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# Physical, Chemical, and Hedonic Characteristics of Mango *Arumanis* (*Mangifera indica* L.) Jelly Drink with Varied Carrageenan Addition as Gelling Agent

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**ABSTRACT**
*This study contributed to evaluate the effect of different concentrations of kappa carrageenan on the physicochemical and sensory properties of Arumanis mango (Mangifera indica L.) jelly drink. Kappa carrageenan, a sulphated polysaccharide extracted from red seaweed, is widely used in the food industry as a gelling, thickening, and stabilizing agent. Arumanis mango, known for its sweet taste and strong aroma, has limited natural pectin content, thus requiring additional hydrocolloids for gel formation. Four concentrations of kappa carrageenan (0.35%, 0.40%, 0.45%, and 0.50%) were tested using a Completely Randomized Design with five replications. Physicochemical parameters (syneresis, viscosity, pH and moisture content) and sensory attributes (texture, taste, aroma, color, and overall acceptance) were evaluated. Results showed that carrageenan concentration significantly (p<0.05) influenced all tested parameters. Increasing carrageenan levels enhanced viscosity and pH while reducing syneresis moisture content. Sensory analysis revealed that the 0.40% carrageenan treatment (P2) produced the most desirable texture and overall acceptability. This study highlights that the optimal carrageenan concentration ensures a balance between physicochemical stability and consumer preference, contributing new insight into the development of high-quality jelly drinks from local mango varieties.*

**KEYWORDS**
*Arumanis* mango; Jelly drink; Kappa carrageenan; Physicochemical properties; Sensory evaluation

## 1. INTRODUCTION

Jelly drink is a semi-solid beverage with a soft gel structure, widely consumed for its refreshing texture and convenience when consumed with a straw [1], [2]. It is generally produced from fruit juice combined with hydrocolloids that serve as gelling agents [3]. Mango (*Mangifera indica* L.) is one of the most popular tropical fruits due to its unique aroma, sweet flavor, and attractive color. The *Arumanis* variety, in particular, is highly valued in Indonesia for its distinct sensory qualities and broad availability throughout the year [4], [5]. However, mangoes contain only a small amount of natural pectin (approximately 0.50–1.25%), which is insufficient to form a stable gel structure [6]. Therefore, additional gelling agents are required to achieve desirable product characteristics [1], [2].

Carrageenan, a linear sulphated polysaccharide extracted from red edible seaweeds (*Rhodophyta*), is commonly used in food systems as a thickener, stabilizer, and gelling agent [7]. Among its types, kappa carrageenan is most suitable for jelly products, as it forms a firm yet elastic gel that maintains stability in sugar-based systems and remains soluble at moderate processing temperatures [3]. Previous studies have


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demonstrated the effectiveness of carrageenan in enhancing the physicochemical and sensory properties of jelly-based foods [8], [9], [10]. However, research on the application of kappa carrageenan in mango-based jelly drinks, particularly those using the *Arumanis* variety, remains limited.

Therefore, this study was conducted to evaluate the effect of different varying concentrations of kappa carrageenan on the physical, chemical, and sensory characteristic of *Arumanis* mango jelly drinks. By identifying the optimal concentration, this research provides evidence-based recommendations for developing jelly drinks with improved consumer acceptability and stability, thereby contributing to the utilization of local fruit resources in functional beverage production.

## 2. MATERIALS AND METHODS

### 2.1. Materials

The raw materials used in this study included *Arumanis* mango (*Mangifera indica* L.) obtained from local market in Semarang, commercial-grade kappa carrageenan (food grade), granulated sugar (Gulaku, Indonesia), commercial bottled drinking water (Aqua, Danone Indonesia), distilled water, and pH buffer solutions (pH 4 and pH 7) (Merck, Germany). The equipment consisted of a digital pH meter (Hanna Instruments® HI98107, Romania), Brookfield viscometer (Brookfield® DV-E, USA), analytical balance (Ohaus® Pioneer PA214, USA), laboratory oven (Memmert® UN30, Germany), and desiccator (Duran®, Germany). Additional utensils included a hand blender (Philips® HR1600, Netherlands), thermometer (Thermo Scientific®, USA), stainless steel pot, spatula, plastic strainer, Whatman® filter paper (Grade 1, UK), porcelain crucibles (Pyrex®, USA), and plastic jelly cups (Food Grade PP cups, Indonesia).

### 2.2. Preparation of *Arumanis* Mango Juice

Fresh, fully ripe *arumanis* mangoes were selected based on uniform green-yellow skin color, sweet aroma, and soluble solids content of approximately 14 °Brix. The fruit was washed, peeled, and the pulp was separated. A total of 100 g of mango pulp was blended with 500 mL of drinking water until a homogeneous mixture was obtained. The mixture was filtered through a fine strainer to obtain clear *arumanis* mango juice.

### 2.3. Preparation of Arumanis Mango Jelly Drink

The jelly drink formulation consisted of 100 mL *arumanis* mango juice, 10 g sugar, and kappa carrageenan according to treatment concentrations (Table 1). The mixture was heated in a stainless steel pot at 90 °C for 5 minutes with continuous stirring until the carrageenan was completely dissolved [11]. The hot jelly solution was poured into plastic cups and cooled at room temperature, then stored at 4 °C to allow gel formation.

Table 1. *Arumanis* mango jelly drink formulation.

| Ingredients | P1 | P2 | P3 | P4 |
|---|---|---|---|---|
| Mango juice (mL) | 100 | 100 | 100 | 100 |
| Carrageenan (mL) | 0.35 | 0.40 | 0.45 | 0.50 |
| Sugar (g) | 10 | 10 | 10 | 10 |

Note: P1–P4 indicate carrageenan concentrations of 0.35%, 0.40%, 0.45%, and 0.50%, respectively.

### 2.4. Syneresis Evaluation

Syneresis was determined according to the method by Park et al. (2021) [12] with slight modification. Approximately 3 g jelly sample was placed in a filter paper-lined plastic cup and stored at 4 °C in a refrigerator for 24 hours. Syneresis percentage was calculated using equation (1).

$$Syneresis\ (\%) = \frac{Initial\ gel\ weight - final\ gel\ weight}{Initial\ gel\ weight} \times 100 \quad (1)$$

### 2.5. Viscosity Evaluation

Viscosity was measured using a Brookfield viscometer with spindle No. 2 at 60 rpm for 30 seconds. The jelly sample was placed in a beaker and the spindle was immersed up to the specified level. After starting the device, the torque reading (%) was multiplied by the appropriate factor provided in the instrument manual to obtain the viscosity in centipoise (cP). Each treatment was measured using five samples.

### 2.6. pH Measurement

The pH was measured using a calibrated digital pH meter (buffer solutions of pH 4 and 7). The electrode was rinsed with distilled water, dried with tissue, and then immersed in the sample. The pH value was recorded once the reading stabilized [13]. Sample were allowed to reach room temperature prior to measurement.

### 2.7. Moisture Content Determination

Moisture content was determined using the AOAC oven-drying method, in which a 2 g jelly sample was placed in a pre-dried porcelain crucible and dried in an oven at 105 °C for 4 hours. The sample was cooled in a desiccator for 15 minutes and weighed. This process was repeated (drying, cooling, weighing) until a constant weight was achieved [14]. Moisture content was calculated using equation (2).

$$Moisture\ content\ (\%) = \frac{B - C}{B - A} \times 100 \tag{2}$$

Where A is the weight of the empty crucible (g), B is the weight of the crucible plus the sample before drying (g), and C is the weight of the crucible plus the sample after drying (g).

### 2.8. Sensory Evaluation

A hedonic test was conducted to evaluate texture, taste, aroma, color, and overall acceptance. Thirty semi-trained panellists (aged 18–25 years, familiar with jelly drink products) participated in the evaluation. A 5-point hedonic scale was used, ranging from 1 (dislike very much) to 5 (like very much). Panellists were provided with coded samples in randomized order under controlled conditions.

### 2.9. Experimental Design

A completely randomized design (CRD) was applied with one treatment factor, which is kappa carrageenan at four levels (0.35%, 0.40%, 0.45%, and 0.50%, w/v), denoted as P1, P2, P3, and P4, respectively. Each treatment was replicated five times, yielding 20 experimental units.

### 2.10. Statistical Analysis

Data on physicochemical were analyzed using analysis of variance (ANOVA) followed by duncan's multiple range test (DMRT) when significant differences were found ($p<0.05$). Sensory evaluation results were analysed using the Kruskal-Wallis test, followed by the Mann-Whitney post hoc test when significant differences occurred.

## 3. RESULTS AND DISCUSSION

### 3.1. Physical Characteristics of *Arumanis* Mango Jelly Drink

#### 3.1.1. Syneresis

The addition of kappa carrageenan significantly affected of the syneresis of the *Arumanis* mango jelly drink ($p<0.05$). The highest syneresis was found in treatment P1 (11.71%), while the lowest was in treatment P4 (8.77%) (Table 2). The data indicate that increasing carrageenan concentration from P1 to P4 resulted in a decreasing trend in syneresis values. This reduction is due to carrageenan's hydrocolloid properties, which increase water-binding capacity and strengthen the gel network. These findings are consistent with previous studies reporting that higher carrageenan concentrations reduced syneresis in rosella-sirsak jelly drink [15] and papaya jelly drink [16]. Stronger gel matrices limit free water release, thereby improving product stability during storage.

#### 3.1.2. Viscosity

Viscosity also increased significantly with carrageenan concentration ($p<0.05$). Treatment P1 exhibited the lowest viscosity (459.2 cP), whereas P4 reached the highest (749 cP). A positive correlation between carrageenan level and viscosity has been widely documented, while increasing carrageenan concentration leads to higher viscosity in a wide range of jelly drinks. This effect is due to carrageenan's ability to form a denser gel network, which thickens the liquid and improves the drink's texture and mouthfeel [17], [18], [19]. This is because carrageenan molecules interact through helical structures that entrap water, forming a denser gel network. The addition of carrageenan to beverages such as ready-to-drink mango juice has been shown to enhance physical stability and prevent sedimentation; however, excessive viscosity can lower consumer acceptance, as overly thick gels are difficult to consume through a straw. An optimal formulation is achieved when the carrageenan dosage is sufficient to maintain stability without producing excessive thickness, thereby providing a preferred "melt-in-the-mouth" sensation [11].

Table 2. Physical characteristics of *arumanis* mango jelly drink.

| Treatment | Syneresis (%) | Viscosity (cP) |
|---|---|---|
| P1 | $11.71^{a} \pm 0.32$ | $459.2^{a} \pm 1.64$ |
| P2 | $11.04^{b} \pm 0.26$ | $653.0^{b} \pm 2.12$ |
| P3 | $10.94^{c} \pm 0.27$ | $746.2^{c} \pm 3.03$ |
| P4 | $8.77^{c} \pm 0.29$ | $749.0^{a} \pm 3.03$ |

Note: Different superscript letters in the same row indicate significant differences ($p<0.05$). P1–P4 indicate carrageenan concentrations of 0.35%, 0.40%, 0.45%, and 0.50%, respectively.

### 3.2. Chemical Characteristics of *Arumanis* Mango Jelly Drink

#### 3.2.1. pH

The jelly drinks' pH increased significantly ($p<0.05$) with carrageenan concentration, ranging from 5.59 (P1) to 6.39 (P4) (Table 3). This rise in pH can be attributed to the mildly alkaline nature of carrageenan (approx. pH 9.5–10.5), which acts to partially neutralize the organic acids naturally present in mango juice. Such neutralization reduces acidity and shifts the acid-base balance of the beverage upward [9], [20]. Several studies report that the addition of carrageenan does not always cause significant changes in the pH of pineapple jelly drink [3]. However, in krai-based jelly drinks, an increase in carrageenan significantly raises the pH [21]. Another study using strawberry-based drinking jelly made with a seaweed-derived gelling agent (*Gracilaria*/*Gracilaria fisheri*) observed that higher gelling agent concentrations increased the pH and TSS/TA (total soluble solids to titratable acidity) ratio, resulting in a sweeter, less acidic profile [22]. These findings reinforce that carrageenan—and similar hydrocolloids/seaweed gelling agents—serve not only as gel formers but also as modulators of acidity in fruit jelly systems.

Table 3. Chemical characteristics of *arumanis* mango jelly drink.

| Treatment | pH | Moisture content (%) |
|---|---|---|
| P1 | $5.59^{a} \pm 0.11$ | $90.23^{a} \pm 0.11$ |
| P2 | $5.83^{b} \pm 0.04$ | $90.20^{a} \pm 0.10$ |
| P3 | $6.13^{c} \pm 0.14$ | $90.16^{a} \pm 0.13$ |
| P4 | $6.39^{d} \pm 0.03$ | $89.67^{b} \pm 0.17$ |

Note: Different superscript letters in the same column indicate significant differences ($p<0.05$). P1–P4 indicate carrageenan concentrations of 0.35%, 0.40%, 0.45%, and 0.50%, respectively.

#### 3.2.2. Moisture Content

Moisture content decreased slightly with higher carrageenan concentration from 90.23% (P1) to 89.67% (P4). While no significant differences were observed among P1, P2, and P3, a notable decrease occurred at P4. Carrageenan binds free water within its gel network, thereby reducing measurable moisture. Comparable results were found in pumpkin sheet products and mangrove *pidada* (*Sonneratia*) fruit jelly drinks [9] where hydrocolloids improved water retention and reduced free moisture content.

## 3.3. Sensory Evaluation of *Arumanis* Mango Jelly Drink

### 3.3.1. Texture

Panellists rated treatment P2 (0.40% carrageenan) with the highest texture score (4.28), significantly different ($p<0.05$) from other treatments (Table 4). This indicates that 0.40% carrageenan provided an optimal gel structure—firm enough to maintain shape but elastic enough to be consumed through a straw. In contrast, P1 (0.35%) was too soft, whereas P3 and P4 (>0.45%) were judged as excessively firm or rubbery. Similar trends have been observed in papaya jelly drinks [16] and *galoba* jelly drink [23], where moderate carrageenan concentration yielded the most acceptable texture.

Table 4. Hedonic scores of *arumanis* mango jelly drink.

| Treatment | Texture | Taste | Aroma | Color | Overall |
|---|---|---|---|---|---|
| P1 | $2.92^{a} \pm 0.64$ | $3.84^{a} \pm 1.64$ | $3.48^{a} \pm 0.11$ | $3.52^{b} \pm 0.11$ | $3.64^{b} \pm 0.63$ |
| P2 | $4.28^{b} \pm 0.61$ | $4.04^{a} \pm 2.12$ | $3.36^{a} \pm 0.04$ | $3.44^{a} \pm 0.10$ | $4.08^{ab} \pm 0.81$ |
| P3 | $3.04^{a} \pm 0.78$ | $3.76^{a} \pm 3.03$ | $3.32^{a} \pm 0.14$ | $3.56^{a} \pm 0.13$ | $3.12^{ab} \pm 0.52$ |
| P4 | $2.44^{a} \pm 0.82$ | $3.80^{a} \pm 3.03$ | $3.32^{a} \pm 0.03$ | $3.64^{a} \pm 0.17$ | $3.08^{ab} \pm 0.70$ |

Note: Different superscript letters in the same column indicate significant differences ($p<0.05$). P1–P4 indicate carrageenan concentrations of 0.35%, 0.40%, 0.45%, and 0.50%, respectively.

### 3.3.2. Taste

Taste scores ranged from 3.76 to 4.04, with no significant differences among treatments ($p>0.05$). Panellists generally rated all samples between "slightly like" and "like," indicating a consistent acceptance of flavor across treatments. Since carrageenan has a neutral taste profile, its presence did not affect the overall flavor of the jelly drink. This finding is consistent with previous reports indicating that carrageenan, unlike certain hydrocolloids such as guar gum or xanthan gum that may impart off-flavors or residual mouthfeel, does not interfere with the inherent sensory attributes of fruit-based products [9], [23]. Its functionality is mainly expressed through textural modification and stabilization rather than flavor alteration, which makes it particularly suitable for beverages where maintaining the characteristic taste of the fruit is essential for consumer acceptance. Similar observations have been documented in jelly products and other hydrocolloid-based desserts, where carrageenan addition enhanced gel strength and clarity without modifying flavor perception, thereby ensuring that sensory quality was primarily determined by the base fruit matrix rather than the gelling agent [24], [25].

### 3.3.3. Aroma

Aroma scores ranged from 3.32 to 3.48, also showing no significant differences ($p>0.05$). The natural aroma of *arumanis* mango dominated all samples, and carrageenan did not contribute any distinct scent, as it lacks volatile compounds [26]. Consequently, variations in carrageenan concentration had little to no impact on the overall aroma profile, resulting in minimal and statistically insignificant differences among treatments. This observation is consistent with the role of carrageenan as a structural hydrocolloid rather than a flavor-active ingredient, since its primary function is to modify texture and stabilize the beverage matrix rather than influence volatile release [27]. Moreover, fruit-derived volatile compounds, particularly terpenes, esters, and aldehydes that characterize the unique aroma of *arumanis* mango, were strong enough to mask any subtle matrix effects potentially caused by carrageenan addition [28], [29]. Similar findings have been reported in other fruit-based jelly or beverage systems, where hydrocolloids improved physical stability without altering the aroma profile, confirming that consumer-perceived aroma is primarily determined by the fruit base rather than the gelling agent used [30].

#### 3.3.4. Color

Color acceptance ranged from 3.44 to 3.64, with no significant effect observed ($p>0.05$). Since carrageenan lacks natural pigments, the appearance of the jelly drink was mainly determined by the carotenoid pigments of *arumanis* mango, particularly β-carotene, which provides the characteristic yellow-orange color [31]. This result is consistent with previous studies on pumpkin jelly and other fruit-based gels, where carrageenan did not alter color attributes due to its role as a stabilizer rather than a colorant. [32], [33].

#### 3.3.5. Overall Acceptance

Overall preference was highest for P2 (4.08), indicating that moderate carrageenan concentration provided the best balance between texture and sensory quality. Multiple studies confirm that moderate carrageenan concentrations provide the best balance between chewiness, firmness, and overall acceptability in fruit-based gels and jellies. For example, in jelly candies and plant-based products, formulations with intermediate carrageenan levels (typically around 1–2%) received the highest sensory scores for texture and overall liking, as they maintained an appealing chewiness without becoming too firm or rubbery [34], [35]. In contrast, excessive carrageenan in P3–P4 produced overly rigid textures that reduced consumer liking. These findings are consistent with previous reports on mango-based jelly candy, emphasizing the need for optimal hydrocolloid levels to ensure desirable sensory properties and consumer preference [3], [36].

## 4. CONCLUSION

The results of this study demonstrate that increasing the concentration of carrageenan in the formulation of *arumanis* mango jelly drink significantly influences its physicochemical and sensory properties. Higher carrageenan levels led to increased pH and viscosity, while moisture content and syneresis values decreased. These changes indicate improved water retention and gel strength as carrageenan concentration increases. Among the tested formulations, the addition of 0.40% carrageenan produced the most desirable product, as evaluated by sensory panellists. This formulation achieved a balanced texture that was neither too firm nor too fragile, contributing to an overall favorable acceptance. Therefore, 0.40% carrageenan is considered the optimal concentration for developing a jelly drink with both good physicochemical stability and consumer acceptability.

## AUTHOR CONTRIBUTION

All author contributed equally to the main contributor to this paper. All authors read and approved the final paper. **Siti Susanti** contributed to the research implementation, including sample preparation, data collection, and supported initial data analysis and manuscript writing. **Asya Sabila Urai** conducted laboratory analyses, assisted in sample preparation, data collection, and initial draft writing. **Bhakti Etza Setiani** supervised the laboratory work, validated the methodology, provided critical review, and contributed to experimental design and data interpretation. **Anang Mohamad Legowo** was responsible for internal review and manuscript editing. **Maela Rizky Kusumastuti** led the manuscript writing and revision process, served as the corresponding author, and finalized the manuscript for submission.

## CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

## REFERENCES

[1] O. D. Indriani and A. N. Khairi, "Physico-chemical characteristics of jelly drink with variation of red dragon fruit peel (*Hylocereus polyrhizus*) and additional sappan wood (*Caesalpinia sappan*)," *J. Agri-Food Sci. Technol.*, vol. 4, no. 1, pp. 37–48, 2023, https://doi.org/10.12928/jafost.v4i1.7069.

[2] E. N. Dewi and L. Purnamayati, "The effect of natural dye from *Caulerpa* sp. microcapsules on jelly drink quality," *Food Res.*, vol. 7, pp. 1–11, 2023, https://doi.org/10.26656/fr.2017.7(S3).1.

[3] S. Rittisak, N. Lonuch, S. Buakeeree, and S. Yimtoe, "Development of jelly drink from cultivated banana pseudo stem juice (*Musasapientum* L.) and pineapple juice supplemented with pineapple pulp," *Food Res.*, vol. 7, no. 2, pp. 52–59, 2023, https://doi.org/10.26656/fr.2017.7(2).721.

[4] M. Sato, M. M. M. Ikram, H. Pranamuda, W. Agusta, S. P. Putri, and E. Fukusaki, "Characterization of five Indonesian mangoes using gas chromatography–mass spectrometry-based metabolic profiling and sensory evaluation," *J. Biosci. Bioeng.*, vol. 132, no. 6, pp. 613–620, 2021, https://doi.org/10.1016/j.jbiosc.2021.09.006.

[5] N. W. A. Maryani, L. Suriati, and I. P. Candra, "Addition of sugar and cmc to the characteristics of *arumanis* mango jam (*Mangifera indica* L.)," *SEAS Sustain. Environ. Agric. Sci.*, vol. 7, no. 1, pp. 39–51, 2023, https://doi.org/10.22225/seas.7.1.6599.39-51.

[6] R. Duran, R. Torres, and Y. Peralta-Ruiz, "Effect of temperature, ph and concentration of soluble solids on the rheological behavior and molecular mass of pectin obtained from mango vallenato shell (*Mangifera indica* L.)," *Adv. J. Food Sci. Technol.*, vol. 16, pp. 35–40, 2018, https://doi.org/10.19026/ajfst.16.5934.

[7] T. Udo, G. Mummaleti, A. Mohan, R. K. Singh, and F. Kong, "Current and emerging applications of carrageenan in the food industry," *Food Res. Int.*, vol. 173, p. 113369, 2023, https://doi.org/10.1016/j.foodres.2023.113369.

[8] F. N. 'Abidah, P. Haryanti, and K. Karseno, "Physicochemical and sensory characteristics of black grass jelly drink on variations in type and concentration of hydrocolloids," *Indones. J. Food Technol.*, vol. 2, no. 1, p. 39, 2023, https://doi.org/10.20884/1.ijft.2023.2.1.7368.

[9] Jariyah, Rosida, I. Defri, and P. E. K. Wardani, "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. 02006, 2022, https://doi.org/10.1051/matecconf/202237202006.

[10] B. Yudhistira, S. R. Hamidah, and F. Punthi, "Physical, chemical, and sensory characteristics of star fruit (*Averrhoa carambola* L.) jelly candy with various concentrations of carrageenan-konjac and carrageenan-pectin," *AgriHealth J. Agri-Food Nutr. Public Health*, vol. 5, no. 1, p. 76, 2024, https://doi.org/10.20961/agrihealth.v5i1.85331.

[11] S. Giridharaprasad, D. K. Ravi, K. Miller, and B. Rajoo, "Optimization of incorporating κ-Carrageenan-based gels on improving cloud stability, physical stability, and viscosity of ready-to-drink mango juice," *J. Food Sci.*, vol. 86, no. 9, pp. 4017–4025, 2021, https://doi.org/10.1111/1750-3841.15874.

[12] J. J. Park, I. F. Olawuyi, G. D. Park, and W. Y. Lee, "Effects of gelling agents and sugar substitutes on the quality characteristics of carrot jelly," *Korean J. Food Preserv.*, vol. 28, no. 4, pp. 469–479, 2021, https://doi.org/10.11002/kjfp.2021.28.4.469.

[13] N. Charoenphun, P. Noonim, S. Lekjing, C. Nitikornwarakul, N. H. Pham, and K. Venkatachalam, "Physicochemical properties, antioxidant activity, and flavor profile of strawberry fruit-based novel drinking jelly made with *Gracilaria fisheri* seaweed as a gelling agent at varying concentrations," *Gels*, vol. 11, no. 1, p. 54, 2025, https://doi.org/10.3390/gels11010054.

[14] AOAC, "A.O.A.C 2005," *Official methods of analysis of the association of official agriculture chemist*, Maryland: AOAC International, 2005. https://books.google.co.id/books?id=rrEmAAAACAAJ&redir_esc=y.

[15] Y. F. Gani, T. I. P. Suseno, and S. Surjoseputro, "Perbedaan konsentrasi karagenan terhadap sifat fisikokimia dan organoleptik jelly drink rosela-sirsak," *J. Teknol. Pangan Dan Gizi*, vol. 13, no. 2, pp. 87–93, 2014, https://doi.org/10.33508/jtpg.v13i2.1508.

[16] J. Vania, A. R. Utomo, and C. Y. Trisnawati, "Pengaruh perbedaan konsentrasi karagenan terhadap karakteristik fisikokimia dan organoleptik jelly drink pepaya," *J. Teknol. Pangan Dan Gizi*, vol. 16, no. 1, pp. 8–13, 2017, https://doi.org/10.33508/jtpg.v16i1.1385.

[17] H. Tao, L. Guo, Z. Qin, B. Yu, Y. Wang, J. Li, Z. Wang, X. Shao, G. Dou, and B. Cui, "Textural characteristics of mixed gels improved by structural recombination and the formation of hydrogen bonds between curdlan and carrageenan," *Food Hydrocoll.*, vol. 129, p. 107678, 2022, https://doi.org/10.1016/j.foodhyd.2022.107678.

[18] X. Li, X. Chen, and H. Cheng, "Impact of κ-carrageenan on the cold-set pea protein isolate emulsion-filled gels: Mechanical property, microstructure, and in vitro digestive behavior," *Foods*, vol. 13, no. 3, p. 483, 2024, https://doi.org/10.3390/foods13030483.

[19] K. Belova, E. Dushina, S. Popov, A. Zlobin, E. Martinson, F. Vityazev, and S. Litvinets, "Enrichment of 3d-printed k-carrageenan food gel with callus tissue of narrow-leaved lupin *Lupinus angustifolius*," *Gels*, vol. 9, no. 1, p. 45, 2023, https://doi.org/10.3390/gels9010045.

[20] M. Robal, T. Branner, S. Matsukawa, H. Ogawa, K. Truus, B. Rudolph and R. Tuvikene, "Monocationic salts of carrageenans: Preparation and physico-chemical properties," *Food Hydrocoll.*, vol. 63, pp. 656–667, 2017, https://doi.org/10.1016/j.foodhyd.2016.09.032.

[21] E. H. Widowati and D. Larasati, "Konsentrasi karagenan terhadap fisitokimia dan organoleptik jelly drink krai," *J. Litbang Provinsi Jawa Tengah*, vol. 16, no. 2, pp. 153–164, 2019, https://doi.org/10.36762/litbangjateng.v16i2.761.

[22] N. A. H. A. Nasir, M. H. Yuswan, N. N. A. K. Shah, A. Abd Rashed, K. Kadota, and Y. A. Yusof, "Evaluation of physicochemical properties of a hydrocolloid-based functional food fortified with *Caulerpa lentillifera*: A d-optimal design approach," *Gels*, vol. 9, no. 7, p. 531, 2023, https://doi.org/10.3390/gels9070531.

[23] G. H. Augustyn, "Effect of carrageenan concentration on sensory characteristics of jelly drink galoba," *J. Agrosilvopasture-Tech*, vol. 1, no. 1, pp. 16–20, 2022, https://doi.org/10.30598/j.agrosilvopasture-tech.2022.1.1.16.

[24] X. Song, B. Chiou, Y. Xia, M. Chen, F. Liu, and F. Zhong, "The improvement of texture properties and storage stability for kappa carrageenan in developing vegan gummy candies," *J. Sci. Food Agric.*, vol. 102, no. 9, pp. 3693–3702, 2022, https://doi.org/10.1002/jsfa.11716.

[25] S. Roy, S. A. Hussain, W. G. Prasad, and Y. Khetra, "Effect of kappa-carrageenan inclusion in the stabilizer blend on rheology, texture, and physical properties of high protein ice cream," *Int. Dairy J.*, vol. 159, p. 106052, 2024, https://doi.org/10.1016/j.idairyj.2024.106052.

[26] E. Bylaite, Ž. Ilgūnaitė, A. S. Meyer, and J. Adler-Nissen, "Influence of λ-carrageenan on the release of systematic series of volatile flavor compounds from viscous food model systems," *J. Agric. Food Chem.*, vol. 52, no. 11, pp. 3542–3549, 2004, https://doi.org/10.1021/jf0354996.

[27] M. Wei, M. Shan, L. Zhang, N. Chen, H. Tie, Y. Xiao, and Z. Li, "Preparation of gelatin/κ-carrageenan active films through procyanidins crosslinking: Physicochemical, structural, antioxidant and controlled release properties," *Food Hydrocoll.*, vol. 153, p. 110023, 2024, https://doi.org/10.1016/j.foodhyd.2024.110023.

[28] H. Xie, L. Meng, Y. Guo, H. Xiao, L. Jiang, Z. Zhang, H. Song, and X. Shi, "Effects of volatile flavour compound variations on the varying aroma of mangoes 'tainong' and 'hongyu' during storage," *Molecules*, vol. 28, no. 9, p. 3693, 2023, https://doi.org/10.3390/molecules28093693.

[29] H. Liu, K. An, S. Su, Y. Yu, J. Wu, G. Xiao, and Y. Xu, "Aromatic characterization of mangoes (*Mangifera indica* L.) using solid phase extraction coupled with gas chromatography–mass spectrometry and olfactometry and sensory analyses," *Foods*, vol. 9, no. 1, p. 75, 2020, https://doi.org/10.3390/foods9010075.

[30] M. Alam, S. Kaur, B. N. Dar, and V. Nanda, "Classification, techno-functional properties, and applications of diverse hydrocolloids in fruits-based products: A concise review," *J. Food Sci.*, vol. 90, no. 3, p. e70119, 2025, https://doi.org/10.1111/1750-3841.70119.

[31] M. E. Maldonado-Celis, E. M. Yahia, R. Bedoya, P. Landázuri, N. Loango, J. Aguillón, Restrepo, and J. C. Guerrero Ospina, "Chemical composition of mango (*Mangifera indica* L.) fruit: Nutritional and phytochemical compounds," *Front. Plant Sci.*, vol. 10, p. 1073, 2019, https://doi.org/10.3389/fpls.2019.01073.

[32] S. Astuti, O. Nawansih, S. Hidayati, and O. S. Anggraini, "Evaluation of the chemical properties, chewiness level, and sensory of yellow pumpkin (*Cucurbita moschata*) jelly candy in various ratios of caragenan and gum arabic," *J. Tek. Pertan. Lampung J. Agric. Eng.*, vol. 13, no. 1, p. 178, 2024, https://doi.org/10.23960/jtep-l.v13i1.178-187.

[33] H. V. Lin, A. Frasetto, E. J. Kowalik Jr, A. R. Nawrocki, M. M. Lu, J. R. Kosinski, J. A. Hubert, D. Szeto, X. Yao, G. Forrest, D. J. Marsh, and L. Brennan, "Butyrate and propionate protect against diet-induced obesity and regulate gut hormones via free fatty acid receptor 3-independent mechanisms," *PLoS ONE*, vol. 7, no. 4, p. e35240, 2012, https://doi.org/10.1371/journal.pone.0035240.

[34] J.-H. Han, D.-H. Keum, S.-J. Hong, Y.-J. Kim, and S.-G. Han, "Comparative evaluation of polysaccharide binders on the quality characteristics of plant-based patties," *Foods*, vol. 12, no. 20, p. 3731, 2023, https://doi.org/10.3390/foods12203731.

[35] M. Palanisamy, S. Töpfl, K. Aganovic, and R. G. Berger, "Influence of iota carrageenan addition on the properties of soya protein meat analogues," *LWT*, vol. 87, pp. 546–552, 2018, https://doi.org/10.1016/j.lwt.2017.09.029.

[36] A. Vincová, K. Šantová, V. Kůrová, A. Kratochvílová, V. Halámková, M. Suchánková, E. Lorencová, D. Sumczynski, and R. N. Salek, "The impact of divergent algal hydrocolloids addition on the physicochemical, viscoelastic, textural, and organoleptic properties of cream cheese products," *Foods*, vol. 12, no. 8, p. 1602, 2023, https://doi.org/10.3390/foods12081602.