71 ± 0.00^{c}	3.44 ± 0.00^{d}

$^{a-d}$ Different letter within a column are significantly different ($p < 0.05$)

All these factors are important to obtain good quality products [24]. In comparison with the commercial gummy, the result showed that its moisture content and water activity is not quite far its different and commercial gummy has a water activity similar to honey:maltitol formulation due to the presence of sugar in it. The pH of the commercial gummy is lower and from the taste of it, it gives different intensity of acidity with the finalized gummy. Still the pH is still close to the range of gummies candy [24]. Other studies which use pectin extracted from Garcinia atroviridis rind and gelatin extracted from Salmo salar skin to develop gummy contain water activity and moisture content in a range of 0.749–0.754 and 33.16–42.01% respectively [23]. Previous study that developed a gummy jelly by replacing starch with inulin indicated that its pH decreased from 3.46 to 3.0 [9][10][11][34].

Colour

Color is an important indicator of quality and acceptability of foods [6]. Table 2 shows the results of color determination of gummy with different sugar and honey composition. Lightness (L*), red/green value (a*) and blue/yellow value (b*) of the finalized formulation and the other modified formulation gummies were significantly different ($p<0.05$). The lightness of finalized formulation gave the lowest value due to the dark color obtain from the honey. Other formulation had slightly higher lightness value while sugar formulation gives the highest due to the color of the sugar to be white in color. For color there is no specific range that need to be control because it does not entirely affect consumer acceptability. Previous study that shows a range of L*, a* and b* quite similar with finalized gummy formulation is a study about using pectin extracted from Garcinia atroviridis rind. The L*, a*, and b* values 266 were ranging from 30.36-34.97, 1.20-2.23, and 11.30-11.81, respectively [23].

Table 2 Analysis of Gummy Colour Profile with Different Sugar and Honey Composition

Colour	Finalized Formulation	Sugar	Honey:sugar	Honey:maltitol	Commercial
L*(Lightness)	36.46 ± 0.23^{d}	65.80 ± 0.16^{a}	47.95 ± 0.06^{b}	47.28 ± 0.36^{c}	34.27 ± 0.06^{e}
a* (Redness)	0.28 ± 0.01^{e}	1.08 ± 0.04^{c}	2.23 ± 0.01^{a}	1.51 ± 0.13^{b}	0.64 ± 0.02^{d}
b* (Brightness)	2.20 ± 0.13^{e}	12.84 ± 0.01^{a}	7.00 ± 0.06^{d}	8.57 ± 0.06^{c}	11.28 ± 0.09^{b}

[a-d] Different letter within a column are significantly different ($p < 0.05$)

Texture Profile Analysis (TPA)

Texture analysis in gummy candies involves objectively measuring textural properties like hardness to ensure consistent product quality and optimize production processes. This analysis is crucial for gummy candy manufacturers to predict elasticity, minimize time in the stoving oven, and establish upper and lower tolerances for production based on hardness parameter (Ugne *et al.,* 2019). Additionally, hardness, gumminess and chewiness are texture descriptors particularly applicable to gelled confections [5]. The used of honey in this study, highlighting the impact of iron fortification on the properties of gummy candies. The maximum force required to distort the jellies in the first bite is directly related to hardness. Gumminess comes from multiplying hardness and cohesiveness, whereas chewiness comes from multiplying hardness, cohesiveness, and springiness [9] & Bañón, 2015). For these factors, Table 3a and 3b indicate result gained showed significant difference ($p < 0.05$) between formulations.

The strength on the gummy structure under pressure is known as hardness. Finalized gummy formulation gave the lowest value of hardness compared to the others which was 19972.32 ± 52.57. Other formulation developed higher hardness value is due to the addition of sugar. Sugar is known to have lower moisture content than honey thus cause the gummy to be tougher and harder in structure.

Table 3a Analysis of Texture Profile Analysis (TPA) Gummy with Different Sugar and Honey Composition

Sample	Sugar	Honey:sugar	Honey:maltitol
Hardness (N)	57735.90 ± 0.08[a]	30273.44 ± 1027.91[b]	20539.37 ± 61.64[c]
Adhesiveness (N.s)	0.00 ± 0.00[a]	0.00 ± 0.00[a]	-259.85 ± 5.63[b]
Springiness (mm)	0.00 ± 0.00[c]	0.94 ± 0.00[a]	0.84 ± 0.02[b]
Cohesiveness	0.00 ± 0.00[c]	0.87 ± 0.00[a]	0.77 ± 0.00[b]
Gumminess (N)	0.00 ± 0.00[c]	27218.10 ± 530.80[a]	15810.28 ± 6.50[b]
Chewiness (Nmm)	0.00 ± 0.00[c]	25070.63 ± 273.16[a]	13341.11 ± 521.18[b]
Resilience	0.27 ± 0.01[c]	0.54 ± 0.00[a]	0.36 ± 0.01[b]

[a-d] Different letter within a column are significantly different ($p < 0.05$)

Table 3b Analysis of *Texture Profile Analysis (TPA)* Gummy with Different Sugar and Honey Composition

Texture	Finalized formulation	Commercial
Hardness (N)	19972.32 ± 52.57[a]	8642.95 ± 403.63[b]
Adhesiveness (N.s)	-8.25 ± 1.50[ab]	-10.32 ± 5.95[b]
Springiness (mm)	0.97 ± 0.01[a]	0.89 ± 0.00[b]
Cohesiveness	0.81 ± 0.01[a]	0.66 ± 0.00[b]
Gumminess (N)	17547.32 ± 196.36[a]	5678.21 ± 272.80[b]
Chewiness (Nmm)	16654.34 ± 37.12[a]	5208.60 ± 86.73[b]
Resilience	0.52 ± 0.00[a]	0.35 ± 0.01[b]

[a-d] Different letter within a column are significantly different ($p < 0.05$)

Honey in other hand is liquid in room temperature contain higher moisture content than sugar which is in solid form at room temperature. In terms of chewiness and gumminess, finalized gummy formulation sits between other formulations. Table 3a and 3b showed that sugar formulation does not have any value for its chewiness and gumminess due to sugar causing the gummy to be very hard. Sugar confectionary can be neatly divided into those products that are intended to crystallize and those that are not. In products that are intended to crystallize there is a high ratio of sugar to glucose while in those products where crystallization is undesirable there is a much lower ratio [13]. By comparing with commercial gummy, it is safe to say that the finalized formulation needs to be adjusted in terms of its texture profile.

As shown in Table 3b, commercial gummy has the highest hardness, gumminess and chewiness reading which shows that consumer accept those texture characteristics. Further adjustment for the finalized gummy formulation must be done to obtain most acceptable gummy texture. A study conducted [7] in development of antioxidant gummy jelly candy supplemented with Psidium guajava leaf extract resulted in obtaining gumminess and chewiness in the range of 1273-773 N and 1226-701 Nmm respectively. He stated that by adding the crude extract, it decreases the gumminess and chewiness of the product while not effecting on their cohesiveness and springiness [31][32][33].

Consumer acceptability
The consumer acceptability study was not properly conducted. A proper study will be done in a specific place and sensory evaluation will be conducted with rules to be followed. Most consumer acceptability testing is done using 9-point hedonic scale for sensory evaluation (9 = "like extremely"; 8 = "like very much"; 7 = "like moderately"; 6 = "like slightly"; 5 = "neither like nor dislike"; 4 = "dislike slightly"; 3 = "dislike moderately"; 2 = "dislike very much"; 1 = "dislike extremely") [21][36]. Then the sensory evaluation data will be analyzed and interpreted. For this project, consumer acceptability study was not required to be conducted but some random sensory evaluation was done to get an idea and overview of consumer acceptability.

There were two sensory evaluations being done which first was with final year students of Food Science and Technology, UiTM Shah Alam and with company As-Sunnah Sdn Bhd. As mentioned earlier, 28 formulation was developed to get the final product and each formulation was tested its sensory criteria by the students. The sensory criteria evaluated were sweetness, acidic, aroma, texture and acceptability. This feedback from the students really helps in developing the preferred gummy and every new formulation gained will be tested it sensory criteria with As-sunnah Sdn Bhd to get their insights and also their feedback.

4 CONCLUSION

Finalized gummy formulation showed reliable analysis result which complement to the sensory evaluation done by random food testing to develop the most accepted gummy. Honey and sugar prove to affect the development of gummy in terms of its moisture, color and structure. Development of gummy using the finalized formulation gives acceptable texture properties, color and also low in pH, water activity and moisture content value which also helps in prolong the shelf life of the product. For further recommendation, a proper sensory evaluation must be conducted to obtain a better understanding regarding consumer acceptability towards the product. Sensory evaluation will also help in comparing consumer likings with analysis conducted to get into deep understanding of the product physicochemical properties. A proper sensory evaluation can help to develop a better gummy which consist of the characteristic as same as or better than commercial gummy. Other than that, collaboration with gummy manufacturing company in earlier stage till the end can really help to develop 2 types of formulation which are lab scale production and also industry scale production.

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