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# Physicochemical properties, total plate count, and sensory acceptability of gummy guyabano (*Annona muricata*) candy enriched with kappa-carrageenan

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ABSTRACT

Gummy candy is usually made of gelatin- sourced from animals. This study incorporated (κ) kappa-carrageenan-A polysaccharide extract from seaweeds into the gummy guyabano (*Annona muricata* Linnaeus) candy's formulation. κ-carrageenan was incorporated into the gummy guyabano candy at 0%, 1%, 3%, and 5% concentration for CO, T1, T2, and T3, respectively. The effect of incorporating kappa-carrageenan into gummy guyabano candy in terms of physicochemical properties, total plate count, and sensory acceptability was investigated. Results showed that an increase in the addition of κ-car resulted in an increment in most of the physicochemical properties, e.g., carbohydrate content (42.66 ± .98 - 44.93 ± .74) and crude fiber with values 00.19 ± .07 to 00.40 ± .11. Further, a decreasing value for crude protein (16.07 ± .74 - 15.48 ± .24), and fat content (00.32 ± .14 - 00.02 ± .03) was noted. However, no significant difference was found in crude protein. Gel strength was affected by the increasing addition of κ-car. Values recorded were 1029.67 ± 62.74, 735.00 ± 31.19, 1369.33 ± 54.00, and 1278.00 ± 93.54 for CO, T1, T2, and T3, respectively. Total plate count rose as the percentage of κ-car increased, from <250 EAPC/g to 4.66 x 104 cfu/g, but results were within the range of the recommended TPC values by FDA for confectionery products. Moreover, results of sensory acceptability revealed that all formulations were generally accepted, with "Like Moderately" as the lowest rating and the highest rating as "Like Very Much." Thus, kappa-carrageenan has enriched the physicochemical properties of gummy guyabano candy.



## 1. Introduction

Confectionery products are trendy nowadays, products of many types with different shapes, tastes, and odors in a wide range, such as candy gums, jellies, marshmallows, chewing gums, etc. (Csima et al., 2010). Gummy candy comprises agar-agar or gelatin, sweeteners, flavorings, and colorings (Achumi et al., 2018). Gelatin is commonly used in gummy confection because the final product shows two desirable characteristics: Suitable hardness and transparency. It is sourced from pork or bovine animals (Grazela and Morrison, 2002).

However, the use of gelatin has several disadvantages. First, the increasing prices of gelatin could be attributed to the following reasons: The concern that the higher feed prices in Russia and the European Union (EU) may lead to less availability of animals for gelatin production. And the stricter production standards in China have increased production costs. It was also stressed that it is necessary to offer an alternative for a rising and attractive Halal, Kosher, and vegetarian market. Moreover, efforts have been made to find suitable substitutes for gelatin because of the appearance of bovine spongiform encephalopathy (BSE) or mad cow disease and foot-and-mouth disease that are found in gelatin obtained from bovine or porcine sources (McHugh, 2003). Since gelatin is a protein, it is susceptible to thermal and high acid treatments that cause it to undergo degradation, resulting in loss of its functional properties, reduced cooking efficiencies, loss of active ingredients, and possible fouling, which necessitates frequent cleaning of the processing apparatus.

As mentioned above, the disadvantages of gelatin in food products indicate the necessity of replacing it

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with alternative ingredients with less to no health issues. A study on guyabano (*Annona muricata* Linnaeus) Candy recommended finding alternative ingredients for gelatin in gummy candy making due to the mentioned issues associated with using gelatin as an ingredient (Pobar, 2015). With this, the present study aims to address the recommendation of the previous research on gummy guyabano candy. Research on chewy candies (gummy candy made from oxidized starch and gum Arabic) suggested additional hydrocolloids during production. The hydrocolloid could be one agar, xanthan gum, locust bean gum, gellan gum, pectin, carrageenan, and guar gum. A study claimed that carrageenan use instead of gelatin-produced finished products is more tolerant of high temperatures during shipping or storage (Cash, 2000). Carrageenan is a polysaccharide extract obtained from various species of edible red seaweeds (Bui, 2019). This polysaccharide has various forms, which are (κ) kappa-, (ι) iota-, (λ) lambda-, (μ) mu- and (υ) nu-carrageenan. κ-, ι-, and λ-carrageenan are the classes of carrageenan with high commercial value (Campo et al., 2009).

Creating a gummy candy that excludes gelatin or contains lesser gelatin is desirable. Thus, it overcomes the problems associated with gelatin but retains the texture and properties attributed to gelatin that the consumer desires. In this study, (κ) kappa-carrageenan was used to make gummy guyabano candy as an alternative ingredient for gelatin.

## 2. Material and methodology

The ingredients used in gummy guyabano candy production are guyabano or soursop fruits, gelatin, kappa-carrageenan (κ-car), centrifugal sugar, and glucose. Guyabano fruits were bought at the local market, and gelatin, sugar, and glucose were purchased at the local grocery store. Seaweeds are sourced from local growers. All chemicals used were of analytical grade and were readily available in the laboratories where the experiments were conducted.

The biological materials used in this research are guyabano (*Annona muricata*) and seaweeds (*Kappaphycus alvarezii*). In the conduct of the experiments, varied instruments were used, such as a pH meter, to determine the samples' pH. A texture analyzer was used to measure the gel strength. For the proximate analyses, which include ash content, moisture content, crude protein, crude fat, and crude fiber, the following instruments were used: Muffle furnace, drying oven, Kjeldahl protein analyzer, fat analyzer, and fiber analyzer. For the total plate count (TPC) analysis, these are the following instruments used: A petri dish, incubator, and colony counter.

The method of Vijayakumar and Adedeji (2017) was followed in determining the pH of the samples. Analyses of ash content, moisture content, crude protein, crude fat, and crude fiber were performed following the method described by the Association of Official Analytical Chemists (AOAC, 2016). Further, carbohydrate content was obtained by difference [total carbohydrate (%) = 100% - (% moisture + % ash + % fat + % protein)] (Nielsen, 2006). The gel strength of guyabano gummy candy was measured using the manual provided in the texture analyzer (TexturePro CT V1.8 Build 31, Brookfield Engineering Labs. Inc.) fitted with a needle probe (TA7). Moreover, the method described by Maturin and Peeler (2001) in FDA's Bacteriological Analytical Manual (BAM) was followed in determining the TPC of the product's sample.

A sensory score sheet of Nine Point Hedonic scale was utilized by the participants in rating the product using the following numerical rating and descriptions: 9 – Extremely Like, 8 – Like Very Much, 7 – Moderately Like, 6 – Slightly Like, 5 – Neither Like nor Dislike, 4 – Slightly Dislike, 3 – Moderately Dislike, 2 – Dislike Very Much and 1 – Extremely Dislike. Moreover, the test was conducted using a sensory score sheet using the reference described by Lawless and Heymann (2010). The attributes tested were patterned to the study of Utomo et al. (2014) with some modifications.

### 2.1. Description of the experiment

In preparation for kappa-carrageenan, raw seaweeds (*Kappaphycus alvarezii*) are air-dried for 8 hours until no moisture is felt. Dried seaweeds are soaked with water for five hours to reduce the seaweedy odor. Soaked seaweeds are cut into one-inch (1-inch) lengths. The soaked 1-inch length seaweeds were then boiled and strained to obtain an extract (kappa-carrageenan). The boiling and straining process is done three times to obtain a finer extract. The kappa-carrageenan was set aside, ready for use.

Gummy guyabano candies were made for every formulation, i.e., Control, Treatment 1, Treatment 2, and Treatment 3. After the samples were made, they were packed in a sealed plastic bag and labeled accordingly. For the proximate analysis (ash content, moisture content, crude protein, crude fat, and crude fiber), samples were labeled as Sample 1 for CO, Sample 2 for T1, Sample 3 for T2, and Sample 4 for T3, and all samples have three replicates. Moreover, 150 grams of samples per formulation were brought to SEAFDEC - 50 grams for each replicate per formulation. And for pH, a total of 450 grams (for three replicates) per formulation were brought to ISCOF Science Laboratory for the said analysis.

Three samples per formulation with the following specifications: 2.5 cm x 2.5 cm x 10 cm were submitted to UP-RRC Food Science Laboratory for gel strength analysis.

In the analysis of the total plate count, a total of 1500 grams of samples per formulation were brought to SEAFDEC, and the sample quantity was good for three replicates, 500 grams for each replicate. The samples' label is similar to the labeling done on the samples for proximate analysis. Further, all samples that were brought to various laboratories were stored in a polyethylene ice box while on travel.

For the product's sensory attributes, samples from different formulations (CO, T1, T2, and T3) in a single product with the samples submitted for various tests were utilized and coded with three-digit numbers and then subjected to sensory evaluation. Four formulations were used in this study, one control formulation and three treatment formulations. Analysis of samples was only conducted once. However, replications were applied to the samples to be tested. It is worth saying that all the experiments were conducted in triplicate.

Control gummy candies, i.e., without κ-carrageenan, were made according to Pobar's (2015) formulation. This formulation was adapted to prepare the modified gummy candy with κ-carrageenan as an alternative ingredient for gelatin, as shown in Table 1. The different quantities of κ-carrageenan added in the treatment formulations were based on the various study findings that carrageenan is typically used in foods at a very low dose (0.01-3%) (Mitchell and Guiry, 1983; Nussinovitch, 1997; Hassan et al., 2019). Further, the reference formulation yielded 900 grams of gummy candies. In this study, κ-car is added at 0% for Control (CO), 1% for Treatment 1 (T1), 3% for Treatment 2 (T2), and 5% for Treatment 3 (T3) of the total weight of the gummy candy.

**Table 1:** Formulations of gummy guyabano candy using different amounts of κ-carrageenan

| Ingredients | CO | T1 (1%) | T2 (3%) | T3 (5%) |
|---|---|---|---|---|
| Gelatin | 150 grams | 141 grams | 123 grams | 105 grams |
| κ-carrageenan | 0 | 9 grams | 27 grams | 45 grams |
| Blended Guyabano pulp | 500 grams | 500 grams | 500 grams | 500 grams |
| Centrifugal sugar | 440 grams | 440 grams | 440 grams | 440 grams |
| Glucose | 38 grams | 38 grams | 38 grams | 38 grams |

For the preparation of the control product, the candy was prepared by washing the ripe guyabano fruit, separating skins and seeds, and blending the fruit pulp. In a mixing bowl, fruit pulp and unflavored gelatin were mixed until evenly distributed, and centrifugal sugar was added. The mixture is transferred to a pan and is cooked under moderate heat. When caramelization is almost reached, glucose is then added until caramelized. The same procedure was followed in the production of treatment products, but instead of using only gelatin, κ-carrageenan was incorporated with gelatin in different amounts. The process flow of gummy candy preparation is reflected in Fig. 1.

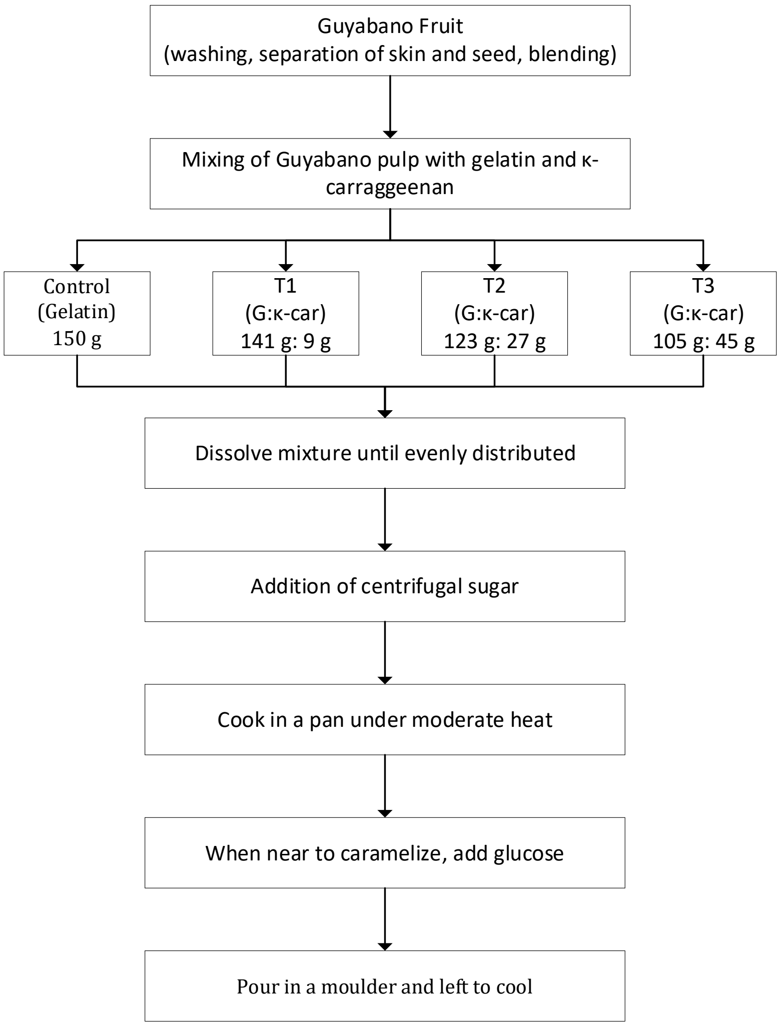


**Fig. 1:** Schematic diagram of gummy guyabano candy preparation

### 2.2. Statistical analysis

Data on the physicochemical properties, total plate count, and sensory evaluation results of gummy candies were expressed as mean ± standard deviation (n = 3). One-way analysis of variance (ANOVA) was utilized by applying Fisher's Least Significant Difference (LSD) for means with significant differences ($p < 0.05$) in physicochemical analyses and TPC. One-way ANOVA was used to prove if there is a significant difference among samples with different treatments. When a hypothesis of several means is tested by using ANOVA, and it is rejected for a given level of significance, Fisher's LSD test is most commonly applied to know which mean(s) is (are) significantly different from which (Sultana et al., 2013).

Moreover, Tukey's test was applied for sensory evaluation with significant differences. Tukey's test was employed after an ANOVA had shown that a significant difference exists and determined where the difference exists. It determines the individual means are significantly different from a set of means (Hayness, 2013). Data were analyzed using the Statistical Package for Social Science (SPSS) for Windows version 17.0.1. Further, results were expressed as mean ± standard deviation, tabulated, and a table of significance was employed to elaborate the results further.

## 3. Results and discussion

### 3.1. Physicochemical properties

The results of physicochemical properties such as pH, proximate analysis, and gel strength being tested in this study's product (gummy guyabano candy) are shown in Tables 2, 3, and 4, respectively.

A significant difference was found among the samples' pH after an F-test ($p<0.05$). Gummy guyabano candy samples from CO exhibited the lowest pH of 3.52; the highest recorded pH was of the T3, with a value of 3.94. Further, results showed an increasing trend, which can be influenced by the varying amounts of hydrocolloids added in the formulations. As shown in Table 1, there is a rising addition of κ-car in the formulations, consequently reducing the gelatin's amount. Gelatin Manufacturers Institute of America recorded pH values of gelatin of 3.8 - 5.5 (Type A) and 5.0 - 7.5 (Type B), which is lesser compared to the pH of carrageenan of 8.04 to 10.09 and 8 - 11, the specification set by JECFA (2006) for the pH range of carrageenan (JECFA, 2006; Chan et al., 2013). However, the pH of the gummy candies tested was within the range (3.0 to 4.5) recommended by Grazela and Morrison (2002) for gummy candies made with carrageenan

**Table 2:** Mean ± SD pH of gummy guyabano candies enriched with different amounts of κ-car

| Parameter | CO | T1 | T2 | T3 |
|---|---|---|---|---|
| pH | 03.52 ± .03 | 03.57 ± .10 | 03.87 ± .02 | 03.94 ± .04 |

**Table 3:** Mean ± SD proximate analysis of gummy guyabano candies enriched with different amounts of κ-car

| Parameters | CO | T1 | T2 | T3 |
|---|---|---|---|---|
| Ash Content | 00.21 ± .02 | 00.37 ± .01 | 00.74 ± .07 | 01.20 ± .03 |
| Moisture Content | 26.06 ± .41 | 27.10 ± .83 | 27.94 ± .04 | 28.23 ± .48 |
| Crude Protein | 16.07 ± .74 | 15.86 ± .07 | 15.62 ± .18 | 15.48 ± .24 |
| Crude Fat | 00.32 ± .14 | 00.05 ± .03 | 00.04 ± .04 | 00.02 ± .03 |
| Carbohydrate | 42.66 ± .98 | 43.38 ± .81 | 44.34 ± .11 | 44.93 ± .74 |
| Crude Fiber | 00.19 ± .07 | 00.22 ± .06 | 00.35 ± .06 | 00.40 ± .11 |

The results in Table 3 showed noticeable treatment-dependent differences in ash content, suggesting that the amount of κ-carrageenan added to T1, T2, and T3 influenced it, as the value relatively increased from CO to T3. The incorporation of κ-car caused the rise of ash content. A study revealed that ash is the most abundant component in κ-carrageenan (Chan et al., 2013). Moreover, it is also because seaweed species, a carrageenan source, are generally rich in ash depending on the species and the area of cultivation (Diharmi et al., 2019). A study indicated that analysis of ash content is performed to determine the total mineral content in foods (Harris and Marshall, 2017). Ismail (2017) emphasized that the ash content of food is a valuable proximate composition for the nutritional value of some foods. Also, carrageenan contains several minerals, such as calcium, iron, sulfate, magnesium, phosphorus, sodium, and potassium (Renuka et al., 2013).

A significant difference was found in the moisture content of the gummy candy samples ($p<0.05$). The lowest moisture content is CO, 26.06 ± .41, and the highest recorded is 28.23 ± .48 of T3. Table 3 shows an increasing trend of moisture content respective to the added amount of κ-car, and this could be because carrageenan is a plant hydrocolloid. Carrageenans are extracted from red seaweeds and are involved in maintaining structure as a significant component of the cell wall (Burey et al., 2008).

Furthermore, carrageenan has been utilized in various products as a water-binding agent that prevents moisture loss during cooking, improves cooked yields, and prevents an undesirable dry texture or bite. It is also incorporated to enhance slicing properties, mouthfeel, and juiciness (Imeson, 2000; Bixler and Porse, 2011). Results further implied that the gummy guyabano candy tested in this study is an intermediate moisture food. Intermediate moisture food has a 15-40% moisture content and can reduce to a level where most microorganisms cannot grow (Sych, 2003). In addition, Ansari et al. (2014) revealed that the moisture content of a food could affect its texture – a sensory property.

For the protein content, a decreasing trend was noted. Recorded values are 16.07 ± .74, 15.86 ± .07, 15.62 ± .18, and 15.48 ± .24 for CO, T1, T2, and T3, respectively. However, from the results (Table 3), a not significant difference was found. It can be deduced that the influencing factor was adding κ-carrageenan and reducing gelatin in treatment formulations. Moreover, the appreciable amount of protein in the samples can be owed to gelatin, as it is a protein found in collagen. Commercially produced gelatin is sourced primarily from pigskin, beef skin, and bones, and some are from fish; all are sources of protein (Mouritsen and Styrbæk, 2017; Hartel et al., 2018). Further, soursop pulp is rich in nutrients like protein (Degnon et al., 2013) and carrageenan is a protein source (Mouritsen and Styrbæk, 2017).

In the treatment results, fat content decreased significantly (00.32 ± .14 to 00.02 ± .03) with the increased addition of κ-car. K-carrageenan can be the cause of the receding amount of fat content. According to Gates (2012), one of the functional properties of carrageenan is fat reduction. Furthermore, the observed lower crude fat contents in the samples wherein κ-car was added suggests that it can be incorporated into a weight-reducing diet (Shemishere et al., 2018). Determining the fat content of a food product is very important because of food regulations, nutritional value, and functional properties (Ellefson, 2017).

The result of carbohydrate content showed a significant difference among samples (Table 3). It indicates that the carbohydrate content increases with the accelerating proportion of κ-car added. Recorded values are: 42.66 ± .98 for CO, 43.38 ± .81 for T1, 44.34 ± .11 for T2, and 44.93 ± .74 for T3. It is noteworthy that carrageenan is a natural carbohydrate (polysaccharide) obtained from edible red seaweed (Necas and Bartosikova, 2013). A study determined the total carbohydrates for commercial and native carrageenan, and the values were 64.82 g.100 g−1 and 56.44 g.100 g−1, respectively (Webber et al., 2012). Further, Estevez et al. (2004) found a value of 54% for the total carbohydrate content of κ-carrageenan for a standard analytical procedure. Also, the high carbohydrate content recorded from the samples can be ascribed to the soursop or guyabano. Degnon et al. (2013), in the proximate composition of soursop pulps, revealed that they are rich in carbohydrates. Based on Table 4, the enhanced κ-car addition increased the crude fiber significantly. Values recorded were .19%, .22%, .35%, and 40% for CO, T1, T2, and T3, respectively. CO is significantly different with T2 and T3 but not with T1. Results are analogous to the study of Gates (2012), wherein it was found that carrageenan enhanced and fortified the fiber content of foods. Results are also coherent with Suryani et al. (2019), wherein crude fiber levels of ice cream made with kappa- and iota-carrageenan are higher than gelatin. Generally, several seaweed species are a good source of dietary fiber (Peñalver et al., 2020). Furthermore, the noted high fiber content in all samples can also be owed to soursop fruit, which contains high dietary fiber (Claros, 2015). For gel strength, the results are shown in Table 4. A significant difference was found; however, no clear effect was noted as to whether κ-car increases or decreases the gel strength of the samples. The results of physicochemical properties in this study that can be associated with gel strength are ash and moisture content. Nguyen et al. (2014) reported a direct relationship between the concentration of KCl and the gel strength of the κ-carrageenan; an increased concentration caused an increase in gel strength. Further, it was also noted that a high concentration of KCl solution causes the carrageenan's high ash content, so the higher the KCl solution's concentration, the higher the ash content (Manuhara et al., 2016). Additionally, κ-carrageenan has a high gelling capacity and forms gels with high gel strength (Hotchkiss et al., 2016). Delgado and Bañón (2015) have correlated that differences in hardness might be due to the capacity of circulating air to stabilize the gel by cooling since the moisture content hardly decreased. Aside from carrageenan, other factors affecting hardness are heating time and temperature (Al-Baarri et al., 2018). Further, from the results, the decreasing and increasing trend of gel strength can be influenced by the temperature during cooking (Valderrama-Bravo et al., 2014).

### 3.2. Total plate count

TPC was performed in each formulation of gummy guyabano candy to estimate the microbial load. It is an essential indicator of the sanitary conditions in which the food product was made because microbial contamination of food poses a serious threat to public health (Dalee et al., 2017). In this study, results (Table 5) reveal that CO samples had the lowest TPC of <250 EAPC/g and the samples from T3 had the highest count of 4.66 x 104 cfu/g. As shown in Table 5, the total plate counts of samples were significantly affected ($p<0.05$) by different treatments as varying amounts of κ-carrageenan were added to each formulation.

A substantial increase in TPC was noted from Control to Treatment 3, which could be associated with the samples' increasing pH values (Table 2).

**Table 4:** Mean ± SD Gel Strength gummy guyabano candies enriched with different amounts of κ-car

| Parameter | CO | T1 | T2 | T3 |
|---|---|---|---|---|
| Gel Strength (g/cm$^2$) | 1030.63 ± 63.00 | 735.00 ± 31.19 | 1369.33 ± 54.00 | 1278.00 ± 94.00 |

**Table 5:** Mean ± SD Total Plate Count of gummy guyabano candies enriched with different amounts of κ-car

| Parameter | CO | T1 | T2 | T3 |
|---|---|---|---|---|
| Total Plate Count | <250 EAPC/g | 770 EAPC/g | 4.26 x $10^4$ cfu/g | 4.66 x $10^4$ cfu/g |

*: Values with different superscripts on the same row indicate significant differences ($p<0.05$)

Kim et al. (2018) revealed that increasing acidity (decreasing pH value) prolonged the onset of microorganisms to log-phase and significantly reduced their growth rate, opposite to this study's result. Besides, in foods with a pH below 4.5, pathogens would not be expected to survive; the organisms present would be limited to yeasts, molds, and a few acid-tolerant bacteria (PHE, 2020). In addition, moisture content can also affect the observed increasing TPC, which agrees with Onilude et al. (2010), in which different succession of microorganisms was noted at relatively higher moisture content. As recommended by the FDA (2013) of the Department of Health in FDA Circular No. 2013-010, an increase in total plate count up to levels exceeding the value of 5 x 106 cfu/g in confectioneries, including candies like gummy candy is regarded as microbiologically unsafe as this indicates potential health hazard or imminent spoilage not fit for human consumption (FDA, 2013). Thus, the TPC values of the gummy guyabano candy samples analyzed from different formulations, i.e., CO, T1, T2, and T3, were within the generally recommended APC or TPC guideline value given by FAD for confectionery products in the Philippines; and considered acceptable and safe for consumption.

### 3.3. Sensory attributes

Sensory evaluation of gummy guyabano candies was performed by effective tests. Affective tests are employed in the food industry to determine the liking and disliking of the panelist and their preference for one product over another (Sharif et al., 2017). The sensory scores of gummy guyabano candies are presented in Table 6. Sensory attributes of gummy candy give panelists the impression of the developed product compared to the existing similar product in the market. The resulting overall sensory experience is crucial for the commercial success of the food product (Sirangelo, 2019). Moreover, Results were presented as mean ± standard deviation.

Sensory analysis of gummy candy samples made from different formulations was assessed according to attributes such as appearance, taste, texture, aroma, elasticity, melt-in-mouth, and for its overall acceptability by semi-trained panelists using a 9-point hedonic scale. As to its appearance, results from Table 6 show that the formulation that had the least value of 6.90 ± .99 is T3 (105 g: 45 g), which could be attributed to its cloudy appearance giving it a dull color; thus, the least preferred in terms of appearance; while T1 (141 g: 9 g) with the highest value of 8.40 ± .70 was the most appealing to panelists which according to them it was attractive because of its enough transparency and milky color. Furthermore, results show a significant difference for samples T2 and T3 ($p<0.05$). In addition, T3 was not significantly different from other formulations; and Treatment 1 had no significant difference with Control and T2 but differed significantly with T3 in Tukey's test results. Based on observations, when the addition of κ-car is increased, the product becomes cloudy in appearance, which is an undesirable characteristic for gummy candy. However, when using only gelatin, the product is quite yellowish, and based on evaluation results, the panelists do not prefer it. Hence, in terms of appearance Treatment 1 is the most preferred. However, no significant difference was found among T1, CO, and T2. According to Submaranian (2007), one of the most crucial quality parameters driving product acceptance by the consumer is the product's appearance.

In terms of taste, T3 was the least accepted by panelists with a value of 6.90 ± .57, which conveys that the product tasted sweet and sour but with a trace of seaweedy taste owing to the quantity of κ-carrageenan added, which is the highest among the formulations (5%). On the other hand, most of the panelists preferred the taste of T2 among the four formulations with a value of 8.10 ± .57, which means that the taste was sweet and sour, desirable for gummy candy, and had no taste of seaweed. Tukey's test results showed that Treatment 3 significantly differed from T2 but not with other formulations. Further, T2 differed significantly with Control and T3 but not with T1. Observation results showed that adding κ-car at 5% gives the product a seaweedy taste; addition at 1% and 3% imparts no seaweedy flavor but retains the natural taste of guyabano, which is sweet and sour. Based on the preference test, T2 is the most preferred for its taste. However, there is no significant difference found between Control and Treatment 1. The desirable taste of the gummy candy, as evident by the sensory ratings, could be due to the unique flavor of soursop from the combination of sugars and acids (0.65–0.85%) and its pulp (de Lima and Alves, 2011; Pareek et al., 2011; Gajalakshami et al., 2020).

T3 was significantly different for the texture attribute from CO, T1, and T2. Moreover, Treatment 3 is the least accepted in terms of texture with a value of 6.70 ± .94, which implies that the texture in products of T3 was the least preferred. Besides, CO is not the most preferred because of the sticky product, and it can cause the candies to adhere to one another when stored in a container firmly. In contrast, the T2 formulation garnered the most acceptable score of 8.20 ± .63, which can be deduced that it had stickiness and rigidness suitable for gummy candy. T2 differs significantly from T3 but not from the rest of the formulations. Yield from observation noted that the addition of κ-car made the stickiness of gummy candy weaker, resulting in apparent rigidity. Using only gelatin produced a sticky, gummy candy that adhered to each other when stored in a container. The preference test indicated that T2 is the most preferred one because of the sufficient stickiness and rigidity ideal for a gummy candy for storage, and T3 is the least preferred because of the not ideal stickiness and rigidity.

Texture defines the shape and, more critically, the chewing character of a wide range of products like gummy articles or jelly fruits (Endress and Mattes, 2003). The varying degree of liking to the texture could be due to adding a different quantity of κ-car. The result is incongruent with Hartel et al. (2018) stating that mixing hydrocolloids in gummy and jelly candies provide more significant variation in product texture due to the complex interactions in mixed or composite gels.

The Aroma of T3, with a value of 7.00 ± .67, was the least accepted by panelists. It infers that it had a seaweedy odor, which competed with the scent of the guyabano. T2, with a score of 8.20 ± .63, was the most accepted by panelists, which means that the product was fragrant. The aroma of guyabano is noticeable, not overpowered by the odor emitted from the added κ-carrageenan. Moreover, Tukey's test revealed a significant difference among the scores of the hedonic aroma test on the formulations. T3 was significantly different from Control, T1, and T2. To add, T2 did not differ considerably from CO and T1 but is significantly different from T3. Based on the results, the least and highest rating for the aroma attribute has equivalent descriptive ratings of like moderately and Like Very much, respectively. Findings are parallel with the observations that when the incorporation of κ-car is at 5%, the seaweedy odor from κ-car is quite evident, resulting in the disappearance of the guyabano's scent.

**Table 6:** Mean ± SD Sensory scores of gummy guyabano candies enriched with different amounts of κ-car

| Parameter | CO | T1 | T2 | T3 |
|---|---|---|---|---|
| Appearance | 8.10 ± .74 | 8.40 ± .70 | 7.90 ± .74 | 6.90 ± .99 |
| Taste | 7.60 ± .70 | 7.90 ± .32 | 8.10 ± .57 | 6.90 ± .57 |
| Texture | 7.60 ± .70 | 7.70 ± .49 | 8.20 ± .63 | 6.70 ± .94 |
| Aroma | 7.70 ± .48 | 8.00 ± .47 | 8.20 ± .63 | 7.00 ± .67 |
| Elasticity | 7.80 ± .42 | 7.90 ± .56 | 8.40 ± .52 | 8.00 ± .67 |
| Melt-in-mouth | 7.00 ± .82 | 7.50 ± .53 | 8.10 ± .57 | 8.20 ± .42 |
| Overall acceptability | 7.70 ± .48 | 7.80 ± .42 | 8.20 ± .42 | 7.00 ± .47 |

Moreover, at 1% and 3% incorporation of κ-car, no nuisance odor of κ-car was observed. The effective test revealed that T2 is the most preferred formulation in terms of its aroma because the incorporated κ-car blended well with the guyabano's scent. However, no significant difference was noted between CO and T1 formulations. This result showed that the products' aromas in CO, T1, and T2 are desirable and can be attributed to soursop's pleasant and distinctive smell (Gajalakshami et al., 2020).

Scores on the elasticity attribute revealed a difference among treatments in the preference test. Moreover, 7.80 ± .42 is the lowest score attained by the control formulation, which suggests that the samples made from the formulation were slightly elastic, making it the least preferred by panelists. Still, the control did not vary significantly among the different treatments after the ANOVA test. While the highest recorded score is 8.40 ± .52 of the T2, which insinuates that the product's elasticity is the most accepted by panelists and can be credited to the ideal elasticity generated by the formulation. Nonetheless, it was revealed that T2 differed significantly from Control, T1, and T3. Observations of the product implied that the addition of κ-car has a slight impact on the elasticity of the gummy candy, and the effect is insignificant in all formulations.

The degree of liking of the melt-in-mouth varied significantly among formulations ($p>0.05$) after the ANOVA test. Control formulation garnered the lowest score of 7.00 ± .82, signifying that it was the least accepted by the panelist. Moreover, Control varied significantly with Treatments 2 and 3. Nevertheless, T3, with a value of 8.20 ± .42, was the most preferred by panelists for the mouthfeel attribute but did not significantly differ from Treatment 2 or between Control and T1. When correlated with the observation, it was found that incorporation of κ-car had yielded a stronger melt-in-mouth which can be owed to the major functional properties that it improves gel strength, resulting in T3 as the most preferred one. However, no significant difference was found between T2. Further, the relatively high rating in Treatments 1, 2, and 3 for melt-in-mouth characteristics can be attributed to the utilized κ-car combined with gelatin in forming synergistic gelation to produce gels having similar 'melt-in-mouth' properties as gelatin gels (Karim and Bhat, 2008). Further, the incorporated carrageenan improved mouthfeel and juiciness (Imeson, 2000).

The statistical analysis resulted in significant differences in overall acceptance of different gummy guyabano candy formulations. The overall acceptability scores for each gummy guyabano candy formulation showed that T3 was the least accepted by panelists with an acceptable value of 7.00 ± .47, equivalent to "Like Moderately." In contrast, the most accepted formulation is the T2 with a score of 8.20 ± .42, which on the hedonic scale corresponds to "Like Very Much." Further, Tukey's test revealed that Treatment 2 was not significantly different from Control and Treatment 1 but significantly different from Treatment 3. T2 is the most accepted formulation, which other sensory attribute results can support. Only the melt-in-mouth characteristic of the product, wherein T2 is not the most preferred. The consolidated results of various sensory attributes revealed that T3 is the least preferred in appearance, taste, texture, and aroma, and T2 is the most preferred for its taste, texture, aroma, and elasticity. However, as per the overall acceptability of samples, slight differences were noted among the gummy candies made from different formulations. Thus, it is apparent that the four formulations were liked and accepted by panelists, T3 is the least accepted, and T2 is the most accepted formulation. Lawless and Heymann (2010) stated that a product's acceptability represents one of the most critical sensory analysis tests.

## 4. Conclusion

Results demonstrated the feasibility of producing gummy guyabano candy added with κ-car. Moreover, adding κ-car to gummy guyabano candy significantly affects the physicochemical properties, total plate count, and sensory attributes. Generally, the enrichment of gummy guyabano candy with κ-carrageenan improved the quality of the samples in terms of physicochemical properties. For ash content, increasing values were noted from CO to T3 (00.21 ± .02 - 01.20 ± .03), and carrageenan contains several minerals, such as calcium, iron, sulfate, magnesium, phosphorus, sodium, and potassium (Renuka et al., 2013). Moisture content increased from 26.06 ± .41 (CO) to 28.23 ± .48 (C3), improving slicing properties, mouthfeel, and juiciness (Imeson, 2000). Crude fat decreased (00.32 ± .14 - 00.02 ± .03), indicating that the food product can be incorporated into a weight-reducing diet (Shemishere et al., 2018). Increased results were observed in carbohydrate content from 42.66 ± .98 to 44.93 ± .74 of CO to T3, respectively. Carbohydrates provide the fuel the body uses to build and repair itself. And for crude fiber, values also increased (00.19 ± .07 - 00.40 ± .11). Fiber-rich diet often has a lower fat content and is richer in micronutrients (Dhingra et al., 2012). Furthermore, results showed that the extent of the effect is dependent on the concentration of κ-car added.

It was found that the experimental gummy guyabano candy in Treatment 2 (123 g: 27 g, gelatin to κ-car ratio) has optimum physicochemical properties, i.e., pH, ash content, crude protein, crude fat, carbohydrate, crude fiber, and gel strength were 03.87, 00.74%, 15.62%, 00.04%, 44.34%, .35%, 1369.33 g/cm2, respectively; and the TPC which is 4.26 x 104 cfu/g was within the recommended range by BFAD for confectioneries. Moreover, Treatment 2 was the most preferred in the following sensory attributes: Taste, texture, aroma, and elasticity. It also received the highest overall acceptability score. Hence, in this study, the optimum formulation in making gummy guyabano candy added with kappa-carrageenan was T2.

## Compliance with ethical standards

## Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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