# EVALUATION OF PHYSICOCHEMICAL PROPERTIES AND BIOACTIVE COMPOUNDS OF PUMPKIN JELLY AS A DYSPHAGIA FOOD

Nguyen Minh Xuan Hong[1]*, Nguyen Van Duong[1], Hoang Quang Binh[2], Nguyen Thi Thu Hang[3]

*[1] Nong Lam University*
*[2] Quy Nhon University*
*[3] Dong Nai Technology University*
*Corresponding author: Nguyen Minh Xuan Hong, nmxhong@hcmuaf.edu.vn

**GENERAL INFORMATION**

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**ABSTRACT**

Dysphagia is one of the most prevalent issues that has become more widespread in recent years, among elderly individuals . Modifying the texture of the food is a fundamental factor for safe swallowing in patients with dysphagia since inadequate consistency can result in severe complications such as aspiration pneumonia or dehydration. Therefore, this study created pumpkin jelly as a dysphagia food using gelling agents which is a mixture of 1:1 ratio gelatin and carrageenan. Various concentrations of gelling agents were investigated. The result showed that the samples containing 1% and 2% gelling agents reached the suitable hardness values for dysphagia food, which were 7.03 and 10.53 ($\times 10^3$ N/m$^2$), respectively. Moreover, both concentrations also reached level 5, the level feasible for dysphagic patients according to the International Dysphagia Diet Standardization Initiative (IDDSI). The sample with 1% gelling agents had higher content of polyphenols, flavonoids, carotenoids, and antioxidant activity as well as flavor quality than the 2% sample. Overall, the gelling agent concentration at 1% was the most suitable option for the pumpkin jelly as a dysphagia diet.

## 1. INTRODUCTION

Nowadays, people are more and more concerned about specific functional foods that supply for each group age, especially for the elderly group. As age increases, the elderly face problems with chewing, swallowing, digestion. The percentage of people with mastication and swallowing impairments is rapidly expanding due to advanced age (Sura et al., 2012). Moret-Tatay et al. (2015) reported that dysphagia, a disorder that makes swallowing difficult and impossible and can raise the risk of choking, is one of the major concerns in handling the situation of the increased elderly population. These negative consequences reduce oral intake, which results in malnutrition. Thus, a variety of therapies are used in the management of dysphagia, including texture-modified food and thickened fluids, which make swallowing slower and, as a result, safer and more effective (Moret-Tatay et al., 2015). Food products for dysphagia should be easily chewed and swallowed such as smooth custards, milk pudding, ice cream, soy frozen desserts, and jellied desserts (Sura et al., 2012). Hence, a jelly product used for dysphagia patients must be controlled well its texture property. It should meet the hardness index recommendation for criteria II of dysphagia diet, which is from $1x10^3$ to $1.5x10^4$ $N/m^2$ (Yoshioka et al., 2016), as well as adapt the requirement of The International Dysphagia Diet Standardization Initiative (IDDSI, 2019). Besides the role as a dysphagia food (i.e., a good texture), jelly should provide beneficial health and great flavor quality.

Fresh pumpkin contains 92.2% moisture, 0.15% fat, 0.98% protein, 0.76% ash, 0.56% crude fiber and 5.3% carbohydrates (See et al., 2007). The beneficial health that pumpkin brings is extremely great because it also contains many bioactive substances are phenolics, flavonoids, and carotenoids, which are abundantly present in the fruit's peel, flesh, and seeds (Hussain et al., 2022). Moreover, pumpkin also has a good flavor and is used widely in many food recipes around the world. Because of the mentioned positive features, pumpkin is a favorable ingredient to make jelly products. However, the investigations about pumpkin jelly for dysphagia patients had still limitations. On the other hand, gelatin and κ-carrageenan are composed of polymer chains that are able to undergo a thermo-reversible conformational coil-to-helix transition under certain temperatures. The combination of these two ingredients aims to take their advantages, which are the elasticity of gelatin as well as the water retention capacity and mechanical strength of carrageenan, thereby providing structural stability to the jelly. In a mixed κ-carrageenan–gelatin gel, the network structure is stabilized by three types of nodes, namely, the triple helices of gelatin and the intra- and intermolecular double helices of κ-carrageenan (Derkach et al., 2015). Therefore, this study aimed at investigating the effect of hydrocolloids level on the texture of pumpkin jelly as well as physicochemical properties and sensory quality.

## 2. METHODOLOGY

### 2.1. Materials

Round pumpkin (*Cucurbitaceae*) was purchased from a local market. Selected pumpkin was the fruit at uniform ripeness (yellowish) and not damaged, moldy or rotten. After being transported to the laboratory, raw pumpkin were washed under clean water to remove impurities on the skin, then peeled and cut the pulp into pieces (1.5 - 2 cm). Finally, samples were packed in plastic bags and stored in the freezer at temperature below -18ºC.

Commercial gelatin (Bloom 200) and kappa-carrageenan was obtained from the Path company, Ho Chi Minh City, Vietnam.

### 2.2. Chemical

The main chemicals used in the study were at analytical grade, including: methanol, acetone, aluminum chloride, sodium carbonate (Xilong, China); calcium chloride, ethanol, hexane (Guangdong Guanghua, China); sodium hydroxide 0.1N, phenolphthalein, ascorbic acid, potassium persulphate (Himedia, India); 2,2-diphenyl-1-picrylhydrazyl (DPPH) (ICP, Japan), gallic acid, reagent Folin-Ciocalteu 2N, quercetin (Merck, Singapore).

### 2.3. Processing procedure for pumpkin gelly

The defrosted pumpkin pulp was steamed at 100ºC for 20 min to make it softer and then blended with water by using a kitchen blender (Philips HR2118, Indonesia) to collect pumpkin puree. Next, whole milk powder, sugar, gelatin, and carrageenan were added and stirred well. The mixture was heated to 85ºC for 30 min by using an infrared cooker (Sanko SI – 718S, Japan) with power was maintained from 300 to 600 Watt to obtain a homogeneous paste sample. After that, it was shaped in plastic bags of laminated aluminum with the size and the net weight of each bag was 10 x 20 cm and 50g, respectively. The samples were then sterilized in a retort (MOY-40L, Japan) at 121ºC for 15 min. Finally, they were cooled and kept in a refrigerator (4-10ºC) for at least 24 hours for complete gelation.

### 2.4. Experimental design for investigation of gelling agent concentration

The specific content of each ingredient used in making pumpkin jelly was performed in Table 1. The concentrations of hydrocolloid agents were examined by using one-way factorial experiment with 7 difterent levels ranging from 1 to 10%. The pumpkin gelly samples were analyzed their texture, physicochemical and sensory properties to find the optimum formula.

**Table 1.** Formula of pumpkin jelly

| Ingredient | Gelling agent concentration (%) | | | | | | |
|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **6** | **8** | **10** |
| Carrageenan (g) | 0.5 | 1 | 1.5 | 2 | 3 | 4 | 5 |
| Gelatin (g) | 0.5 | 1 | 1.5 | 2 | 3 | 4 | 5 |
| Whole milk powder (g) | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Sugar (g) | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Steamed pumpkin (g) | 42 | 41.5 | 41 | 40.5 | 39.5 | 38.5 | 37.5 |
| Water (g) | 42 | 41.5 | 41 | 40.5 | 39.5 | 38.5 | 37.5 |
| Total (g) | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

### 2.5. Analytical methods

#### *2.5.1. Texture analysis*

The texture of pumpkin gelly was determined through the hardness index ($N/m^2$) using a texture analyzer instrument (Zick/Roell Z1.0, Germany) with a cylindrical probe of 15 mm diameter. The force value detected when the probe touched the sample with a rate of 0.5 mm/sec. The distance of the probe comes through a sample that was fixed at 4-mm depth. The analysis was carried out at ambient temperature (25°C) and completed within 60s.

#### *2.5.2. International dysphagia diets standardization initiative (IDDSI) test*

The samples were cut into 15 × 15 × 15 mm pieces. In fork drip test, the samples were scooped up with the fork and observing their flow behavior through the prongs. In spoon tilt test, a teaspoon full of sample was scooped, hold steady above a plate, then tilted the spoon sideways slowly. In fork pressure test, a fork with pressure was applied to observe their behavior. During each test, the jelly's behavior was compared with IDDSI descriptions (IDDSI, 2019).

#### *2.5.3. Analysis of physicochemical properties*

Water holding capacity (WHC) was measured by centrifuging (DLAB - DM0506) 5g of sample with filter paper as an absorber in 10 mins at 4000 rpm at room temperature. WHC was expressed as percentage of water retained per 100 g water present in the sample prior centrifuging (Khemakhem et al., 2019).

$$\text{WHC (\%)} = \frac{Weight\ after\ centrifugation}{Weight\ before\ centrifugation} \text{ x } 100 \quad (1)$$

Total soluble solid (TSS) was evaluated by a refractometer (YIERYI, 0-33%, China). The pH of the sample was determined using a benchtop pH meter (Mettler Toledo, Vietnam). Total acidity was evaluated by titration method which was referenced by ISO 750:1998.

#### *2.5.4. Determination of biological compounds*

*Extraction of biological compounds:*

Antioxidant compounds present in the product were extracted with methanol according to the method of Xu et al. (2008) with slight modifications. In a 50 mL centrifuge tube, 1 g of the crushed sample was extracted with 5 mL of methanol 80% for 30 mins at room temperature without light exposure. After filtering, the obtained extract was used within a day for evaluating bioactive compounds.

*Total phenolic content (TPC):*

0.3 mL of the diluted extract was shaken well with 1.5 mL Folin–Ciocalteu 10% and allowed to stand at room temperature for 5 min. The solution was then gently mixed with 1.2 mL of 7.5% $Na_2CO_3$. After 30 min, the samples were recorded their optical densities (OD) at 765 nm wavelength using a UV-VIS spectrophotometer (Jenway 7305, England). Blank sample included solvent and reagent. The TPC was calculated follow to equation (2) and expressed as mg equivalent of gallic acid/100g dry matter (mg GAE/100g dm) (Lim et al., 2007).

$$TPC = \frac{(y-b)\ x\ V\ x\ df\ x\ 100}{a\ x\ m\ (100\% - moisture\%)\ x\ 1000} \quad (2)$$

where, y is the OD of the analyzed sample; a and b are the coefficients in the gallic acid standard curve equation (10-70 g/mL); V is the volume of extracted fluid (mL); df is the dilution factor; m is the mass of sample(g); 100/1000 is the conversion factor from µg/g to mg/100g.

*Total flavonoid content (TFC):*

2 mL of test sample were mixed with 0.1 mL of 10% aluminum chloride solution and 0.1 mL of 0.1 mM potassium acetate solution. After 30 min, the sample was recorded the OD at 415 nm wavelength using a UV-VIS spectro-photometer (Jenway 7305, England). The TFC was calculated follow equation (3) and expressed as mg quercetin equivalents per 100g dry matter (mg QE/100g dm). Blank sample included solvent and reagent (Do et al., 2014).

$$TFC = \frac{(y-b)\ x\ V\ x\ df\ x\ 100}{a\ x\ m\ (100\% - moisture\%)\ x\ 1000} \quad (3)$$

where, y is the OD value of the analyzed sample; a and b are the coefficients in the quercetin standard curve equation (5-30 g/mL); V is the volume of extracted fluid (mL); df is the dilution factor; m is the mass of sample (g); 100/1000 is the conversion factor from µg/g to mg/100g.

*Antioxidant activity (AA):*

The analytical method using DPPH reagent was referenced according to Phuong et al. (2020). In a test tube, 0.1 mL of the sample extract was mixed with 2 mL of DPPH working solution. After stabilizing at room temperature for 30 min, the sample was recorded the OD at 517 nm wavelength using a UV-VIS spectro-photometer (Jenway 7305, England). The AA was calculated follow equation (4) and displayed as mg equivalent of ascorbic acid per 100 g of dry matter (mg AAE/100g dm). Blank sample included only solvent.

$$AA = \frac{(y-b)\ x\ V\ x\ df\ x\ 100}{a\ x\ m\ (100\% - moisture\%)\ x\ 1000} \quad (4)$$

where , y is the OD value of the analyzed sample; a and b are the coefficients in the gallic acid standard curve equation (20-100 g/mL); V is the volume of extracted fluid (mL); df is the dilution factor; m is the mass of sample(g); 100/1000 is the conversion factor from µg/g to mg/100g.

*Total carotenoid content (TCC):*

In a 50 mL centrifuge tube, 1 g of sample was ground and mixed with 1 g of $CaCl_2$ and 30 mL of solvent (50% hexane, 25% acetone, 25% ethanol). The mixture was shaken well for 20 min at room temperature, then added with 15 mL of distilled water and continued stirring for 10 min. After filtering, the extract was transferred to the separatory funnel to separate the aqueous phase and collect the carotenoid phase. Its OD at 450 nm wavelength was recorded using a UV-VIS spectrophotometer (Jenway 7305, England). The blank sample contained only solvent. The TCC was calculated according to the formula (5) and performed as μg/g dry matter (mg AAE/100g dm) (Knockaert et al., 2012).

$$\text{TCC} = \frac{A \times V \times 10^4 \times df}{E_{1cm}^{1\%} \times W\ (100\% - moisture\%)}\ (5)$$

where , A denotes absorbance at λ max; V is the total extraction volume; $E_{1cm}^{1\%}$ is an extinction coefficient = 2560 for of β-carotene in hexane; W indicates mass of sample used for analysis (g); df is the dilution factor; $10^4$ is the unit conversion factor.

### 2.5.5. Sensory evaluation

Although the dysphagia patients should be better for sensory evaluation, these patients have not been found under an effort in the surrounding area. The difference between dysphagia patients and normal person is an abnormal delay in the movement of a food bolus from the oropharynx to the stomach (Ala'A et al., 2015), and can be solved by modifying the texture of food product that the current study was conducting. In addition, there were no literature documents have been found to indicate that the differences in the perception of color, aroma, flavor between dysphagia patients and normal people. Therefore, the pumpkin jelly's sensory can be also evaluated by people who did not have dysphagia symptom, and everyone was able to understandingly communicate.

Samples with three-digit random number were served in a white dish. Distilled water was provided for rinsing of the palate during the testing. The pumpkin jelly was evaluated its color, aroma, flavor, and overall acceptance by 16 panelists using the 9-point hedonic scale, from 1 (dislike extremely) to 9 (like extremely).

### 2.6. Statistical analysis

All tests were performed in triplicate. The results are presented as mean ± standard deviation. The data recorded in each experiment were calculated and graphed by Microsoft Excel 2019. The analysis of variance (ANOVA) for one factor with 95% confidence level and the least significant difference (LSD) were performed by the SPSS 20.0 software.

## 3. FINDINGS AND DISCUSSION

### 3.1. Physicochemical properties of pumpkin pulp materials

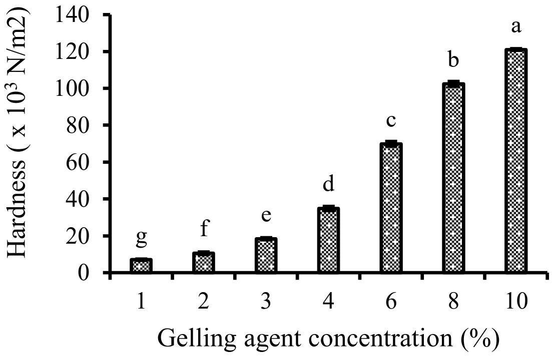
The physicochemical properties of pumpkin materials are presented in Table 1. The results indicated that pumpkin pulp has a high moisture content and edible portion of 87.37%, and 82.35% respectively. It is evident from the data that pumpkin fruit was a good source of TCC, TPC, TFC and antioxidant activity. All the obtained values show no discrepancy with earlier reports regarding fresh pumpkin values (Rodriguez-Amaya et al., 2008; Mokhtar et al., 2021). The data in Table 2 proved that pumpkin is a good material for producing nutritious food product for dysphagia people.

**Table 2.** Physicochemical properties of pumpkin pulp materials

| Attribute | Results |
|---|---|
| Weight (g) | 4294.16 ± 318.32 |
| Moisture content (%) | 87.37 ± 1.55 |
| Edible portion (%) | 82.35 ± 2.18 |
| Total acidity (%) | 0.03 ± 0.007 |
| Total soluble solid (ºBx) | 8.8 ± 0.2 |
| pH | 6.86 ± 0.01 |
| Total phenolic content (mg/100g dm) | 216.35 ± 10.85 |
| Total flavonoid content (mg/100g dm) | 45.29 ± 1.26 |
| Antioxidant activity (DPPH) (mg/100g dm) | 188.69 ± 10.67 |
| Total carotenoid content (μg/g dm) | 127.24 ± 5.67 |

### 3.2. Textural properties of pumpkin jelly

The hardness characteristics of pumpkin jellies were shown in Figure 1.




Data with different letters are significantly different ($p < 0.05$)

**Figure 1.** The hardness value of pumpkin jellies at different concentrations of gelling agent

The hardness value of jellies remarkably increased from 7.03 to 121.06 $\times 10^3$ $N/m^2$, with an increase in gelling agents from 1% to 10% (w/w). This phenomenon is because kappa-carrageenan polymers form a random formation in solution when the temperature is above the melting point. When it is being cooled, the random formation turns into a double helical chain that allows the formation of cross ties to continuously create a network (matrix). Subsequent cooling causes the polymers to become crosslinked and form a strong gel (Kaya et al., 2015). Besides, gelatin can also form junction zones by its helix and develop a three-dimensional network (Guo et al., 2003).

Moreover, the formation of additional network junctions comprising stacks of gelatin triple helices interacting with κ-carrageenan double helices was suggested to be the reason for the strengthening of the mixed gel (Derkach et al., 2018).

In general, the hardness value of pumpkin jelly was prepared by a combination of gelatin and carrageenan (1:1) at 1% (w/w), and 2% (w/w) belonged to the dysphagia diet of criteria II (Yoshioka et al., 2016).

### 3.3. IDDSI Tests

The IDDSI test was performed through fork pressure test, fork drip test, and spoon tilt test, and the results are shown in Table 3 (IDDSI, 2019).

Food texture recommended for dysphagia diets should be soft, moist, elastic, smooth, and easy to swallow. Sticky, adhesive textures, and thin liquids should be avoided since these textures can cause food residue to accumulate in the oropharynx and may lead to aspiration after swallowing.

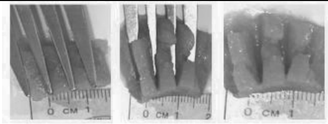
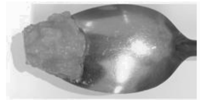
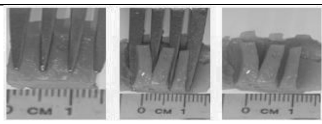
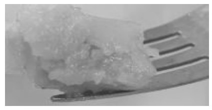
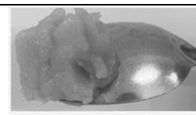
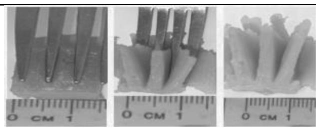
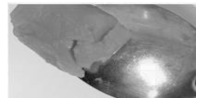
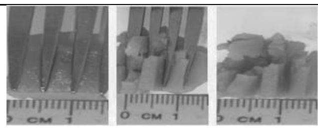
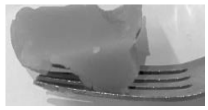
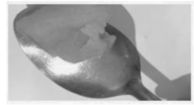
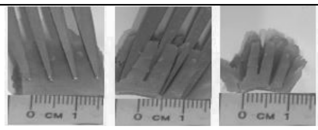
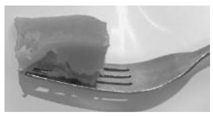
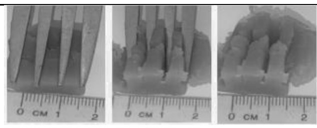
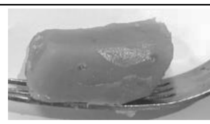
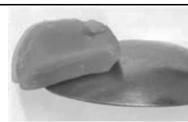
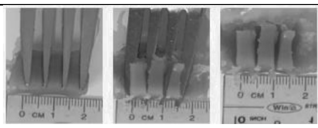
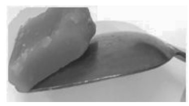
In fork pressure test, samples at all formulas were easily passed through the prongs of the fork with no lumps and minimal granulation, and a clear pattern was made on the sample's surface. Additionally, the jelly samples were easily mashed and deformed with little pressure, and they did not return to their original shape after removing the fork.

In fork drip test, all samples were piled above the fork, and there was no sample flow through the fork prongs or created a short tail below the fork. The jelly with gelling agent concentration from 1% to 2% had a semi-solid texture, whereas the reaming concentrations had a clear rectangular cube shape on the fork.

In spoon tilt test, all samples were cohesive enough to hold their shape on the spoon. Besides, samples easily slide off when the spoon was tilted or turned sideways with the application of a very gentle flick, with little or no food left on the spoon.

The distinct pumpkin jelly texture is quite similar to the various dysphagia food such as the products made from red beans (Kong et al., 2023), oats with fruit puree (Dhillon et al., 2022), and mushrooms (Liu et al., 2021). Therefore, the pumpkin jelly contains gelling agents from 1% to 2% complying with the criteria of level 5 - minced and moist dysphagia food category.

**Table 3.** Categorization of pumpkin jelly using IDDSI evaluation methods

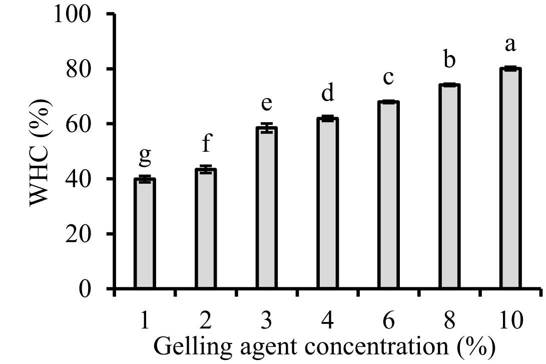
| Sample | Fork Pressure Test | Fork Drip Test | Spoon Tilt Test |
|---|---|---|---|
| G-C: 1% |  |  |  |
| G-C: 2% |  |  |  |
| G-C: 3% |  |  |  |
| G-C: 4% |  |  |  |
| G-C: 6% |  |  |  |
| G-C: 8% |  |  |  |
| G-C:10% |  |  |  |

G-C is gelatin and carrageenan. The numbers 1%, 2%, 3%, 4%, 6%, 8%, 10% are total concentrations of the gelling agents in the sample.

## 3.4. Physicochemical properties of pumpkin jellies

### *3.4.1. Water holding capacity (WHC)*

Water holding capacity reflects the ability of jelly to retain water. Figure 2 showed the changes in WHC of samples containing different concentration of hydrocolloids. WHC of pumpkin jellies ranged from 39.87 to 80.07 (%), and significantly increased with more addition of gelling agents from 1% to 10% (w/w) ($p < 0.05$). Adding gelatin and carrageenan can enhance WHC of jellies, suggesting a stronger network structure. Gelatin can absorb all liquid, while the addition of k-carrageenan significantly decreased the percentage of water loss (Pietrasik, 2003). The results indicate that the hydrocolloid improved water retention of gels.

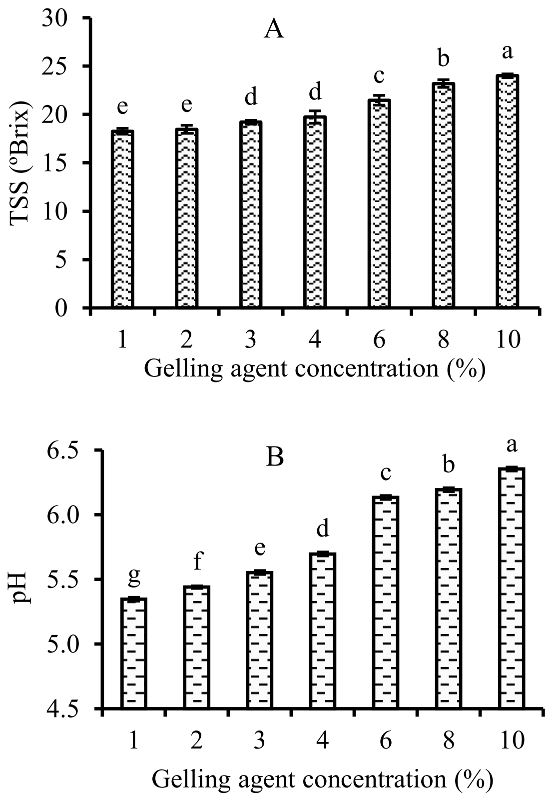


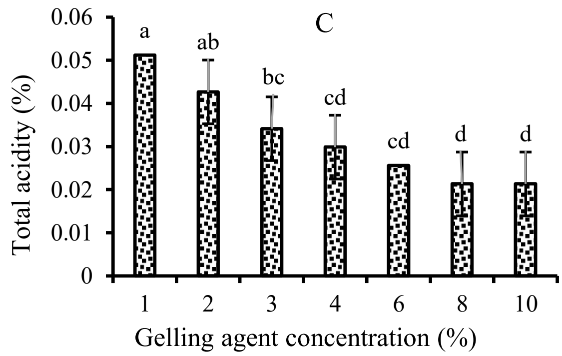

Data with different letters are significantly different (p < 0.05).

**Figure 2.** Water holding capacity of pumpkin jellies at different concentrations of gelling agents

### *3.4.2. Total soluble solid (TSS), pH, and total acidity (TA)*

There is different significance among the manifold samples (p<0.05) about TSS, pH, and TA (Figure 3).




Data with different letters are significantly different (p < 0.05)

**Figure 3.** TSS (A), pH (B), and acidity (C) of pumpkin jellies at different concentrations of gelling agents

The TSS of pumpkin jellies gradually rose from 18.26% to 24.00 % with the increase in the gelling agent concentration. Due to in the presence of the relatively high concentration of gelatin and carrageenan, the macromolecule exhibited an improved solid-holding ability, thus resulting in an increased TSS during the jelly preparation (Kamal et al., 2018).

The pH of pumpkin jellies with the lowest value was 5.35 and the highest value of 6.35 corresponding to samples 1% and 10%, respectively. The pH values of jellies significantly tended to increase with the addition of hydrocolloids (p<0.05). Thus, the addition of hydrocolloids might have a significant effect on the pH of jelly (Kim et al., 2018; Park et al. (2008).

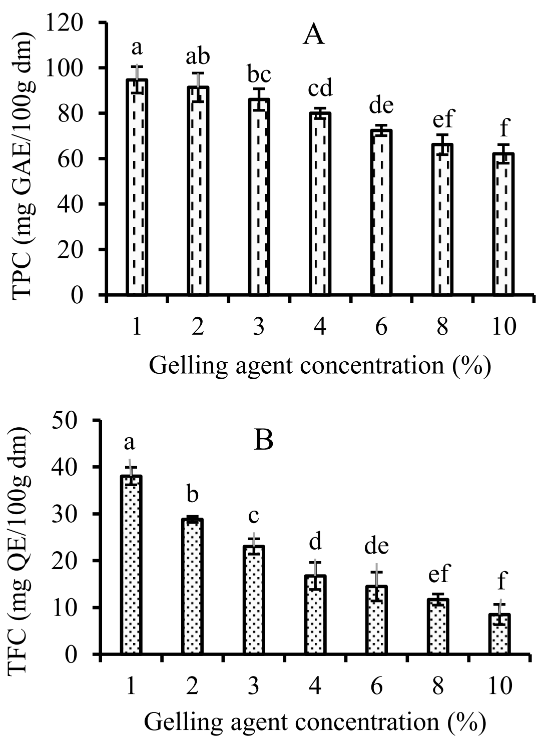
Under these parameters, in contrast, the total acidity of the jelly decreased as the gelling agent concentration increased. The change of TSS and total acidity could affect the flavor of the jelly, which would be confirmed by the sensory test.

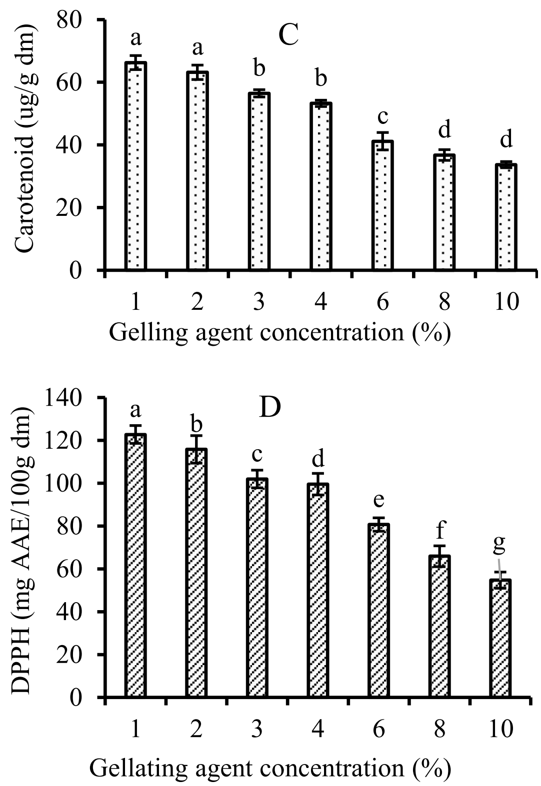
### 3.5. Bioactive compounds

Similar to physicochemical properties, the change in gelling agent concentration leads to the modification in the content of the bioactive compounds in the pumpkin jelly (Figure 4).

The increasing gelling agent concentration from 1% to 10% resulted in reduction of TPC from 94.71 to 62.11 (mg GAE/100g dm), TFC from 38.06 to 8.49 (mg QE/100g dm), and TCC from 66.28 to 33.71 (µg/g). The descent in all biocompounds is also expressed in the deterioration of antioxidant activity in pumpkin jelly, from 122.75 to 54.74 (mg AAE/100g dm).

As the concentration of gelling agents became higher, the bioactive compounds tended to decline due to the lesser amount of pumpkin puree in the formula. Another study on pomegranate candy jelly verified the expansion of content gelatine content gave the reduction of TPC and antioxidant activity of the product due to the decrease in juice content (Cano-Lamadrid et al., 2020). Similarly, the study was conducted by Dobrinas et al., (2021) reporting that the increase in total phenolic content might be related to the increased antioxidant capacity of tea infusions.




Data with different letters are significantly different ($p < 0.05$)

**Figure 4.** The TPC (A), TFC (B), TCC (C), and DPPH (D) values of pumpkin jellies at various gelling agent concentrations

### 3.6. Sensory characteristics

Sensory evaluations were performed to assess the preference for jelly products containing different concentrations of gelling agents. Although the dysphagia patients should be employed for better results, it is risky for them to participate in this study. In addition, there were no literature documents have been found to indicate the differences in the perception of texture, color, aroma, flavor between dysphagia patients and normal people. Therefore, the pumpkin jelly's sensory can be assessed by people who did not have dysphagia symptoms. In this study, the jelly samples was evaluated by 30 trained panellists, ranging in age from 20 – 25 years old.

According to Table 4, there was a statistically significant difference in the color between the sample 10% and the remaining samples. The color of pumpkin jellies has changed from yellow to dark yellow or brown.

Gelatin structure contains major amino acids such as glycine, proline, hydroxyproline, and glutamine (Gorgieva & Kokol, 2011), while kappa-carrageenan structure has 3,6-anhydro-galactose (Necas & Bartosikova, 2013). The addition of both agents may lead to the escalation of reducing sugar and amino acid under high temperature of jelly processing, which are a favorable regime for the occurrence of the non-enzymatic browning reaction.

Regarding aromas and flavor, most of the panelists felt the distinct aroma and sweetness of pumpkin for any case of hydrocolloid concentration. However, the intensity of both traits in sample 8% and sample 10% weaker than the other samples. The reason is the pumpkin puree dropped over the raise of gelling agent, obviously, the descent of the product's sensory characteristic. The previous study on strawberry juice also found a decline in the intensity of taste and aroma sensations due to greater carboxymethyl cellulose concentration (Teleszko et al., 2019).

**Table 4.** The sensory attributes of pumpkin jellies at various gelling agent concentrations

| Samples | Color | Aroma | Flavor | Overall |
|---|---|---|---|---|
| G-C: 1% | $6.69 \pm 0.71^{a}$ | $6.60 \pm 0.63^{ab}$ | $6.80 \pm 0.67^{a}$ | $6.60 \pm 0.63^{ab}$ |
| G-C: 2% | $6.78 \pm 0.83^{a}$ | $6.67 \pm 0.62^{ab}$ | $6.73 \pm 0.60^{a}$ | $6.80 \pm 0.68^{a}$ |
| G-C: 3% | $6.76 \pm 0.86^{a}$ | $6.73 \pm 0.70^{a}$ | $6.73 \pm 0.80^{a}$ | $6.73 \pm 0.80^{ab}$ |
| G-C: 4% | $6.72 \pm 0.99^{a}$ | $6.53 \pm 0.64^{ab}$ | $6.80 \pm 0.67^{a}$ | $6.80 \pm 0.77^{a}$ |
| G-C: 6% | $6.51 \pm 0.96^{a}$ | $6.30 \pm 0.72^{ab}$ | $6.53 \pm 0.83^{a}$ | $6.53 \pm 0.83^{ab}$ |
| G-C: 8% | $6.45 \pm 0.98^{a}$ | $6.06 \pm 0.96^{b}$ | $6.47 \pm 0.74^{a}$ | $6.13 \pm 0.92^{bc}$ |
| G-C: 10% | $5.80 \pm 0.86^{b}$ | $5.47 \pm 0.91^{c}$ | $5.60 \pm 0.74^{b}$ | $5.93 \pm 0.70^{c}$ |

Note: G-C is gelatin and carrageenan, The numbers 1%, 2%, 3%, 4%, 6%, 8%, 10% are total concentrations of the gelling agents in the sample. Data in the same column with different letters are significantly different ($p < 0.05$).

In general, pumpkin jelly samples that had less than 4% hydrocolloid agent reached the overall acceptability score (6.60 - 6.80), better than the other samples (5.93 - 6.53).

## 4. CONCLUSION

This study confirmed that the properties of pumpkin jellies are significantly influenced by the combination of gelatine and carrageenan. Increasing the concentration of gelling agents resulted in the higher hardness, TSS, and pH of jellies while reducing the TPC, TFC, TCC and AA of pumpkin jellies. Samples with higher level of gelling agents led to low preference in sensory evaluation of color, flavour, and aroma.

The pumpkin jelly prepared with 1% concentration of gelling mixture of 1:1 gelatine and carrageenan had the textural parameter adapted to level 5 (minced & moist) of the requirement of the IDDSI and the hardness value belonged to criteria II of dysphagia diet. In addition, it also presented the higher content of TPC, TFC, TCC and AA than other samples. Furthermore, the shelf-life and the nutritional index of pumpkin jelly should be explored to ensure the safety and adequate nutrients for elderly individuals with dysphagia.

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# ĐÁNH GIÁ TÍNH CHẤT LÝ HÓA VÀ CÁC HỢP CHẤT CÓ HOẠT TÍNH SINH HỌC CỦA THẠCH BÍ NGÔ DÀNH CHO NGƯỜI BỊ CHỨNG KHÓ NUỐT

Nguyễn Minh Xuân Hồng[1*], Nguyễn Văn Đường[1], Hoàng Quang Bình[2], Nguyễn Thị Thu Hằng[3]

[1]*Trường Đại Học Nông Lâm Thành Phố Hồ Chí Minh*
[2]*Trường Đại Học Quy Nhơn*
[3]*Trường Đại học Công nghệ Đồng Nai*
*Tác giả liên hệ: Nguyễn Minh Xuân Hồng, nmxhong@hcmuaf.edu.vn

**THÔNG TIN CHUNG**

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**TỪ KHOÁ**

*Chất có hoạt tính sinh học;*
*Người mắc chứng khó nuốt;*
*Thạch bí đỏ;*
*Tính chất hóa lý.*

**TÓM TẮT**

Chứng khó nuốt là một trong những vấn đề phổ biến nhất trong những năm gần đây, đặc biệt là ở người cao tuổi. Thay đổi kết cấu của thực phẩm là yếu tố cơ bản để đem lại an toàn cho những bệnh nhân khó nuốt, vì độ đặc không đủ có thể dẫn đến các biến chứng nghiêm trọng như viêm phổi do hít phải hoặc mất nước. Do đó, nghiên cứu này đã tạo ra thạch bí ngô dành cho người bị chứng khó nuốt bằng cách sử dụng chất tạo gel là hỗn hợp gelatin và carrageenan theo tỷ lệ 1:1. Các nồng độ chất tạo gel khác nhau đã được khảo sát. Kết quả cho thấy các mẫu chứa 1% và 2% chất tạo gel đạt giá trị độ cứng phù hợp cho thực phẩm dành cho người mắc chứng khó nuốt, lần lượt là 7,03 và 10,53 ($\times 10^3$ N/m$^2$). Hơn nữa, cả hai nồng độ đều đạt mức 5, mức khả thi đối với bệnh nhân khó nuốt theo Sáng kiến Chuẩn hóa Chế độ Ăn cho Người Khó nuốt Quốc tế (IDDSI). Mẫu chứa 1% chất tạo gel có hàm lượng polyphenol, flavonoid, carotenoid và hoạt tính chống oxy hóa cũng như chất lượng hương vị cao hơn mẫu 2%. Nhìn chung, nồng độ chất tạo gel ở mức 1% là lựa chọn phù hợp cho sản phẩm thạch bí ngô dành cho người khó nuốt.