ASEAN Journal of Scientific and Technological Reports

Research article

Effect of Extracted Galangal Rhizome and Gelling Agents on Quality Attributes of Galanga Jelly Product

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Abstract: This research aimed to study the effects of extracted galangal rhizome and gelling agents on the quality attributes of the jelly product. The ratios between extracted galangal rhizome and water used in the study were 0:100, 25:75, and 50:50 (w/w). Gelling agents used in the study were only gelatin combined with potato starch. The products were tested by physical characteristics, chemical, and sensory acceptability. The sample product with extracted galangal rhizome was yellower than the product without extracted galangal rhizome. In addition, the higher the amount of extracted galangal rhizome, the greater the yellowness of the product. Increasing the levels of extracted galangal rhizome showed a tendency to increase the *L**, *a**, and *b** values. Results obtained from a texture analyzer showed that using 20g of gelatin, 2.5g of potato starch, and 25% of extracted galangal rhizome had the highest values of hardness, springiness, and chewiness ($P \leq 0.05$) of 7.63 N, 10.21 mm and 76.76 (N•m), respectively. The water activity was in a range of 0.86-0.88 and the moisture content was 18.30-18.74%. Total phenolics content and IC_{50} were 13.52-19.99 mgGAE/g of sample and 0.20-0.32mg/ml of jelly extract, respectively. From sensory evaluation, using 25% of extracted galangal rhizome and 2.5g of potato starch, and 20g of gelatin as gelling agents resulted in the highest overall acceptability.

Keywords: Galangal rhizome; Gelling agents; Jelly desert; Product quality attributes

Citation:
Supaphon, P.; Pangsanthia, P.; Thaiwong, N. Interaction of Gelling Agents on Quality Attributes of Galanga Jelly Product. *ASEAN J. Sci. Tech. Report.* **2022**, *25(2)*, 19-30. https://doi.org/10.55164/ajstr.v25i2.245453.

Article history:
Received: October 26, 2021
Revised: March 29, 2022
Accepted: March 31, 2022
Available online: June 26, 2022

1. Introduction

Galanga (*Alpinia galanga* (L.) Willd.) is a plant in the Zingiberaceae family. Examples of plants in this family are Fingerroot, *Amomum testaceum*, True Cardamom, Ginger, Turmeric, and *Curcuma aromatica*. Galanga is called differently *depending* on its origin such as Se-oe-khoei (Mae Hong Son), Kha yuak (Northern Thailand), Kha luang (Northern and Northeast Thailand), and Katuk karohini (Central Thailand). It is reported that 100 grams of its baby rhizome provide 20 kilocalories [1]. The same amount of galangal rhizome (100 g) also provides 14 g, 9 g, 49 g, 19 g, 9 g, 3g, 16g, and 0.2-1.5% of moisture, total ash, matter soluble in 80% ethanol, matter soluble in water, total sugar, total nitrogen, total protein, and essential oil content (dry wt.), respectively [2]. Galanga has numerous benefits, and its rhizome can be an ingredient in many recipes, spices, and medicines. Moreover, galanga also has medicinal properties. Its rhizome can treat stomachache, colic, and flatulence [3]. Its flower can be put over the skin to heal dermatophytosis [4]. Researchers reported that the dry root and rhizome had been used for their antioxidant, antidiabetic, antiulcer, antidiarrhea, anti-emetic, analgesic, anti-inflammatory, and anticoagulation effects [5-7]. However, galanga is a pungent and spicy herb that needs to be diluted before processing into other products.

Jelly is a trendy dessert nowadays, especially for children and teenagers, because they enjoy its chewy texture. Jelly has a gooey and flexible texture and comes in attractive shapes and colors. Jelly is made of the gelling agent [8]. Carrageenan, gelatin, starch, and pectin are widely used gelling agents [9]. Gelatin is a natural hydrocolloid protein found in animal bones, skin, and connective tissue [10]. This research used gelatin and potato starch as the gel-forming agents. Gelatin is most widely used in the gummy confection or confectionery gel industry as it quickly produces a stable gel texture and plays a role as an emulsifier [11]. Meanwhile, potato starch is more appropriate for gummy-type candies because of its clarity and elasticity over other starches after cooking [12].

After being solubilized, the softness of the jelly can range from soft to hard. This type of gelling agent solubilizes at 40 °C and has pH stability. It is common to use gelatin in desserts to give them a melt-in-your-mouth texture, a good taste, and a good smell [13]. Starch is a food additive used in desserts to help improve the surface of the jelly by thickening and stabilizing it. It prevents the crystallization of sugar, a sweetener that helps form the jelly's shape and prolongs the product's shelf life [14]. According to the Thai Industrial Standard Institute, sweeteners approved for desserts are sucrose, invert sugar, invert syrup, fructose syrup, glucose syrup, etc. The acids commonly used in desserts are citric acid, malic acid, lactic acid, and fumaric acid. Adding an acid is important for the taste and helps stabilize the jelly. However, too much acid would ruin its stabilization of it. Usually, the pH of jelly should be around 2.8-3.5 [15] (p. 2).

This study aimed to study the appropriate ratio of extracted galangal rhizome and gelling agents to make the jelly, galanga jelly's physical and chemical properties, and consumers' acceptance of galanga jelly in terms of senses.

2. Materials and Methods

2.1. Ingredient preparation

Galangal rhizomes were purchased at the local market in Nakhon Ratchasima province, Thailand. The rhizomes had to be fresh, not too immature, or too mature. There were short rhizomes around the roots. The outer skin of the roots was orange-brown. The roots' inside were yellow and in good condition without a foul smell. The rhizomes were cleaned, and unwanted parts such as pseudostems, some root parts went wrong, or soil were cut out. Then, the root was left to dry. After that, the rhizomes were sliced into little pieces and mixed with clean water using a blender (the ratios between galanga rhizome and water were 0:100, 25:75, and 50:50 (w/w), respectively). A cheesecloth was used to strain the extracted galangal rhizome. Then the extracted solution was used for the jelly production process. The galangal rhizome ratios at different levels were determined by the solubility of sample preparation between the rhizome and water. Then, the galangal rhizome was blended with clean water and filtered to be the primary raw material to produce the jelly.

2.2. Jelly production process

According to the study of ingredients in jelly production, there was a direct variation of formulas used. The formulas for the jelly production had different amounts of extracted galangal rhizome. Each formula had ingredients as follows. 100 mL of the extract was mixed with 36.5 g of sucrose, 18.25 g of glucose syrup, and 0.55 g of citric acid. At the same time, the study of results of gelling agents was conducted on gelatin bloom 250 and potato starch. The study used 6 jelly formulas as follows:

0:100+G = Water: Galangal rhizome 0:100 and 20g of gelatin

25:75+G = Water: Galangal rhizome 25:75 and 20g of gelatin

50:50+G = Water: Galangal rhizome 50:50 and 20g of gelatin

0:100+GS = Water: Galangal rhizome 0:100 and 20g of gelatin, 2.5g of potato starch

25:75+GS = Water: Galangal rhizome 25:75 and 20g of gelatin, 2.5g of potato starch

50:50+GS = Water: Galangal rhizome 50:50 and 20g of gelatin, 2.5g of potato starch

The ingredients and process were divided into two parts. The first part was letting the gelatin sit in room temperature water (30 ml) until it became more significant. The second part was mixing extracted galangal rhizome, sucrose, potato starch, and glucose syrup. The mixture had to be simultaneously stirred until the temperature was raised to 110 °C. Then, two parts were mixed and let sit until the final total soluble solids (TSS) content was 70°Brix and pH 3.5. Afterwards, pour the mixture into silicone molds, and put them in the fridge for 24 hours (at a temperature between 4-8 °C and relative humidity between 85-95%). Then, take the jellies out of the silicone molds (size of 2.4 x 2.4 x 1.9 cm3) and store them in containers to study their physical and chemical properties and test consumers' acceptance.

2.3. Physical analysis

2.3.1. Color measurement

The surface color of the jelly was measured with a chroma meter (CR-400, Minolta Co., Osaka, Japan). The measurement was repeated six times. The results were expressed as L* (lightness), a* (redness-greenness), and b* (yellowness-blueness).

2.3.2. Texture analysis

Texture profile analysis (TPA) was carried out using a texture analyzer (TA General, Brookfield engineering Labs Inc., USA) with a 5 kg-load cell. Compression tests evaluated Experiments, which generated a plot of force (g) versus time (s). A 25.4 mm diameter TA 11/1000 probe was used to measure the textural profiles of samples.

2.4. Chemical analysis

2.4.1. Water activity (a_w) and Moisture content

Water activity (a_w) and Moisture content were measured at room temperature (25 °C),

Aqualab equipment (water activity analyzer, aw-SPRINT-TH500, Novasina, Switzerland) and moisture equipment (moisture analyzer, MA37, Sartorius, Germany), respectively.

2.4.2. Total phenolic content and antioxidant activity

Jellies extracts were prepared by mixing one gram of sample with hot water (90-95°C) for 15 min. After centrifugation, the obtained extracts were kept at 4°C until further analysis (applied from [17] (p. 2)).

Extracted galangal rhizomes at different concentrations (galanga rhizome: water at 0:100, 25:75, and 50:50) and galanga jellies (extracted galangal rhizome: water at 0:100+G, 25:75+G, 50:50+G, 0:100+GS, 25:75+GS, and 50:50+GS) were determined for the total phenolic content and antioxidant activity.

The total phenolic content (TPC) measurement process was done by using the method in [18] (p. 360). The extracted sample (100uL) and 100 uL of Folin-Ciocalteu's phenol reagent were mixed for 3 minutes. Then, 1 ml of Na_2CO_3 solution (20%) was added to the mixture. The mixture was then incubated for 30 minutes in a room with no lights. The absorbance was measured at 750 nm to the blank. Gallic acid was used to obtain the standard curve. TPC unit was described in mg, and gallic acid was equivalent to the extracted galangal rhizome per gram (mg GAE/ml sample) and per 100g of galangal jelly (mg GAE/g).

DPPH method was used to determine the antioxidant measurement. The DPPH assay measured the electron-donating ability of the extracts and commercial antioxidants according to the bleaching of purple-coloured methanol solution. The assay added 5 ml of 0.004% DPPH in methanol to 50 μl of samples at different concentrations. After 30 minutes of incubation at room temperature, the absorbance reaches 517 nm. The bleaching of the purple color indicated the positive antioxidant activity. The percentage of free radical inhibition by DPPH was calculated by equation (1) [18] (pp. 360-361).

$$\%I=\left[\frac{(AB-AA)}{AB}\right]\times 100 \quad (1)$$

Where: AB = the absorbance of a blank after 30 min

AA = the absorbance of the sample after 30 min

The results were reported as IC_{50}, calculated from the percentage of free radical inhibition (%I) versus concentrations of the respective sample curve.

2.5. Sensory evaluation

The testers evaluated product acceptance on the nine-point hedonic scale. One point was the least liked and the 9 point was the most appreciated. The sample group was 30 trained panellists, and each person tasted 6 samples simultaneously. The researcher assessed the likings in appearance, colour, flavour, taste, texture, and overall acceptability.

2.6. Statistical Analysis

This study used a Completely Randomized Design (CRD) to analyze the physical and chemical qualities and the consumers' acceptance in terms of senses. The study used Randomized Complete Block Design (RCBD) to assess the rates in terms of senses 3 times. Then, I used the data from the assessment to do the Analysis of Variance (ANOVA) and compared the averages' difference at the confidence level of 95% using SPSS software.

3. Results and Discussion

3.1. Physical analysis

Different amounts of extracted galangal rhizome and gelling agents influenced the physical properties of the jelly product. According to the study, the different amounts of extracted galangal rhizome and gelling agents influenced the product's properties in each formula in terms of color and texture.

3.1.1 Appearance

The appearance of the product from each formula is shown in Figure 1.

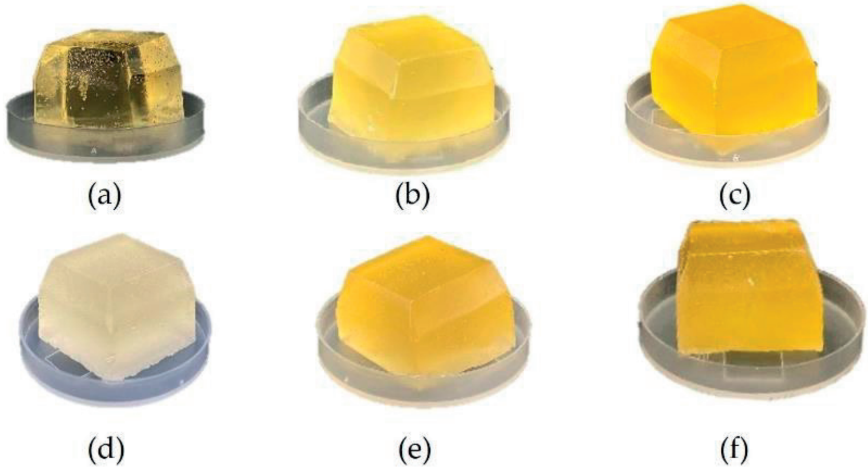

Figure 1. Samples of galanga jelly product with a ratio of extracted galangal rhizome and water at 0:100+G (a), 25:75+G (b), 50:50+G (c), 0:100+GS (d), 25:75+GS (e), and 50:50+GS (f).
Note: G = Gelatin and S = Potato starch

The sample product from every formula ranged from transparent to yellowish transparent. From the figures, the samples products with extracted galangal rhizome (Figures 1b,1c, 1e, and 1f) were yellower than those without extracted galangal rhizome (Figures 1a and 1d). In addition, it was found that a higher amount of extracted galangal rhizome could influence the sample product to be more yellow. However, the different amounts of extracted galangal rhizome and gelling agents could barely affect the shape of the sample product.

3.1.2 Color parameters

The result from color evaluation by the CIE system, which consisted of *L** (lightness), *a** (redness), and *b** (yellowness), as described in Table 1, showed that the different amounts of extracted galangal rhizome had a statistically significant influence on a* (redness) and b* (yellowness) at ($P \leq 0.05$) but did not influence *L** (lightness) at ($P > 0.05$).

Table 1. Effects of galanga and water ratio and type of gelling agents on color parameters of the jelly product

Treatments	Color parameters		
	L* (ns)	***a****	***b****
0:100 + G	53.14 ± 0.44	2.27 ± 0.14^{b}	6.00 ± 0.15^{c}
25:75 + G	53.34 ± 0.57	2.49 ± 0.20^{b}	15.53 ± 0.73^{b}
50:50 + G	53.62 ± 0.50	5.19 ± 0.28^{a}	20.92 ± 0.20^{a}
0:100 + GS	52.89 ± 0.14	2.45 ± 0.38^{b}	6.05 ± 0.07^{c}
25:75 + GS	53.28 ± 0.44	2.56 ± 0.12^{b}	15.85 ± 0.26^{b}
50:50 + GS	53.50 ± 0.47	4.74 ± 0.34^{a}	20.93 ± 0.17^{a}

Note: Values are the means of triplicate ± standard deviation. Those numbers with the different superscript letters in a block differ significantly (P ≤ 0.05). ns, not significant (P > 0.05).
G = Gelatin and S = Potato starch

Using different gelling agents did not significantly influence *L**, *a**, and *b** at (P > 0.05). *L**, *a** ,and *b** ranged between 52.89-53.62, 2.27-5.19, and 6.00-20.93, respectively. Higher amounts of extracted galangal rhizome influenced *a** and *b** to be higher. The sample from the formulas 50:50+G showed the highest *L**, which was 53.62, while the formulas 50:50+G and 50:50+GS showed the highest *a** and *b**, which were 5.19 and 20.93, respectively.

From studying the different amounts of extracted galangal rhizome and gelling agents that influenced the chemical properties of the jelly product. The ratios between extracted galangal rhizome and water used in the study were 0:100, 25:75, and 50:50 (w/w). Gelling agents used in the study were only gelatin combined with potato starch. This study aimed to study physical and chemical properties in appearance, color, texture, moisture, and water activity, including consumers' acceptance in terms of senses. The results showed that the jelly product's properties differed in each formula. The sample product that used extracted galangal rhizome as an ingredient would be yellower than the sample product without extracted galangal rhizome.

Moreover, with the human eye, using a different amount of extracted galangal rhizome and gelling agents could barely affect the shape of the jelly product. From studying the physical and chemical properties of the jelly product, it was found that higher amounts of extracted galangal rhizome would increase the redness and yellowness of the jelly product because galanga has flavonoids [19] (pp. 121-127). Flavonoid is part of polyphonic compounds commonly found in plant-based food. It produces red, yellow, purple, and blue pigmentation [19] (pp. 121-127). Therefore, increasing extracted galangal rhizome would increase flavonoids in the jelly product. The jelly product would have more redness and yellowness.

3.1.3 Texture profiles

According to the study about the different amounts of extracted galangal rhizome and gelling agents that influenced the texture by using texture profile analysis (TPA), it was found that the different amounts of extracted galangal rhizome and gelling agents had a statistically significant influence on hardness (N), springiness (mm), and chewiness (N•m) as described in Table 2.

Hardness (N) is the force from compressing to reduce the amount of the sample but ruin the shape simultaneously. It was found that hardness ranged between 3.33-7.63 N., The different amounts of extracted galangal rhizome and gelling agents had a statistically significant influence on hardness at (P ≤ 0.05). While the sample from the formula 25:75+GS, which was the formula that contained 25% of extracted galangal rhizome and used gelatin and potato starch as gelling agents, had the lowest hardness at 3.33 N, the sample from the formula 0:100+G had the highest hardness at 7.63 N. The sample that used gelatin and potato starch would give higher hardness when compared to gelatin alone (P ≤ 0.05).

Table 2. Effects of galanga and water ratio and type of gelling agents on texture profile of jelly product

Treatments	Hardness (N)	Springiness (mm)	Chewiness (N•m)
0:100 + G	6.61 ± 0.01[b]	9.55 ± 0.48[ab]	54.46 ± 2.41[b]
25:75 + G	3.33 ± 0.00[e]	9.61 ± 0.36[ab]	26.70 ± 2.28[e]
50:50 + G	5.59 ± 0.01[c]	9.03 ± 0.36[bc]	50.60 ± 3.20[b]
0:100 + GS	7.63 ± 0.01[a]	10.21 ± 0.64[a]	76.76 ± 4.58[a]
25:75 + GS	4.91 ± 0.00[d]	8.85 ± 0.29[bc]	38.43 ± 1.26[d]
50:50 + GS	6.43 ± 0.01[b]	8.70 ± 0.38[c]	44.63 ± 3.28[c]

Note: Values are the means of triplicate ± standard deviation. Those numbers with a different superscript letter in a block differ significantly ($P \leq 0.05$).
G = Gelatin and S = Potato starch

In addition, using extracted galangal rhizome as an ingredient in the formula could lower the hardness compared to the formula that did not contain extracted galangal rhizome. Springiness (mm) describes whether the product would return to its original shape after being compressed. It was found that the springiness ranged between 8.70-10.21 mm. The sample from the formula 50:50+G had the lowest springiness at 8.70 mm, while the highest springiness, 10.21 mm, came from the sample from the formula 0:100+G. The sample that used gelatin and potato starch would give higher springiness when compared to gelatin alone. Moreover, using extracted galangal rhizome as an ingredient in the formula tended to lower the springiness. Chewiness (N•m) describes elastic resistance from the food when chewed. It was found that the chewiness ranged between 26.70-76.76 N•m. Using different amounts of extracted galangal rhizome and gelling agents had a statistically significant influence on chewiness at ($P \leq 0.05$). The sample from the formula 25:75+GS had the lowest chewiness at 26.70 N•m ($P \leq 0.05$), while the highest chewiness, which was 76.76 N•m, came from the formula 0:100+GS. Using galanga as an ingredient in the formula could lower the chewiness ($P \leq 0.05$).

Hardness was the force from compressing to ruin the shape of the sample. The chewiness was elastic resistance from the sample when chewing or crushing until the shape was ruined. Springiness was the ability of the sample to return to its original shape after it had been compressed. When combining gelatin and potato starch as gelling agents, the jelly product would have a more robust structure, causing it to be more complex, thicker, and stretchier. It would need more energy to crush. Therefore, the hardness, the chewiness, and the gumminess would be increased because potato starch had macromolecules and consisted of polymer with 2 types of α-D-glucose units: Amylose and Amylopectin. Amylose was a linear polymer of glucose with an α1,4-linked D-glucose bond [21-22] (pp. 1151-1152) (p. 149). Apart from being a gelling agent, the functional properties of potato starch were being a thickening agent [21] (p. 1552). The gel which contained potato starch would be thick. Therefore, mixing potato starch and gelatin would make the structure of the gel harder. The hardness would be higher than gel made from gelatin alone. When the hardness was higher, the chewiness and the springiness would also be higher. In addition, there was a report that mixing corn potato starch with gelatin would make the hardness higher than using gelatin alone because the structure of gel made from only gelatin had porosity. The resulting gel would be soft and velvety. Adding corn potato starch would decrease the porosity and produce a more compact appearance. Hence the hardness would be higher [23] (pp. 240-241). Using 25% of extracted galangal rhizome, potato starch, and gelatin as gelling agents resulted in the highest overall acceptability because of the appropriate galanga smell. Mixing potato starch and gelatin could improve the texture of the jelly; hence it was preferred by the customers.

3.2. Chemical properties

3.2.1. Moisture content and water activity (a_w)

According to the study about moisture content and a_w of jelly products that used different amounts of extracted galangal rhizome and gelling agents, results from the experiments were 18.30-18.74% and 0.86-0.88, respectively. The difference between the amount of extracted galangal rhizome and gelling agents had a statistically significant influence on the jelly product's moisture content ($P \leq 0.05$). The jelly product with extracted galangal rhizome had a higher moisture content than the jelly product without extracted galangal rhizome ($P \leq 0.05$), and the moisture content tended to decrease when the amount of extracted galangal rhizome was increased. The sample from the formula 0:100+GS had the highest moisture content at 18.74%. Using different gelling agents did not have a statistically significant influence on the moisture content of the jelly product ($P > 0.05$), as described in Table 3.

Table 3. Effects of extracted galangal rhizome and water ratio and type of gelling agents on water activity and moisture content of the jelly product

Treatments (extracted galangal rhizome: water)	**Water activity (a_w)** (ns)	**Moisture content (%)**
0:100 + G	0.87 ± 0.17	18.63 ± 0.10^{a}
25:75 + G	0.86 ± 0.74	18.58 ± 0.03^{a}
50:50 + G	0.86 ± 0.75	18.30 ± 0.04^{b}
0:100 + GS	0.87 ± 0.38	18.74 ± 0.11^{a}
25:75 + GS	0.88 ± 0.18	18.43 ± 0.39^{ab}
50:50 + GS	0.87 ± 0.01	18.36 ± 0.14^{b}

Note: Values are the means of triplicate±standard deviation. Those numbers with a different superscript letter in a block differ significantly ($P \leq 0.05$). ns, not significant ($P > 0.05$).
G = Gelatin and S = Potato starch

According to the a_w of the jelly product in table 3, using different amounts of extracted galangal rhizome and gelling agents did not significantly influence the jelly product ($P > 0.05$). The formulas with the lowest a_w were 50:50+G and 25:75+G. Both formulas had the same value, which was 0.86.

From the experiments, a_w and moisture content were 18.30-18.74% and 0.86-0.88, respectively, consistent with the study mentioned above. Increasing extracted galangal rhizome would decrease moisture content. The jelly product that used 50% of extracted galangal rhizome had the lowest moisture content because increasing extracted galangal rhizome would reduce the amount of water, which was a component of jelly, which caused moisture content to decrease. Moreover, In the gelled gummy systems, water acts as a plasticizer to aid gelation of gelatin formation [25] (p. 181). Gelatin has a high affinity for water (the value of bound water 0.44 g/g dry material) in the sucrose/potato starch/gelatin system. The higher the solid content in gelatin solution, the faster the gel formation is affected by gel concentration [8].

Nonetheless, the experiment's water activity and moisture content were consistent with a study indicating that general jelly products had a moisture content of less than 20%, and water activity ranged between 0.7-0.8 [20] (pp. 37-41).

3.2.2. Phenolic compounds and antioxidant activity

The amounts of phenolic compounds and antioxidant activity (IC_{50}) of extracted galangal rhizome in various concentrations (galanga rhizome: water at 0:100, 25:75, and 50:50) and galanga jellies (extracted galangal rhizome: water at 0:100+G, 25:75+G, 50:50+G, 0:100+GS, 25:75+GS, and 50:50+GS) are shown in Figure 2. Considering the amounts of phenolic compounds and IC_{50}, it was found that galangal extract with the highest concentration (0:100) had the most phenolic compounds and IC_{50} ($P \leq 0.05$), which equalled 28.73

± 0.25 mg GAE/g of the sample (extracted solution) and 0.83 ± 0.03 mg/ml of jelly extract, respectively. Considering the amounts of phenolic compounds and IC_{50} of galanga jellies, it was found that the sample of 0:100 extracted galangal rhizome, including the 0:100+G and 0:100+GS jelly samples, which were the control sample, indicated the low amounts of phenolic compounds and IC_{50} while using gelatin or gelatin mixed with potato starch to produce jelly in the same ratios of extracted galangal rhizome which were 50:50+G and 50:50+GS did not cause any difference to the phenolic compounds of the samples, plus the 25:75+G and 25:75+GS jelly samples had statistically different amounts of phenolic compounds ($P \leq 0.05$). However, the amounts of phenolic compounds in both samples were not hugely different, that was 13.52±0.20 mg GAE/g of the sample (e) and 14.96 ± 0.23 mg GAE/g of sample (d), respectively. Similarly, IC_{50} of the 50:50+G and 50:50+GS samples were statistically different but not hugely different, that was 0.32 ± 0.01 mg/ml of jelly extract (C) and 0.28 ± 0.01 mg/ml of jelly extract (D), respectively.

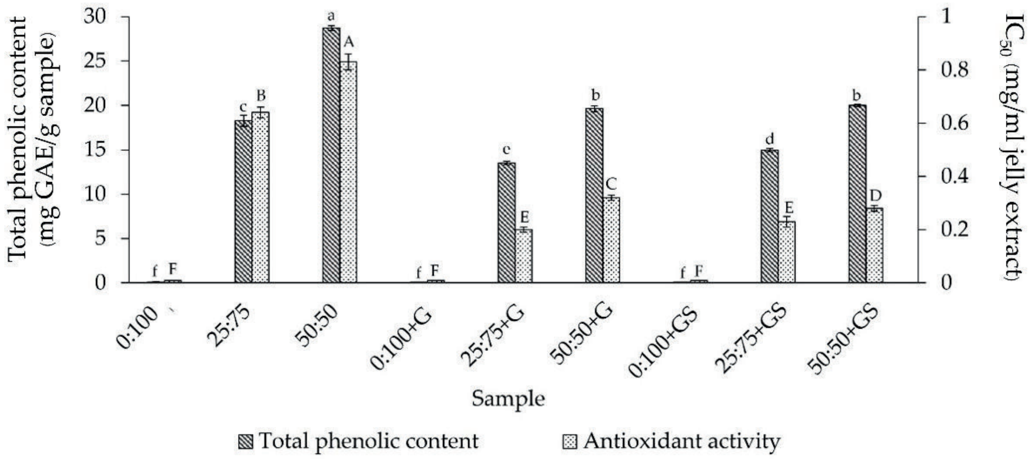

Figure 2. Total phenolic content and IC_{50} of extracted galangal rhizome and galangal jellies.
Note : G = Gelatin and S = Potato starch

The increase and decrease in the amount of extracted galangal rhizome usage caused the amounts of phenolic compounds and IC_{50} of extracted galangal rhizome and galangal jellies to differ. These properties are directly variated according to the quantities of extracted galangal rhizome used as an ingredient to produce the jelly.

According to the review of total phenolic content and IC_{50} of the galangal rhizome extract from water extraction in many research, it was reported that the amount of total phenolic content in galangal rhizome extract derived from water extraction (10% fresh galangal) was 8.25 ± 0.78 mg GAE/g of extraction while the amount of total phenolics in galangal rhizome extract derived from 50% ethanol extraction (10% fresh galangal) was 31.49 ± 4.09 mg GAE/g of extraction and fresh galangal extract derived from water extraction had IC_{50} = 54.39 mg/ml, plus fresh galangal extract derived from ethanol extraction had IC_{50} = 10.50 mg/ml [18] (pp. 358-365) and [24] (pp. 44-46). The total phenolic content of galangal extract from 5% of root-derived from water extraction at the temperatures of 40°C, 50°C, 60°C, and 70°C were approximately 0.0125, 0.0135, 0.014, and 0.0185 mg GAE/mg DW, respectively. The IC_{50} was approximately 0.45, 0.60, 0.74 and 0.50 mg/ml, respectively. In addition, 4% galangal extract had a total phenolic of 442.6 ± 69.1 mg GAE/100g, and the IC_{50} was 3554.9 ± 55.6 ppb [25] (pp. 24-25). Nonetheless, the total phenolic content and IC_{50} were different due to the extraction methods and the concentration of galangal rhizome. For example, [18] (p. 362) extracted galangal by distilling galangal powder at 80°C for 3 hours, while [24] (p. 41) used hot water at different temperatures for 1 hour to extract galangal. [25] (p. 23) extracted galangal by boiling galangal before mixing it with distilled water. The ratio of boiled galangal and distilled water was 1:25.

Many phytochemicals are found in galangals, such as flavonoids, terpenoids, saponins, and phenolic acids, including essential oils [26] (p. 3). Flavonoids are the prominent phytochemicals found in galangal [4] (p.1). Flavonoids can prevent oxidative stress by eliminating free radicals (antioxidant) and antimicrobial properties [26] (p. 4) because flavonoids are sensitive to their environmental conditions (temperature, light, oxygen, and pH) [27] (p.1). Therefore, galangal jelly production used heat to process the product, and it caused IC_{50} of the jelly to be lower when compared to start extract (extracted galangal rhizome). This was similar to the study of [28] that developed the production process of jelly from berry extracts by using the microwave to reduce the heating process from the normal process. Moreover, using gelatin as a gelling agent to produce jelly might cause IC_{50} to be lower. This may be due to the aggregation of gelatin molecules among each other, and the active amino acids along the polypeptide chains were bonded to other reactive groups [29]. The antioxidant activity varied with the types of gelling agent used. The results indicated that different gelling agents contained other antioxidants, which could scavenge radicals at varying degrees [29].

Moreover, using potato starch mixed with gelatin as gelling agents in jelly products, potato starch also affects phenolic compounds when phenolic compounds or purified phenolic compounds (e.g., phenolic acids, flavonoids, coumarins, stilbenes, and tannins) stay into potato starch in terms of gelatinization and retrogradation due to the reaction altering various functional properties of potato starch such as rheological properties, gelatinization, retrogradation, and gelling. While plant extracts addition provides a practical method to modify the potato starch, employing pure phenolic compound gives insight into the mechanism such as phenolic structure-potato starch property relationships [30] due to the reaction of the solubilized polyphenols and potato starch. The hydroxyl and carboxyl groups of the solubilized phenolic compounds may interact with water and indirectly with the hydroxyl groups of potato starch through hydrogen bonding, altering the water and potato starch properties [31-32].

3.3. Sensory evaluation

To evaluate the sensory attributes, including appearance, color, flavour, taste, texture, and overall acceptability of different samples were served to the trained panellists (30 panellists) who were asked to evaluate them on a 1-9 point hedonic scale, and the mean scores obtained by various samples for different sensory attributes are presented in Table 4.

Table 4. Evaluation of sensory attributes of the jelly product

Treatments	Sensory attributes					
	Appearance	Color	Flavour	Taste	Texture	Overall acceptability
0:100 + G	6.33 ± 1.72^{c}	5.13 ± 0.50^{c}	4.73 ± 1.28^{d}	5.33 ± 1.42^{bc}	5.10 ± 1.86^{b}	5.46 ± 1.33^{b}
25:75 + G	7.23 ± 1.45^{ab}	7.06 ± 0.86^{ab}	7.13 ± 1.73^{ab}	6.20 ± 1.32^{a}	6.53 ± 1.22^{a}	6.80 ± 1.27^{b}
50:50 + G	7.46 ± 1.40^{a}	6.56 ± 1.04^{b}	6.33 ± 0.80^{c}	4.90 ± 1.47^{c}	6.10 ± 1.51^{a}	5.60 ± 1.71^{b}
0:100 + GS	6.50 ± 0.27^{bc}	5.53 ± 1.38^{c}	4.40 ± 2.07^{d}	6.00 ± 1.25^{ab}	6.30 ± 1.23^{a}	5.83 ± 1.11^{b}
25:75 + GS	7.23 ± 1.00^{ab}	7.46 ± 0.57^{a}	7.56 ± 0.67^{a}	6.36 ± 1.03^{a}	6.86 ± 0.37^{a}	7.23 ± 1.07^{a}
50:50 + GS	6.80 ± 1.03^{abc}	6.66 ± 0.99^{b}	6.60 ± 1.03^{bc}	5.66 ± 1.97^{abc}	6.20 ± 1.18^{a}	6.03 ± 1.47^{b}

Note: Values are the means of triplicate ± standard deviation. Those numbers with a different superscript letter in a block differ significantly ($P \leq 0.05$). The scale is arranged such that; 9=Like extremely, 8=Like very much, 7=Like moderately, 6=Like lightly, 5=Neither like nor a dislike, 4 = Dislike slightly, 3= Dislike somewhat, 2 = Dislike very much, and 1 = Dislike extremely.
G = Gelatin and S = Potato starch

The average sensory attributes scores of the jelly product were statistically analyzed for variance among the jelly prepared by different samples. The result of sensory attributes on appearance, color, flavour, taste, texture, and overall acceptability gave the average score in the ranges of 6.33-7.46, 5.13-7.46, 4.40-7.56, 5.33-6.36, 5.10-6.86 and 5.83-7.23, respectively. In the case of appearance attribute, sample 50:50+G presented the highest appearance attribute score (7.46), and sample 0:100+G presented the lowest score (6.33). The sample with the highest color, flavour, taste, and texture score was 25:75+GS which were 7.46, 7.56, 6.36, and 6.86, respectively. In the case of color jelly prepared from the sample, 0:100+GS gave the lowest score (4.40). Moreover, sample 0:100+G represented the lowest score on color, taste, and texture, which were 5.13, 5.33 and 5.10, respectively.

In terms of overall acceptability, there was a highly significant difference among the prepared jelly. Table 4 shows that jelly prepared from sample 25:75+GS showed the highest score of other samples (7.23), and sample 0:100+GS got the lowest score (5.83).

Accordingly, using 25% of extracted galangal rhizome, potato starch, and gelatin as gelling agents in galangal rhizome jelly products resulted in the best physical and chemical properties, including the best customer acceptance in terms of senses. That could lead to the selection of suitable gelling agents to use commercially to increase the value and ways to consume galanga, which is one of the Thai herbs.

The reason that the sample 25:75+GS received the highest consumer acceptance rating might be probably the lowest hardness and chewiness. They were then related to the texture profile in Table 2. The texture is critical feature consumers expect from gummy that consistency impacts the chewability of gummy [33] (p. 2). Chewiness measures the level to which the gummy's elasticity texture is chewable and describes the chewing sensation [11] (p. 7). In addition, [33] (pp. 6-7) reported that the gummy, which had low hardness and chewiness values, received a high score of overall acceptability than the high hardness and chewiness values.

4. Conclusions

The amounts of galangal juice and different gelling agents used in the production process affected the quality of the galangal jelly. Using 25% of galangal juice and potato starch mixed with gelatin as gelling agents in galangal jelly received the highest acceptance in terms of overall acceptability (7.23). Due to the galangal has many benefits as nutraceuticals then, galangal has been developed in the jelly form. The jelly product form is a medium for delivering nutrients to consumers more effortless than the tablet form, causing consumers to swallow or chew quickly. Using galangal rhizome as the main substance to develop confectionaries that nutritional value is recommended in the range of 25% to not more than 50%. Galangal rhizomes jelly is the development of health food products that add value to Thai herbs and guidelines for selecting the suitable gelling agent for the commercial jelly product

5. Acknowledgements

The authors express their sincere appreciation to the Rajamangala University of Technology Isan, Nakhon Ratchasima (RMUTI), Thailand, for supporting the study financially.

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