

The Effect of Carrageenan and Konjac Proportion as Gelling Agents on the Physicochemical Characteristics and Hedonic Value of Arum Manis Mango Jelly Drink

Siti Susanti ^a, Hafidhi Izzati ^a, Bhakti Etza Setiani ^a, Hega Bintang Pratama Putra ^a, Maela Rizky Kusumastuti ^{b,*}

^a Food Technology, Department of Agriculture, Faculty of Animal Husbandry and Agriculture, Diponegoro University, Semarang, Indonesia

^b Department of Food and Agricultural Product Technology, Faculty of Agricultural Technology, Universitas Gadjah Mada, Yogyakarta, Indonesia

*Corresponding author, Email: maclarizkykusumastuti@mail.ugm.ac.id

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ABSTRACT

This study investigated the effect of carrageenan and konjac ratios as gelling agents on the physicochemical and sensory properties of *Arumanis* mango (*Mangifera indica* L.) jelly drink. Jelly drinks are increasingly popular functional beverages, but their texture and stability depend heavily on the gelling system applied. Carrageenan forms strong gel networks but is prone to syneresis, whereas konjac glucomannan improves viscosity and elasticity. Their combination is contributed to produce a stable and consumer-acceptable jelly drink. Four gelling agent ratios (100:0, 80:20, 60:40, and 40:60 carrageenan-to-konjac) were prepared in a Completely Randomized Design (CRD) with five replications. Parameters measured included moisture content, pH, syneresis, viscosity, and hedonic acceptance by 25 semi-trained panelists. Results showed that increasing konjac proportion significantly decreased moisture content (90.99–90.05%) and syneresis (27.87–14.59%), while enhancing viscosity (194.50–321.50 cP). The pH decreased with higher konjac levels (5.50–5.22) due to the presence of organic acids in mango interacting with konjac glucomannan. Sensory evaluation revealed that texture was significantly affected, with the 60:40 carrageenan-to-konjac ratio (P2) achieving the highest acceptance for chewiness and ease of sipping. Color, taste, and aroma showed no significant differences across treatments, although mango aroma dominated the product profile. Overall, the combination of carrageenan and konjac demonstrated a synergistic effect in improving stability and consumer preference. The 60:40 ratio was identified as the most favorable formulation. This research contributes to the development of functional jelly drinks based on tropical fruits.

KEYWORDS

Carrageenan; Jelly drink; Konjac; Mango *arumanis*; Physicochemical properties

1. INTRODUCTION

Jelly drinks are semi-solid beverages with a higher water content than traditional jellies or puddings, making them easier to sip while still providing a chewy texture. This is achieved by using lower concentrations of gelling agents (such as seaweed-derived carrageenan or agar) and higher water content, resulting in a semi-solid, pourable texture [1], [2]. Traditional jellies and puddings, in contrast, have a denser gel matrix and less water, making them set solidly. This beverage category has gained popularity in Asia due to its refreshing sensory attributes and potential as a functional drink enriched with vitamins, minerals, and dietary fiber. Mango (*Mangifera indica* L.) is one of the most widely cultivated tropical fruits in Indonesia, particularly the *Arumanis* variety, which is known for its high sweetness, distinctive aroma, and rich nutritional value [3]. However, the low pectin content (around 1 % by weight of the final product)

of mango pulp limits its ability to form stable gels, necessitating the addition of external gelling agents to develop jelly-based products [4].

Carrageenan, a sulfated polysaccharide extracted from red seaweeds, is widely applied as a gelling agent due to its ability to create strong and stable gels across various pH levels [5]. Despite its advantages, carrageenan gels are often brittle and susceptible to syneresis during storage, reducing consumer acceptability [6]. In contrast, konjac glucomannan, a hydrocolloid derived from *Amorphophallus konjac*, exhibits strong water-binding capacity, high viscosity, and elastic gel-forming ability. The combination of carrageenan and konjac has been reported to improve gel stability and texture by reducing syneresis, enhancing viscosity, and increasing elasticity.

Previous studies demonstrated the synergistic effects of carrageenan-konjac blends on papaya jelly [7], while the addition of konjac has been found to enhance the elasticity of coconut water jelly [8]. However, studies specifically investigating the effect of carrageenan and konjac combinations on the quality of *Arumanis* mango-based jelly drinks remain limited. Therefore, further research is needed to address this gap. Another reason to investigate jelly drinks is their growing market demand as convenient, ready-to-drink products that appeal to both children and adults. Unlike traditional fruit juices, jelly drinks provide a unique texture profile while retaining the nutritional benefits of fruit. Developing stable, consumer-acceptable mango jelly drinks is therefore important for diversifying value-added products from mangoes and reducing postharvest losses.

The novelty of this research lies in evaluating the effect of different carrageenan-to-konjac ratios on the physicochemical and sensory properties of *Arumanis* mango jelly drinks, filling a research gap not yet addressed by earlier studies. In particular, the study emphasizes the relationship between gelling agent combinations and product quality attributes, including syneresis, viscosity, moisture content, pH, and hedonic values. This research is expected to provide scientific insights into optimizing hydrocolloid combinations for jelly drinks and contribute to the development of functional fruit-based beverages with improved consumer appeal.

2. MATERIALS AND METHODS

2.1. Materials

The main ingredients used were fully ripened *Arumanis* mangoes obtained from a local farm in Central Java, Indonesia. Mangoes were selected based on uniform ripeness, indicated by yellowish-green skin color, strong aroma, and firmness appropriate for consumption. Each mango weighed approximately 350–400 g, with total soluble solids ranging from 18–20 °Brix, ensuring consistent sweetness and maturity for the study. Other materials included kappa carrageenan (Brata Food, Indonesia), konjac powder (Hubei Yizhi Konjac Biotechnology Co., China), granulated sugar (Gulaku, Indonesia), and mineral water (Aqua, Indonesia). Analytical-grade chemicals, such as NaOH and HCl, were obtained from Merck (Germany) for pH calibration.

Instruments used Philips HR2221/00 blender (Netherlands) for juice preparation, stainless steel sieves (80 mesh, 180 µm) for filtration, stainless steel pots, and measuring cups for processing, a Memmert UN30 drying oven (Germany) and a Duran® desiccator (Germany) for moisture analysis, a Hanna Instruments HI2211 pH meter (Romania), a Brookfield DV-E Viscometer (USA) for viscosity measurement, and Whatman No. 1 filter paper (Cytiva, UK) for syneresis analysis. All instruments were calibrated before use.

2.2. Mango Juice Preparation

Mango juice was prepared using a slightly modified method [9]. Mango pulp was separated from the seeds and blended with 500 mL of mineral water for 2 minutes to obtain a puree. The puree was then filtered through an 80-mesh stainless steel sieve (180 µm) to remove fibrous material. From approximately 350 g of mango pulp, about 700–750 mL of clarified juice was obtained after filtration. The juice was immediately used in jelly drink preparation to minimize enzymatic browning and microbial contamination.

2.3. Jelly Drink Preparation

The jelly drink was prepared following a modified method [10]. Mango juice was mixed with sugar (10% w/v) and different carrageenan-to-konjac ratios (100:0, 80:20, 60:40, and 40:60). Each formulation was prepared in triplicate using a Completely Randomized Design (CRD) with five replications. The mixtures were heated at 90 °C for 10 minutes while stirring continuously until homogeneous. After heating, the mixture was poured into 100 mL plastic cups, cooled at room temperature (± 28 °C) for 30 minutes, and stored for analysis.

2.4. Physicochemical Analysis

The physicochemical properties of the jelly drinks were analyzed using standard procedures. Moisture content was determined by the oven-drying method at 105 °C until a constant weight was achieved, and the results were calculated as percentage moisture on a wet basis [11]. The pH was measured with a calibrated digital pH meter (Hanna HI2211) by immersing the electrode in the homogenized jelly drink sample [12]. Viscosity was measured using a Brookfield DV-E Viscometer equipped with spindle No. 2 at 50 rpm and 25 °C, and the values were expressed in centipoise (cP) [13]. Syneresis was assessed by placing 20 g of jelly drink on Whatman No. 1 filter paper for 2 hours at room temperature. The released water was then weighed and expressed as percentage syneresis relative to the initial sample weight [10].

2.5. Hedonic Evaluation

A sensory test was conducted with 25 semi-trained panelists (aged 20–30 years) recruited from university students familiar with jelly drinks. Attributes tested included color, taste, aroma, texture, and overall acceptability, using a 5-point hedonic scale (1 = dislike very much, 5 = like very much). Evaluations were carried out in a controlled sensory laboratory. Data were analyzed with the Kruskal–Wallis test and Mann–Whitney U test for significant differences ($p < 0.05$). Reference methods followed by Sukotjo et al. (2021) [14].

2.6. Statistical Analysis

Physicochemical data were analyzed using Analysis of Variance (ANOVA). Duncan's Multiple Range Test (DMRT) was applied for mean separation at $p < 0.05$. All analyses were performed with SPSS version 25.0 (IBM Corp., USA).

3. RESULTS AND DISCUSSION

3.1. Syneresis and Viscosity

The physical properties of *Arumanis* mango jelly drinks are presented in Table 1. Syneresis values decreased significantly from 27.87% (100% carrageenan) to 14.59% (40:60 carrageenan-to-konjac). ANOVA results indicated that the ratio of carrageenan to konjac had a significant effect on syneresis ($p < 0.05$). Duncan's Multiple Range Test (DMRT) revealed that treatment P2 significantly differed from P0 and P1, but not from P3.

Table 1. Syneresis and viscosity of jelly drink.

Treatment	P0	P1	P2	P3
Syneresis (%)	27.87 \pm 1.28 ^a	22.82 \pm 1.06 ^b	15.83 \pm 1.70 ^c	14.59 \pm 0.78 ^c
Viscosity (cP)	194.50 \pm 3.70 ^a	198.00 \pm 5.70 ^a	275.50 \pm 4.47 ^b	321.50 \pm 4.18 ^c

Note: Different lowercase letters indicate significant differences ($p < 0.05$). Treatments P0–P3 represent carrageenan:konjac ratios of 100:0, 80:20, 60:40, and 40:60, respectively.

Syneresis refers to the release of water from a gel matrix due to gel structure contraction. Syneresis in colloidal gels involves compaction and fluid expulsion, with distinct spatial and temporal relaxation patterns between solid and liquid particles [15]. Increasing konjac proportion significantly reduced syneresis. Higher konjac levels improved gel strength and elasticity, thus reducing water separation [16]. Konjac glucomannan is highly hydrophilic due to its abundant hydroxyl groups [17], allowing it to absorb

and retain water effectively. Additionally, acetyl groups in glucomannan enhance solubility and viscosity, leading to a more stable and flexible gel structure [18], [19]. Similar results were reported by Parnanto et al. (2025) [7] in papaya jelly and by Darsana et al. (2019) [8] in coconut water jelly, both showing that hydrocolloid blends effectively reduce syneresis. Excessive syneresis negatively affects consumer perception and product stability. Thus, konjac's ability to suppress water release is beneficial for jelly drink quality.

Viscosity, a measure of a fluid's thickness, ranged from 194.50 cP (P0) to 321.50 cP (P3), with a significant increase observed as the konjac proportion increased (Table 1). Carrageenan forms gels via double-helix network structures, enhancing gel strength [20]. However, carrageenan gels are generally brittle and less elastic [21]. In contrast, konjac glucomannan has a higher water-binding capacity and viscosity due to its high molecular weight and strong intermolecular interactions [22], making it an effective thickening and stabilizing agent [23]. Comparable findings were also reported by Amelia et al. (2023) [24] in okra–pineapple jelly and Karmila et al. (2023) [25] in ginger-based gels. The 60:40 carrageenan-to-konjac ratio (P2) yielded a viscosity of 275.50 cP, considered optimal, as it provided smoothness without excessive thickness, enhancing drinkability.

3.2. Moisture Content and pH

As shown in Table 2, moisture content in the jelly drinks ranged from 90.99% (P0) to 90.05% (P3). Although the values decreased slightly as konjac increased, all treatments remained above the minimum standard set by SNI-01-3552-1994 (>85%) [26]. This result is consistent with papaya jelly [7] and coconut water jelly [8], which also maintained >90% moisture. ANOVA showed a significant effect of gelling agent ratio on moisture content ($p < 0.05$). DMRT results showed that P0 and P1 were not significantly different, but both differed from P2 and P3.

The decrease in moisture content with increased konjac concentration may be due to konjac's strong water-binding capacity during gel formation. Higher konjac levels promote the formation of a compact, uniform, and continuous gel network that physically entraps water, further limiting moisture migration and syneresis [27], [28]. This is consistent with the viscosity data, where higher konjac levels correlated with increased viscosity and reduced free water. The reduction in free water raises total soluble solids, which contributes to increased viscosity and lower moisture content [29].

Table 2. Moisture content and pH of jelly drink.

Treatment	P0	P1	P2	P3
Moisture (%)	90.99 ± 0.40 ^a	90.89 ± 0.25 ^a	90.41 ± 0.11 ^b	90.05 ± 0.18 ^c
pH	5.60 ± 0.005 ^a	5.51 ± 0.023 ^b	5.37 ± 0.033 ^c	5.22 ± 0.021 ^d

Note: Different lowercase letters indicate significant differences ($p < 0.05$). Treatments P0–P3 represent carrageenan:konjac ratios of 100:0, 80:20, 60:40, and 40:60, respectively.

The pH values ranged from 5.60 (P0) to 5.22 (P3). Higher konjac content led to lower pH, attributed to interactions between glucomannan and mango's organic acids, such as tartaric, oxalic, malic, ascorbic, and citric acids, which increase the availability of free protons (H⁺), resulting in a lower pH in the gel matrix [30]. ANOVA and DMRT confirmed significant differences among all treatments ($p < 0.05$). The control (P0) had the highest pH, while P3 had the lowest. Carrageenan tends to raise pH due to its alkaline nature (pH 9.5–10.5), whereas konjac glucomannan has a neutral to slightly acidic range (pH 4.0–7.0) [30], [31]. Conversely, carrageenan exhibited a weak alkaline effect, raising the pH when used at higher ratios [32]. Similar pH trends were reported in okra–pineapple jelly [24] and ginger jelly [25]. Maintaining a pH of 5.2–5.6 is advantageous because it ensures microbial stability while preserving the fresh, slightly acidic taste characteristic of mango beverages.

3.3. Hedonic Properties

Sensory evaluation was conducted with 25 semi-trained panelists who assessed color, taste, texture, aroma, and overall acceptance (Table 3). Among these attributes, only texture and overall acceptance

showed significant differences ($p < 0.05$), while color, taste, and aroma did not vary significantly across treatments.

Table 3. Hedonic test results.

Attribute	P0	P1	P2	P3
Color	3.08 ± 0.95 ^a	3.40 ± 0.76 ^a	3.48 ± 1.00 ^a	3.32 ± 0.85 ^a
Taste	3.48 ± 1.00 ^a	3.56 ± 0.86 ^a	3.80 ± 0.73 ^a	3.20 ± 0.90 ^a
Texture	2.28 ± 0.84 ^a	3.44 ± 0.86 ^b	4.32 ± 0.73 ^c	3.11 ± 0.90 ^a
Aroma	3.12 ± 0.92 ^a	3.32 ± 0.94 ^a	3.76 ± 0.83 ^a	3.44 ± 0.86 ^a
Overall	3.44 ± 0.86 ^a	3.40 ± 0.91 ^a	3.84 ± 0.85 ^a	3.08 ± 0.71 ^b

Note: Different lowercase letters indicate significant differences ($p < 0.05$). Treatments P0–P3 represent carrageenan:konjac ratios of 100:0, 80:20, 60:40, and 40:60, respectively.

Panelist scores for color ranged from 3.08 (P0) to 3.48 (P2), with no significant differences ($p > 0.05$). This indicates that the carrageenan–konjac ratio did not affect the visual appearance of the jelly drinks. Both hydrocolloids are colorless and do not interact with fruit pigments [33]. The golden-orange hue of the drinks was primarily due to the mango pulp, which masked minor variations. These results are consistent with those of Amelia et al. (2023) [24] who reported that the addition of hydrocolloid did not significantly influence color in pineapple–okra jelly beverages.

Taste scores ranged from 3.20 (P3) to 3.80 (P2), with no statistically significant differences. This suggests that the gelling agents had little impact on flavor perception. Since carrageenan and konjac are tasteless, panelists likely based their evaluations on the inherent sweetness and acidity of mango juice. Previous studies on ginger jelly [25] and papaya jelly [7] also confirmed that hydrocolloids do not substantially alter fruit-derived taste profiles.

Texture showed the most pronounced variation among attributes, ranging from 2.28 in P0 to 4.32 in P2. The lowest score in P0 (100% carrageenan) reflected a brittle and rigid gel that lacked elasticity, consistent with prior research demonstrating that excessive carrageenan leads to fragile structures [21]. The addition of konjac markedly improved texture by enhancing elasticity and reduced brittleness [34], as observed in P1 (3.44) and especially in P2 (4.32). However, at the highest konjac proportion (P3), texture scores declined (3.11) because the gel became denser and less palatable as a drink. This aligns with findings by Amelia et al. (2023) [24] who noted that overly firm textures in jelly beverages reduce consumer acceptance.

Aroma scores ranged between 3.12 (P0) and 3.76 (P2), with no significant differences. Hydrocolloids are neutral and odorless [35], allowing mango's natural aroma compounds, such as terpenes and esters, to dominate sensory perception. Similar results were reported in pineapple–okra jelly [24], where aroma was unaffected by hydrocolloid ratios. Color and aroma were not significantly affected, as carrageenan and konjac are neutral, odorless hydrocolloids [8], [24]. The high juice content in mango products ensures a rich concentration and effective release of volatile aroma compounds, making the mango aroma the dominant sensory attribute [36].

Overall acceptance score ranged from 3.08 (P3) to 3.84 (P2). The highest score was obtained by P2, indicating that a 60:40 carrageenan-to-konjac ratio provided the most balanced combination of desirable textural qualities and consumer preference. In contrast, P3 received the lowest overall score, demonstrating that excessive konjac negatively affected drinkability despite improvements in gel stability. These findings confirm the importance of optimizing hydrocolloid ratios to achieve consumer-preferred sensory profiles, as highlighted in earlier studies on jelly-based beverages [7], [24]. The results indicate that texture is the primary determinant of consumer preference in jelly drinks. While color, taste, and aroma remained relatively constant, the balance between carrageenan's rigidity and konjac's elasticity dictated overall acceptance. The identification of P2 (60:40) as the optimal formulation is particularly relevant for industry, as it provides a guideline for producing mango jelly drinks with both functional stability and high consumer appeal.

4. CONCLUSION

The combination of carrageenan and konjac as gelling agents significantly influenced the physicochemical and sensory properties of *Arumanis* mango jelly drinks. Increasing the proportion of konjac decreased moisture content, syneresis, and pH, while enhancing viscosity and gel elasticity. Sensory evaluation revealed that the texture was the most affected attribute, with the 60:40 carrageenan-to-konjac ratio producing the most favorable balance of chewiness and ease of sipping, leading to the highest overall acceptance. Compared with the Indonesian National Standard (SNI 01-3552-1994), all treatments met the required moisture content characteristics for jelly products. The findings highlight the synergistic role of carrageenan and konjac in improving product stability and consumer preference. The result suggests that a 60:40 carrageenan-to-konjac formulation is optimal for mango-based jelly drinks and can be recommended for industrial-scale production. This study provides new insights into the application of hydrocolloid combinations in functional beverages, offering potential to diversify mango-based products and reduce postharvest losses of tropical fruits.

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 execution of the research, including sample preparation, data collection, initial analysis, and further manuscript development. **Hafidhi Izzati**: Responsible for sample production, physicochemical and hedonic testing, data documentation, and drafting the manuscript. **Bhakti Etza Setiani**: Supervised the laboratory work, validated the methodology, critically reviewed the manuscript content, and provided conceptual direction and experimental design. **Hega Bintang Pratama Putra**: Contributed to statistical analysis, internal review, and manuscript editing. **Maela Rizky Kusumastuti**: Led the manuscript writing and revision process, served as the corresponding author, and managed communication with the journal and final manuscript preparation.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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