EFFECT OF CARRAGEENAN CONCENTRATION ON THE QUALITY OF ORANGE FRUIT (*Citrus nobilis*) JELLY

NGUYEN LE YEN NHI[1], NGUYEN TRUNG TRUC[1,a]

[1] *Vinh Long University of Technology Education, Vinh Long*

[a] *Corresponding author: trucnt@vlute.edu.vn*

Received: 27/8/2025; Reviewed: 24/10/2025; Accepted: 27/3/2026

ASTRACT

Orange is a popular fruit and contains high nutritional content, especially biological compounds such as vitamin C and phenolic. Jelly products made from oranges often use gelling agents such as pectin, agar or gelatin. Therefore, research to find new gelling agents from natural polysaccharides is necessary. The study aimed to investigate the effects of carrageenan ratios (0.5%; 1%; 1.5%; 2%; 2.5%) added and determine the best ratio for product quality. The results showed that the carrageenan ratios added had a significant effect on the sensory indicators, physical and chemical properties of the product. In particular, the ratio of 1.5% carrageenan gave the best product quality with color values L, a*, b* of 36.51; 16.79; 42.00; The content of vitamin C and total phenolic reached 21.08 mg/ 100 g and 44.94 mg GAE/ 100 g. This result provides a database on the application of carrageenan gelling agent for orange jelly products, contributing to the diversification of orange products on the market.*

***Keywords**: antioxidant, carrageenan, citrus nobilis, jelly.*

1. INTRODUCTION

Citrus nobilis, commonly known as Cam Sanh, belongs to the Rutaceae family and is an important fruit crop widely cultivated in northern provinces of Vietnam such as Ha Giang and Tuyen Quang. In addition, the Mekong Delta region is considered the major cultivation area of Cam Sanh in southern Vietnam [1]. Cam Sanh contains various nutrients and bioactive compounds, including vitamin C, polyphenols, carotenoids, organic acids, and dietary fiber [2]. However, since 2023, the cultivation area of Cam Sanh has expanded rapidly and spontaneously, leading to a continuous decline in market prices and difficulties in product consumption [3]. Moreover, Cam Sanh is mainly consumed in its fresh form and has a relatively short shelf life, while its nutritional values gradually decrease during storage. Therefore, developing value-added products from Cam Sanh could contribute to enhancing its economic value and extending product shelf life. Current products derived from Cam Sanh include orange wine [4], dried orange products [5], fruit jam [6], and orange jelly [7].

Nowadays, jelly products are popular among consumers of all ages due to their unique texture, natural origin, and nutritional benefits [8]. Common gelling agents currently used include gelatin, agar, and pectin. However, the use of gelatin is associated with Halal regulations and requires low-temperature conditions for gel formation. Agar produces a brittle and firm gel structure, which may reduce consumer acceptance [9]. Meanwhile, pectin generally requires high sugar concentrations or calcium ions and low pH conditions to form gels. Therefore, investigating alternative gelling agents derived from natural polysaccharides is necessary. Carrageenan is a natural polysaccharide extracted from red seaweed and has been recognized as safe (GRAS) by the United States Food and Drug Administration (FDA). It is one of the most commonly used food additives, functioning as a gelling agent, stabilizer, and emulsifier in food products [10,11]. Carrageenan is widely applied in meat products, dairy products, desserts, and jelly-based products [12]. Depending on the concentration used, carrageenan can significantly influence the physical properties of products, such as hardness, viscosity, and gel stability.

Carrageenan was selected for this study because of its advantages, including its ability to form gels with good elasticity and reduce syneresis in jelly products [8]. A recent study by Yudhistira et al. (2024) also demonstrated that carrageenan significantly affects the quality characteristics of jelly products, including hardness, chewiness, and sensory properties. Currently, many gelling agents still present certain limitations. For instance, pectin requires a high sugar content for gel formation and exhibits poor solubility and rapid swelling in water, which may affect the release of active compounds and does not align with the current trend toward low-sugar food products. In addition, gelatin-based gels generally require low-temperature conditions to maintain structural stability. Therefore, carrageenan was selected as the gelling agent due to its ability to provide good gel elasticity and minimize water separation [10]. Although carrageenan has been widely applied in food gel systems, studies on the effects of carrageenan concentration on the quality characteristics of jelly products derived from natural fruit juices remain limited, particularly for specific raw materials and processing conditions. Therefore, investigating and evaluating the effects of carrageenan concentration on jelly quality characteristics is necessary to provide additional scientific evidence for the application of this hydrocolloid in food processing.

The objective of this study was to investigate the effects of carrageenan concentration on changes in jelly quality characteristics, including color, hardness, vitamin C content, phenolic content, and sensory properties of the product.

2. MATERIALS AND METHODS

2.1 Materials

Cam Sanh (*Citrus nobilis)* oranges were purchased from a local market in Vinh Long Province, Vietnam. Fruits were selected based on sensory criteria, including uniform shape, greenish-yellow peel color, fresh stems, absence of mechanical damage, and a weight range of 200–250 g per fruit. Other materials used in this study included refined sugar (Bien Hoa brand, purity 99.8%) and carrageenan. The carrageenan used in this study was κ-carrageenan powder supplied by Marcel Trading Corporation (Quezon City, Philippines), with a purity of ≥ 90%.

2.2 Hoá chất

The chemicals used in this study included: metaphosphoric acid (HPO_3, China), thiourea (CH_4N_2S, China), di-indophenol ($C_{12}H_6Cl_2NO_2Na.2H_2O$, India), 2,4-dinitrophenol ($C_6H_4N_2O_5$, China), acid sulfuric (H_2SO_4, China), methanol (CH_3OH, China), foline-Ciocalteu's (India), sodium carbonate (Na_2CO_3, China).

2.3 Method

2.3.1 Orange jelly production process

The oranges were washed under running water to remove dirt and impurities adhering to the peel. The oranges were then juiced, and the extracted juice was filtered through a sieve to remove seeds, pulp, and coarse impurities. The obtained juice was mixed with sugar to achieve a total soluble solids content of 30 °Bx, while carrageenan was added at different concentrations of 0.5, 1.0, 1.5, 2.0, and 2.5% (w/v). The concentration range of 0.5 - 2.5% was selected based on preliminary experiments conducted prior to the main study. The mixture was stirred thoroughly until a homogeneous solution was obtained and subsequently heated at 85 ± 2 °C for 5 min. After heating, the mixture was poured into molds (50 mL per mold) and allowed to cool at room temperature until complete gel formation. The jelly products were then stored at 4 °C until further analysis.

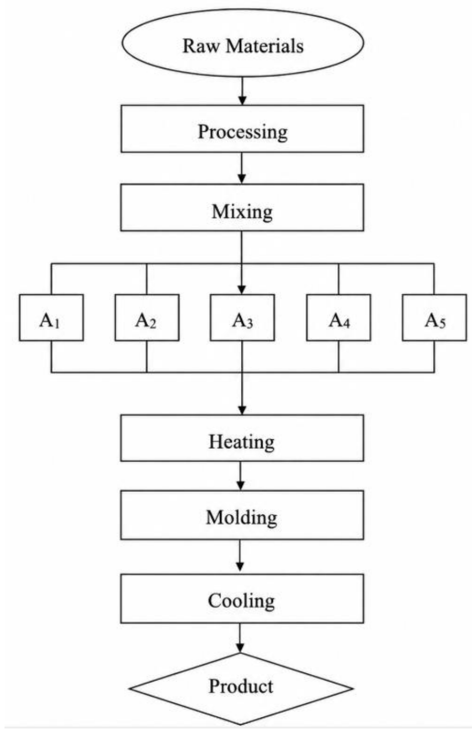

Figure 1. Preparation process of orange jelly supplemented with carrageenan (A1: 0.5%; A2: 1.0%; A3: 1.5%; A4: 2.0%; A5: 2.5%).

2.3.2 Analytical methods

Color measurement of jelly

The color of jelly samples from different treatments was determined using a Hunter Lab colorimeter (MH-C800 4500L, USA). The recorded parameters included L* value representing lightness (0 - 100), a* value representing the color transition from green (-) to red (+), and b* value representing the color transition from blue (-) to yellow (+). Each sample was measured at three different positions, and the average value was calculated to ensure the accuracy and representativeness of the results [13].

Hardness of jelly

The hardness of orange jelly was determined using a texture analyzer (TMS PRO, Food Technology Corporation, USA). Jelly samples were prepared with a diameter of 50 mm and a height of 20 mm. Measurements were performed using a cylindrical probe (5 mm diameter) moving in a penetration mode at a speed of 100 mm/min, with a penetration depth of 15 mm. Each sample was measured at three different positions, and the average value was used to ensure the accuracy and representativeness of the results.

Total phenolic content of jelly

Jelly samples were ground using a porcelain mortar. Subsequently, 0.2 g of jelly was transferred into an Eppendorf tube containing 1.5 mL of cold methanol, vortexed for 1 min, and centrifuged at 10,000 rpm for 5 min at 4 °C to obtain the extract for total phenolic analysis. Total phenolic content was determined according to the method of Singleton et al. [14]. The reaction mixture consisted of 100 µL of extract (methanol was used instead of extract for the blank sample), 250 µL of Folin-Ciocalteu reagent, 750 µL of 7.5% sodium carbonate, and 2 mL of distilled water. The mixture was vortexed and incubated in a temperature controlled water bath at 40 °C for 30 min. The absorbance was measured at 750 nm, and the results were calculated based on a gallic acid standard curve under the same conditions. Total phenolic content was expressed as mg gallic acid equivalents per 100 g sample (mg GAE/100 g sample).

Vitamin C content of jelly

Jelly samples were extracted using 0.2 g of finely ground jelly and 1.4 mL of cold 5% metaphosphoric acid solution, followed by vortexing for 1 min and centrifugation at 10,000 rpm for 5 min at 4 °C to obtain the extract for vitamin C analysis. Vitamin C content was determined according to Nguyen et al. [15] with minor modifications. The reaction mixture consisted of 0.4 mL extract, 0.6 mL of 0.02% di-indophenol, 0.8 mL of 2% thiourea, and 0.6 mL of 2% dinitrophenylhydrazine. The mixture was vortexed and incubated in a temperature-controlled water bath at 50 °C for 1 h. Subsequently, 1 mL of 85% sulfuric acid was added, followed by incubation at 25 °C for 30 min. The absorbance was measured at 540 nm, and the results were calculated based on a vitamin C standard curve under the same conditions. Vitamin C content was expressed as mg/100 g sample.

Sensory evaluation of jelly

The sensory properties of jelly were evaluated using Quantitative Descriptive Analysis (QDA). The sensory panel consisted of 50 university students who participated in the product evaluation. Samples were randomly coded prior to evaluation to minimize sensory bias. Panelists were asked to score color, aroma, taste, and texture attributes using a 5-point scale. In addition, the overall acceptability of the product was evaluated using a 9-point Hedonic scale ranging from 1 (dislike extremely) to 9 (like extremely).

2.3.3 Statistical analysis

All experiments were conducted in triplicate, and the results were expressed as mean ± standard deviation (SD). Differences among treatments were analyzed using analysis of variance (ANOVA) at a significance level of $p < 0.05$ with Statgraphics Centurion XVIII software. When significant differences were observed, means were further compared using the Least Significant Difference (LSD) test at the 5% significance level.

3. RESULTS AND DISCUSSION

3.1 Effect of carrageenan concentration on the color characteristics of jelly

Color is one of the most important sensory attributes affecting consumer acceptance of food products. Orange jelly products exhibit a characteristic yellow-orange color, which is mainly due to the presence of natural pigments in fresh orange juice, particularly carotenoids such as β-cryptoxanthin and β-carotene [16]. The results regarding the effect of carrageenan concentration on color changes in orange jelly are presented in Table 3.1. Specifically, the L* value (lightness) gradually decreased from 38.28 to 34.38 as the carrageenan concentration increased from 0.5% to 2.5%; however, no statistically significant differences were observed among the treatments ($P > 0.05$). This indicates that the product tended to become darker as the carrageenan concentration increased [17].

Regarding the a* and b* values, both generally decreased with increasing carrageenan concentration. The a* and b* values showed statistically significant differences ($P < 0.05$) among the treatments. At a carrageenan concentration of 0.5%, the samples exhibited the highest values (17.85 for a* and 44.48 for b*), while the lowest values were observed at 2.5% carrageenan concentration (14.59 for a* and 34.65 for b*). Significant differences in a* and b* values began to appear at a carrageenan concentration of 2%, where polymer chains increasingly interacted and formed denser network structures, thereby enhancing light scattering and causing differences among the samples [17].

As the carrageenan concentration increased, the color of the product was affected due to the jelly structure becoming firmer and more elastic. Furthermore, the increase in viscosity and the formation of a denser gel structure by carrageenan reduced the light reflectance on the product surface, resulting in differences in product color. These findings are consistent with the study by Harijono et al. (2011) [18].

Overall, the addition of carrageenan at different concentrations did not significantly affect the L* value, but significant differences in a* and b* values were observed at carrageenan concentrations of 2% and 2.5%.

Table 3.1. Effect of carrageenan concentration on the color changes of jelly.

Carrageenan concentration (%)	*L**	*a**	*b**
0.5	$38.28^{a} \pm 3.06$	$17.85^{a} \pm 2.09$	$44.48^{a} \pm 0.37$
1.0	$36.63^{a} \pm 2.29$	$16.95^{a} \pm 0.27$	$42.72^{a} \pm 1.91$
1.5	$36.51^{a} \pm 0.21$	$16.79^{a} \pm 0.12$	$42.00^{a} \pm 0.45$
2.0	$34.58^{a} \pm 3.37$	$14.76^{b} \pm 1.05$	$37.39^{b} \pm 1.55$
2.5	$34.38^{a} \pm 2.65$	$14.59^{b} \pm 0.75$	$34.65^{b} \pm 2.20$

Note: Different letters within the same column indicate significant differences among treatments at the P < 0.05 significance level.

3.2 Effect of carrageenan concentration on jelly hardness

Hardness is an essential and important quality parameter for jelly because it reflects the stability of the gel structure as well as consumer acceptability [9]. The results presented in Table 3.2 showed that jelly hardness gradually increased from 0.177 N to 1.33 N as the carrageenan concentration increased from 0.5% to 2.5%. This indicates that carrageenan concentration affected the hardness of the product. At carrageenan concentrations of 2.0% and 2.5%, the highest hardness values were observed, reaching 1.28 N and 1.33 N, respectively. These concentrations may be considered the overlap concentration of polymer chains, where statistically significant differences were observed compared with the remaining concentrations. At a carrageenan concentration of 0.5%, the lowest hardness value (0.177 N) was recorded. This could be attributed to the gelling ability and concentration of carrageenan, which promotes intermolecular interactions and cross-linking among polymer chains, leading to the formation of a three-dimensional network structure capable of retaining and immobilizing water within the gel matrix. As a result, a firmer structure with improved resistance to flow was formed [17]. In addition, the water-binding capacity reduced the distance between particles, making the mixture denser, stronger, and more stable [9]. These findings are consistent with the study conducted by Harahap et al. (2022), which reported that jelly hardness increased with increasing carrageenan concentration from 3% to 4% [19].

Bảng 3.2 Effect of carrageenan concentration on jelly hardness.

Carrageenan concentration (%)	Hardness (N)
0.5	$0.177^{c} \pm 0.05$
1.0	$0.57^{b} \pm 0.04$
1.5	$0.68^{b} \pm 0.07$
2.0	$1.28^{a} \pm 0.15$
2.5	$1.33^{a} \pm 0.23$

Note: Different letters within the same column indicate significant differences among treatments at the P < 0.05 significance level.

3.3 Effect of carrageenan concentration on total phenolic content (TPC) of jelly

Bioactive compounds such as TPC are often degraded and reduced during thermal processing; therefore, the TPC content of jelly samples was determined to evaluate the ability to preserve antioxidant compounds after processing. The results presented in Table 3.3 showed that carrageenan concentration significantly affected the TPC of orange jelly ($p < 0.05$), with values ranging from 41.36 to 46.88 mg GAE/100 g. At a carrageenan concentration of 0.5%, the TPC was the lowest (41.36 mg GAE/100 g). As the carrageenan concentration increased from 0.5% to 2.5%, the TPC increased markedly. Notably, at 2.5% carrageenan, the highest TPC was observed (46.88 mg GAE/100 g). This phenomenon may be explained by the ability of carrageenan to form a three-dimensional gel network capable of binding and retaining polyphenol compounds, thereby reducing the oxidation and degradation of these compounds in the product. In addition, carrageenan contains sulfated polysaccharides that inhibit hydroxyl radical formation, thereby enhancing antioxidant activity and protecting polyphenol compounds from degradation caused by heat treatment and oxygen exposure [20]. These findings are consistent with the study by Lima et al. (2025) [21].

Bảng 3.3 Effect of carrageenan concentration on total phenolic content of jelly.

Carrageenan concentration (%)	Total phenolic content (mg GAE/100 g)
0.5	$41.36^{b} \pm 1.56$
1.0	$42.19^{b} \pm 0.78$
1.5	$44.94^{a} \pm 0.65$
2.0	$46.45^{a} \pm 0.39$
2.5	$46.88^{a} \pm 1.46$

Note: Different letters within the same column indicate significant differences among treatments at the $P < 0.05$ significance level.

3.4 Effect of carrageenan concentration on the vitamin C content of jelly

Vitamin C content is an important parameter for evaluating the nutritional value of orange jelly. In addition, investigating the effects of different carrageenan concentrations on the retention of this antioxidant compound provides a basis for optimizing the product formulation. The results presented in Table 3.4 showed that carrageenan concentration had a statistically significant effect on the vitamin C content of jelly ($p < 0.05$), with values ranging from 14.56 to 22.37 mg/100 g. At a carrageenan concentration of 0.5%, the vitamin C content was the lowest (14.56 mg/100 g). As the carrageenan concentration increased, the vitamin C content showed an increasing trend. Notably, at a concentration of 2.5%, the highest vitamin C content was observed (22.37 mg/100 g). This increase may be explained by the fact that carrageenan is a hydrocolloid with the ability to bind water and form a double-helix network within the gel system. As the carrageenan concentration increased, the gel network structure became denser and more stable, thereby limiting oxygen diffusion and slowing down oxidation processes, which effectively protected vitamin C within the product matrix [22]. These findings are consistent with the study by Mulyani et al. (2025) [12].

Bảng 3.4 Effect of carrageenan concentration on vitamin C content of jelly.

Carrageenan concentration (%)	Vitamin C content (mg/ 100 g)
0.5	$14.56^{c} \pm 0.85$
1.0	$16.83^{b} \pm 0.18$
1.5	$21.08^{a} \pm 1.05$
2.0	$19.86^{a} \pm 1.67$
2.5	$22.37^{a} \pm 0.38$

Note: Different letters within the same column indicate significant differences among treatments at the P < 0.05 significance level.

Sensory Evaluation of Jelly

The sensory characteristics of the product were evaluated based on color, aroma, taste, texture, and overall acceptability. The results presented in Table 3.5 showed that the scores for color, aroma, and taste among the treatments were not significantly different, with values ranging from 4.33–4.40 for color, 4.07–4.50 for aroma, and 3.10–3.60 for taste. In contrast, texture and overall acceptability were significantly affected by carrageenan concentration ($p < 0.05$). Among the treatments, the sample containing 1.5% carrageenan achieved the highest scores for texture (4.7) and overall acceptability (7.62). These results indicate that a carrageenan concentration of 1.5% was the most suitable level for orange jelly in this study, as it provided an appropriate hardness and the highest consumer preference while maintaining favorable sensory attributes. Increasing carrageenan concentration above 1.5% did not result in further sensory improvement and may reduce consumer acceptability.

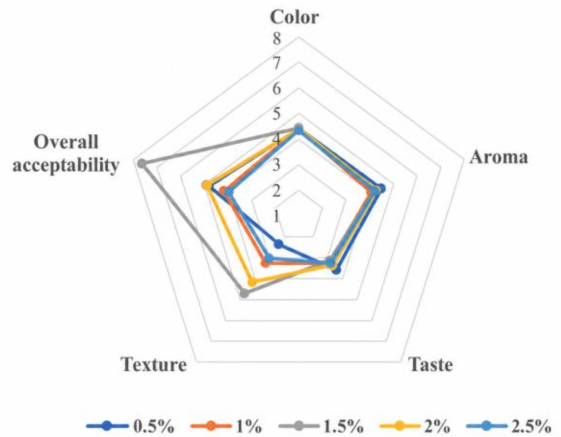

Figure 1. *Effect of carrageenan concentration on the sensory quality of jelly*

4. CONCLUSION

The results of this study showed that gel hardness was closely associated with sensory quality and the retention of bioactive compounds in the product. As carrageenan concentration increased, a denser gel network was formed, resulting in increased product hardness; however, excessively high hardness may reduce consumer acceptability due to an overly firm texture. In addition, the carrageenan gel network contributed to the retention and protection of bioactive compounds such as vitamin C and phenolic compounds, thereby limiting their diffusion and degradation and helping maintain the nutritional value of the product.

In this study, at a carrageenan concentration of 1.5%, the product achieved an appropriate hardness (0.68 N), while the color values L*, a*, and b* were 36.51, 16.79, and 42.00, respectively. The product also received high sensory evaluation scores, with color, aroma, taste, and texture scores of 4.4, 4.21, 3.10, and 4.7, respectively, while the overall acceptability score reached 7.62, representing the highest value among all treatments evaluated. Furthermore, the nutritional value of the product was maintained, with a vitamin C content of 21.08 mg/100 g and a total phenolic content of 44.94 mg GAE/ 100 g. The findings suggest that carrageenan has promising potential for application in orange jelly production. Future studies may investigate the combination of carrageenan with pectin or gelatin to further improve product texture, sensory quality, and broaden its application potential.

REFERENCES

[1]. Lưu, M. C., et al. (2023), "*Determination of phenolic and flavonoid contents and antioxidant activity of King mandarin (Citrus nobilis)*," TNU Journal of Science and Technology, 228(13), pp. 374-382.
[2]. K. A. Sir Elkhatim, R. A. A. Elagib, and A. B. Hassan, (2018), "*Content of phenolic compounds and vitamin C and antioxidant activity in wasted parts of Sudanese citrus fruits*," Food Sci. Nutr., 6(5), pp. 1214-1219.
[3]. Nga, N. (2025). "Why are Vinh Long king mandarins difficult to sell despite low prices?" Industry and Trade Newspaper, March 22, 2025. Available at: Industry and Trade Newspaper article (Accessed July 31, 2025).
[4]. S. Selli, (2007), "*Volatile constituents of orange wine obtained from moro oranges (citrus sinensis [L.] osbeck),*" J. Food Qual., 30(3), pp. 330-341.
[5]. Phan, T. T. Q., Duong, K. T., Le, D. N., Nguyen, L. T. V., Kha, C. T., Nguyen, V. A., and Duong, T. P. L. (2021). "*Effects of pretreatment processes on the quality of dried king mandarin (Citrus sinensis)*." Can Tho University Journal of Science, 57(Special Issue: Food Technology), 151–160.
[6]. N. A. Afoakwah, F. K. Amagloh, G. K. Mahunu, S. W. Ayyub, W. Tchabo, and P. Owusu-Ansah, (2023), "*Quality evaluation of orange-fleshed sweet potato-pineapple blended jam*", J. Agric. Food Res., 12(1), 100540.
[7]. M. B. Lima, F. M. Domingos, J. J. F. de Jesus Lima, R. de Souza Monteiro, O. D. H. dos Santos and P. A. P. Pereira, (2019), "*Characterization and influence of hydrocolloids on low caloric orange jellies*", Emir. J. Food Agric., 31(1), pp. 7-15.
[8]. T. Udo, G. Mummaleti, A. Mohan, R. K. Singh, and F. Kong, (2023), "*Current and emerging applications of carrageenan in the food industry*", 173(2), 113369.
[9]. R. I. Mulyani, (2025), "*Antioxidant activity and vitamin C content of different formulations of tomato (Solanum lycopersicum), adlay seed (Coix lacryma-jobi L.) and carrageenan (Eucheuma cottonii) jelly drink*," Food Res., 9(3), pp. 256–267.
[10]. A. Hu, Y. Liu, and S. Wu, (2024), "*A review on polysaccharide-based jelly: Gell food*", Food Chem X, vol. 23, 101562.
[11]. L. C. Soedirga and Marchellin, (2022), "P*hysicochemical Properties of Jelly Candy Made with Pectin from Red Dragon Fruit Peel in Combination with Carrageenan,*" Caraka Tani J. Sustain. Agric., 37(1), pp. 1-14.
[12]. Nhan, M. T., and Diep, K. Q. (2014), "Effects of ingredient composition on the texture, anthocyanin content, and vitamin C content of strawberry gummy candy," Can Tho University Journal of Science, (Special Issue: Agriculture), pp. 50–60.
[13]. V. L. Singleton, J. A. Rossi Jr., and Rossi J A Jr. (1965), "*Colorimetry of Total Phenolics with Phosphomolybdic-Phosphotungstic Acid Reagents,*" Am. J. Enol. Vitic., 16(3), pp. 144-158.
[14]. N. Q. Duy et al., (2020), "*Effects of extraction conditions on antioxidant activities of roselle (Hibiscus sabdariffa L.) extracts*," in Materials Science Forum, vol. 977, pp. 201-206.
[15]. F. Habibi, A. Sarkhosh, J. Kim, M. Shahid, F. Gmitter, and J. Brecht, (2023), "*Citrus Fruit Pigments,*" EDIS, 2023(6), pp. 165-187.
[16]. D. Saha and S. Bhattacharya, (2010), "*Hydrocolloids as thickening and gelling agents in food: A critical review*", 47(6), pp. 587–597.
[17]. N. Rochmawati and D. E. Ermawati, (2021), "*The Effect of Carrageenan Concentration on the Physical and Chemical Properties of Gummy Turmeric Acid Jamu*," Maj. Farm., 17(2), pp. 230–237.
[18]. F. H. Harahap, N. Harini, W. Warkoyo, and R. Anggriani, (2022), "*Effect of The Ratio of Beetroot Juice with Pineapple Core Juice and Carrageenan Concentration from Seaweed (Eucheuma cottonii) on Jelly Candy Quality*," Food Technol. Halal Sci. J., 5(1), pp. 45-61.
[19]. Jariyah, Rosida, I. Defri, and P. E. K. Wardani, (2022), "*The Physicochemical Properties of the Jelly Drink Produced by Mixing Pedada (Sonneratia caseolaris) and Young Coconut Juices with Carrageenan*," MATEC Web Conf., vol. 372, p. 202006.
[20]. M. B. Lima, H. V. Santos, J. C. Barbosa, L. O. Penna, and P. A. P. Pereira, (2023), "*Effect of hydrocolloid concentration in low-calorie orange jellies on preservation of bioactive compounds and antioxidant capacity,"* An. Acad. Bras. Cienc., 95(4), e20191092.
[21]. S. Sukotjo, H. Irianto, S. Leonita, and N. Y. Sari, (2022), "*The Effects of Tomato Concentration on Sensory and Chemical Properties of Jelly Drink*," Proc. 6th Int. Conf. Food, Agric., Nat. Resour. (IC-FANRES 2021), vol 16, pp. 184-189.
[22]. R. Rupert, K. F. Rodrigues, V. Y. Thien, and W. T. L. Yong (2022), "*Carrageenan from Kappaphycus alvarezii (Rhodophyta, Solieriaceae): Metabolism, Structure, Production, and Application*", Front. Plant Sci., 13, 859635.