

The Effect of Seaweed Carrageenan (*Kappaphycus Alvarezii*) Concentration on Vitamin C Content, Moisture Content, pH and Sensory Characteristics of Tomato Sauce

Naila Dwi Rahmasari¹, Andriyana Monica Sahidu², Ahmad Shofy Mubarak^{2*}, Lailatul Lufiyah², Eka Saputra², Sri Subekti²

¹Fisheries and marine biotechnology master Program, Faculty of Fisheries and Marine, Universitas Airlangga, Indonesia.

²Departement of Marine, Faculty of Fisheries and Marine, Universitas Airlangga, Indonesia.

*Correspondence Author: mubarak.as@fpk.unair.ac.id

Submitted: 01 March 2026

Revised: 15 April 2026

Accepted: 23 April 2026

ABSTRACT

Keywords:
carrageenan; pH;
tomato sauce;
vitamin C; viscosity

Tomato sauce generally requires a thickening agent to improve its viscosity. Synthetic thickeners such as carboxymethyl cellulose (CMC) may increase pH, making them less suitable for meeting the quality requirements of tomato sauce, which is naturally acidic. This study aimed to evaluate seaweed carrageenan (*Kappaphycus alvarezii*) as a natural thickener and to determine the effect of different concentration levels on vitamin C content, moisture content, viscosity, pH, and sensory characteristics of tomato sauce. This study used a completely randomized design with five treatments and four replications, a positive control with 0.25% CMC, and carrageenan treatments at concentrations of 0.25%, 0.30%, and 0.35%, each with four replications. Chemical and physical parameters were analyzed using one-way ANOVA followed by Duncan's multiple range test, while sensory evaluation data were analyzed using the Kruskal-Wallis test followed by the Mann-Whitney test at a 95% confidence level. The results showed that increasing carrageenan concentration significantly increased vitamin C content and viscosity, while significantly reducing moisture content and pH ($p < 0.05$). The 0.35% carrageenan treatment produced the highest vitamin C content (4.00 mg/100 g), the lowest moisture content (70.63%), the highest viscosity (15.58 cPs), and a pH of 3.25. Sensory evaluation indicated that carrageenan significantly affected texture but had no significant effect on appearance, aroma, or taste. Carrageenan at a concentration of 0.35% was considered the optimal level for producing tomato sauce with the best physicochemical quality and texture while maintaining an appropriate pH range for tomato sauce.

INTRODUCTION

Sauce is a complementary food product in the form of a paste, made from fruits or vegetables that are processed with the addition of seasonings to enhance the appearance, aroma, and taste of food. Sauces commonly produced in Indonesia include tomato sauce, chili sauce, and sambal sauce. According to the Indonesian National Standard (SNI) No. 01-3546-2004, tomato sauce is a product derived from a mixture of tomato puree or tomato paste obtained from ripe tomatoes and processed with spices and permitted food additives. Tomatoes are a fruit vegetable with strong potential for agribusiness development due to their high nutritional and economic value. Tomatoes contain essential nutrients such as proteins, carbohydrates, fats, minerals, and vitamins A, B1, and C (Ali et al., 2021). Globally, tomatoes are recorded as the vegetable with the highest production volume, reaching approximately 192 million tons in 2023, indicating that this commodity plays a significant role in the global food

system and horticultural trade. In addition to its importance in terms of production, tomatoes also have strong economic significance in international trade. A study by Govindasamy et al. confirms that tomatoes are a commodity that is strongly influenced by price dynamics, agricultural policies, and export markets; in the case of Mexico, tomato exports even generated revenues of nearly USD 3 billion in 2023, indicating that tomatoes are not only valuable as a cultivated commodity, but also as a source of foreign exchange and a driver of the agribusiness supply chain (Govandasamy *et al.*, 2025).

The main components in tomato sauce production include tomatoes, salt, sugar, garlic, flavor enhancers, spices, and thickening agents. Tomatoes as the primary raw material contain a high moisture content of approximately 94%, resulting in a very thin sauce texture (Herlina, 2016). Therefore, the addition of a thickening agent is necessary to improve the viscosity of tomato sauce. One of the most commonly used synthetic thickeners is carboxymethyl cellulose (CMC).

However, synthetic thickeners such as CMC may influence the pH value of food products. CMC is a hydrocolloid containing carboxyl groups that can undergo hydrolysis, potentially contributing to changes in pH (Rikardo & Rosidah, 2025). Increasing the concentration of CMC tends to be associated with a rise in product pH. Ismayanti (2024) also reported that CMC may increase pH due to its nature as a salt derived from a strong base and a weak acid, which can result in a more alkaline solution. This condition is not in accordance with SNI 01-3546-2004, which specifies that tomato sauce should have an acidic pH range of 3–4. In addition, several studies have indicated that excessive or prolonged use of CMC may be associated with certain health concerns, particularly related to gastrointestinal effects, although the evidence is still limited and requires further investigation (Martino et al., 2017). Therefore, the development of alternative natural thickening agents is considered important.

Carboxymethyl cellulose (CMC/E466) is a food additive that is still considered safe by regulation at reported levels of use for the general population. However, several recent studies have shown that long-term exposure may pose a biological concern, particularly in the gastrointestinal tract. Preclinical studies have shown that CMC can alter the composition of the gut microbiota, reducing microbial diversity, disrupting the normal interaction between intestinal mucus and bacteria, and promoting low-grade inflammation, which in animal models can exacerbate colitis and create an environment conducive to colon carcinogenesis. In healthy humans, controlled feeding trials have also shown that CMC consumption can disrupt the composition of the gut microbiota and fecal metabolism and increase postprandial abdominal complaints, thus supporting the hypothesis that this compound has the potential to disrupt gut homeostasis (Chassaing *et al.*, 2022). However, evidence regarding cancer development in humans remains inconclusive because most data still come from animal studies, while claims of kidney damage from consuming CMC as a food additive are also not supported by strong human clinical evidence. Available findings are mostly from animal toxicology studies and are insufficient to conclude a direct causal relationship in humans. Therefore, it can be scientifically stated that long-term use of CMC, especially when excessive, has the potential to be associated with intestinal health disorders and preclinically can support inflammatory processes and carcinogenesis, but the risks to the kidneys and cancer in humans still require further evidence (Chassaing *et al.*, 2015).

Carrageenan can serve as a thickening agent under low pH conditions because it is not easily hydrolyzed, making it suitable for acidic food products such as tomato sauce. Carrageenan is a hydrocolloid compound extracted from red seaweed and is widely used as a stabilizer, emulsifier, and thickener. Its stabilizing ability is attributed to the presence of negatively charged sulfate groups along its polymer chain, which are hydrophilic and capable of binding water or other hydroxyl groups (Supriyantini et al., 2017). Carrageenan appears slightly brownish-white, and when dissolved in hot water, it forms a transparent gel. Thus, it does not alter the color of tomato sauce and may even enhance brightness during heating as the carrageenan structure breaks down.

Previous research by Nugiharti (2021) demonstrated that carrageenan addition in grapefruit jelly drink production could maintain and increase vitamin C content. The highest carrageenan concentration (1.2%) resulted in 69.27% vitamin C retention, whereas the lowest concentration (0.8%) yielded 50.49%. These findings indicate that higher carrageenan concentrations lead to higher vitamin C levels in the product. This is supported by the fact that seaweed contains vitamin C up to 4 mg/100 g and promotes greater colloidal dispersion when kappa-carrageenan is added (Haryu et al., 2016). Such colloidal dispersion, often referred to as a double-helix structure, becomes stronger and more abundant, thereby inhibiting vitamin C oxidation. A higher double-helix structure also forms a firmer gel, which can prevent cofactors that accelerate vitamin C oxidation (Rama, 2025).

Vitamin C in tomatoes is generally susceptible to degradation during high-temperature processing, particularly during cooking, which may reduce its concentration. This degradation occurs because most vitamins are water-soluble, and heating at certain temperatures can increase evaporation of both water and dissolved vitamins (Fitriani, 2022).

Another study by Pratiwi (2021) investigated carrageenan addition in squid offal sauce production. The highest carrageenan concentration (0.35%) resulted in the lowest moisture content (34.36%), while the control treatment without carrageenan (0%) produced the highest moisture content (54.72%). These results indicate that increasing carrageenan concentration reduces moisture content due to its hydrocolloid properties, which enable it to bind water and form gels during heating. Moisture content is a key factor determining food shelf life, as it affects physical and chemical properties, microbiological changes, and enzymatic activity (Purohit et al, 2023). Tambunan (2024) also noted that tomato sauce, with its thick texture and attractive color, is a promising product for nutrient fortification to enhance its functional benefits.

Based on this background, the present study was conducted to evaluate the potential of seaweed carrageenan (*Kappaphycus alvarezii*) as an alternative thickening agent in tomato sauce production. This research focuses on the effects of different carrageenan concentrations on vitamin C content, moisture content, viscosity, pH value, and sensory characteristics of the resulting product. The objectives of this study are to determine the effect of different concentrations of seaweed carrageenan (*Kappaphycus alvarezii*) on the vitamin C content, moisture content, viscosity, pH value, and sensory characteristics of tomato sauce, as well as to identify the optimal concentration of carrageenan that produces tomato sauce with the best physicochemical and sensory quality. It is expected that this study will identify the optimal carrageenan concentration to produce tomato sauce with the best physicochemical and sensory quality, while also contributing to the development of innovative food additives based on local natural resources.

METHOD

Time and Location of the Study

This research was conducted from February to May 2024 at the Chemical Analysis Laboratory. and the Food Laboratory, Faculty of Fisheries and Marine Sciences, Universitas Airlangga, Surabaya, Indonesia.

Research Materials

The research materials consisted of the equipment and ingredients used throughout the study.

a. Research Equipment

The equipment used in this study included an analytical balance, knife, basin, blender, stove, pan, stirring tools, bottles, filter, beaker glass, pH meter, moisture analyzer, viscometer, and organoleptic evaluation forms.

b. Research Ingredients

The materials used in this study included ripe orange-colored tomatoes (*Solanum lycopersicum*), seaweed carrageenan (*Kappaphycus alvarezii*), CMC, distilled water (aquadest),

starch (amylum), 0.01 N iodine solution, salt, vinegar (acetic acid), and seasonings such as garlic, refined white sugar, pepper, and flavor enhancers.

Research Method and Experimental Design

This study employed an experimental method with a descriptive quantitative approach through tomato sauce production trials with the addition of seaweed carrageenan (*Kappaphycus alvarezii*) to observe product characteristics and texture. The experimental procedure was based on Irianto (2005) with variations in carrageenan concentration of 0%, 0.10%, 0.15%, 0.20%, and 0.25% of tomato weight, with modifications including the addition of a positive control (P0₂) using 0.25% CMC as a thickener.

The experiment was arranged in a Completely Randomized Design (CRD) consisting of five treatment levels. Each treatment was replicated four times, resulting in a total of 20 experimental units. The treatments included tomato sauce without carrageenan addition (P0₁: 0%), tomato sauce with 0.25% CMC addition (P0₂), tomato sauce with 0.25% carrageenan addition (P1), tomato sauce with 0.30% carrageenan addition (P2), and tomato sauce with 0.35% carrageenan addition (P3).

Experimental Procedures

The procedures in this study included tomato sauce production and the evaluation of vitamin C content, moisture content, pH, viscosity, and sensory characteristics.

1. Tomato Paste Preparation

Tomato paste is an intermediate processed tomato product that is further processed into tomato sauce. The tomato paste preparation procedure followed Dzhiboderova-Zarcheva et al. (2024). A total of 500 g of tomatoes were washed with clean water to remove adhering impurities and then drained. The tomatoes were boiled for 20 minutes, peeled, and the flesh was cut into small pieces. The tomato flesh was blended and filtered to obtain tomato juice. The filtered material was then cooked for 5 minutes at $70 \pm 2^\circ\text{C}$ and mixed with sugar, salt, garlic powder, pepper powder, acetic acid, and flavor enhancers until tomato paste was formed. This temperature was selected to reduce variability during processing and to minimize excessive thermal degradation of heat-sensitive compounds such as vitamin C.

2. Tomato Sauce Preparation

The resulting tomato paste was supplemented with carrageenan or CMC according to the treatment. After the thickening agent was added, the paste was cooked for an additional 5 minutes until it formed tomato sauce. The sauce was then removed from heat, cooled, and transferred into sterilized bottles. The final product was pasteurized for 30 minutes in hot water at 70°C . Subsequently, vitamin C content, moisture content, viscosity, pH, and sensory (organoleptic) characteristics were evaluated. The tomato sauce formulation with carrageenan or CMC is presented in Table 1.

Table 1. Formulasi saus tomat dengan penambahan karaginan

Ingredients	P0 ₁	P0 ₂	P1	P2	P3
	%				
Tomatoes	90.96	90.71	90.71	90.66	90.61
Salt	1.09	1.09	1.09	1.09	1.09
Sugar	7.28	7.28	7.28	7.28	7.28
Pepper powder	0.09	0.09	0.09	0.09	0.09
Garlic powder	0.22	0.22	0.22	0.22	0.22
Vinegar (acetic acid)	0.36	0.36	0.36	0.36	0.36
Carrageenan	0	0	0.25	0.30	0.35
CMC	0	0,25	0	0	0
Total	100	100	100	100	100

Tomato Sauce Analysis

The tomato sauce production process involved several analyses to ensure that the final product had good nutritional content and high-quality sensory characteristics.

1. Vitamin C Content Analysis

Vitamin C content was determined using the iodimetric titration method (AOAC, 1995). A 5 g sample was weighed, dissolved in a 100 mL Erlenmeyer flask, and diluted to volume. The solution was filtered, and 25 mL of the filtrate was pipetted. A few drops of starch indicator were added, followed by rapid titration with 0.01 N iodine solution until a blue color appeared. Vitamin C content was calculated using the following formula:

$$\text{Vit. C (mg/100gram)} = \frac{(V12 \times 0.88 \times Fp) \times 100}{W s (\text{gram})}$$

Where:

V12 = volume of iodine solution (mL)

0,88 = mg ascorbic acid equivalent to 1 mL of 0.01 N iodine

Fp = dilution factor

W s = sample weight (g)

2. Moisture Content Analysis

Moisture content was determined using a moisture analyzer following Nurhidayati (2021). The moisture analyzer was preheated for 30 minutes at 105°C. A 2.5 g tomato sauce sample was placed on an aluminum tray and inserted into the instrument until the moisture content result appeared on the display.

3. Viscosity Testing

Viscosity was measured by placing the sample into a viscometer until the spindle was fully immersed. The spindle speed was set at 50 rpm, and the viscosity value was recorded (Purohit et al, 2023).

4. pH testing

pH was measured using a pH meter. A 10 g sample was dissolved in 50 mL of distilled water, then diluted to 100 mL and homogenized. The pH meter was calibrated using pH 4 and pH 7 buffer solutions. The electrode was immersed into the sample solution, and the pH value was recorded.

Sensory (Organoleptic) Evaluation

Sensory evaluation was conducted using 35 untrained panelists, which is appropriate for hedonic testing as it represents general consumer preferences. The number of panelists was considered sufficient to support statistical analysis and improve the reliability of the sensory data. Organoleptic testing is a method that utilizes human senses as the primary tool to assess the quality of processed food products (Mulyana et al., 2018). The sensory evaluation followed SNI 01-3546-2004 standards for tomato sauce quality. Attributes evaluated included texture, color, aroma, and taste. Panelists were asked to indicate their preference levels using an organoleptic evaluation form. To ensure data reliability, all evaluations were conducted under controlled and standardized conditions. The sensory data obtained were analyzed using the Kruskal–Wallis test to determine significant differences among treatments.

Data Analysis

Data on vitamin C content, moisture content, viscosity, and pH were first tested for normality and then analyzed using one-way ANOVA at a 95% confidence level with SPSS software. If significant differences were detected, Duncan's Multiple Range Test (DMRT) was applied as a post hoc analysis. Sensory data including color, taste, aroma, and texture were analyzed using the Kruskal–Wallis test at a 95% significance level. When significant differences among treatments were observed, further analysis was performed using the Mann–Whitney test.

RESULT AND DISCUSSION

Vitamin C Content of Tomato Sauce

The vitamin C content of tomato sauce after the addition of carrageenan and CMC as thickening agents ranged from 2.06 to 4.00 mg/100 g. Based on the mean values presented in Table 2, vitamin C content increased with increasing carrageenan concentration. The highest value was obtained in treatment P3 (0.35% carrageenan) at 4.00 ± 0.082 mg/100 g, whereas the lowest vitamin C content was found in the positive control P0₂ (0.25% CMC) at 2.06 ± 0.041 mg/100 g. The one-way ANOVA results indicated that variations in carrageenan concentration had a significant effect ($p < 0.05$) on the vitamin C content of tomato sauce. Duncan's multiple range test further confirmed significant differences among treatments, as indicated by different superscript letters.

Table 2. Vitamin C Content of Tomato Sauce

Treatment	Vitamin C Content (mg/100 g) \pm SD
P0 ₁ (0% carrageenan)	2.97 ± 0.046^a
P0 ₂ (0,25% CMC)	2.06 ± 0.041^b
P1 (0,25% carrageenan)	3.45 ± 0.071^c
P2 (0,30% carrageenan)	3.87 ± 0.047^d
P3 (0,35% carrageenan)	4.00 ± 0.082^e

The addition of carrageenan significantly influenced vitamin C content, moisture content, viscosity, pH, and sensory characteristics, particularly texture. However, it did not significantly affect appearance, aroma, or taste. Carrageenan has hydrocolloid properties that enable it to bind water molecules and other compounds such as vitamin C (Mulyani, 2020), resulting in reduced moisture content and increased viscosity. These changes contribute to the texture and consistency of tomato sauce. The properties of carrageenan are strongly influenced by concentration, temperature, pH, ionic strength, and the presence of other components in the food matrix. The viscosity of carrageenan solutions generally increases with increasing concentration but can decrease at higher temperatures. In acidic food systems, the properties of carrageenan also require special attention because this polysaccharide is susceptible to depolymerization through acid-catalyzed hydrolysis, especially at low pH and high temperatures, which can ultimately lead to a decrease in viscosity and loss of gel-forming ability (Mendes et al, 2024).

Carrageenan is a natural hydrocolloid extracted from red seaweed (Rhodophyceae) and is chemically classified as a sulfated linear polysaccharide composed primarily of repeating units of galactose and 3,6-anhydrogalactose. Based on the number and position of its sulfate groups, carrageenan is divided into three main types: κ -carrageenan, ι -carrageenan, and λ -carrageenan. These structural differences determine its functional properties in food systems. κ -carrageenan generally forms strong but relatively stiff or brittle gels, especially in the presence of potassium ions; ι -carrageenan forms softer and more elastic gels, especially with calcium ions; while λ -carrageenan generally does not form gels, but functions very well as a thickener because it produces thicker solutions. In the food industry, carrageenan is known for its ability to thicken, form gels, stabilize dispersions, improve texture, and increase water retention, making it widely used in sauces, dairy products, desserts, and various other processed foods (Jabeen et al. 2025) therefore its addition tends to increase vitamin C content while lowering pH. Furthermore, carrageenan has no strong taste or aroma, explaining its minimal influence on those sensory attributes, although its hydrocolloid behavior significantly improves texture. The use of carrageenan as a thickener was proven to increase vitamin C content. The highest concentration (0.35%, P3) produced the greatest vitamin C value (4.00 mg/100 g). This finding is consistent with Mulyani (2020), who reported that carrageenan can bind vitamin C and organic acids, protecting them from degradation during heating. Similar results were reported by Mulyani et al (2025), where carrageenan increased vitamin C content through colloidal dispersion (double-helix structure) that inhibits oxidation. Conversely, CMC

resulted in the lowest vitamin C content due to its weaker protective mechanism against oxidation and reduced stability under heating (Halik, 2022).

Moisture Content of Tomato Sauce

The moisture content of tomato sauce after the addition of carrageenan and CMC ranged from 70.63 to 81.22%. Based on the mean values in Table 3, the highest moisture content was observed in treatment P0₁ (0% carrageenan) at 81.22 ± 0.526%, while the lowest moisture content was found in P3 (0.35% carrageenan) at 70.63 ± 0.750%. One-way ANOVA results showed that carrageenan concentration significantly affected moisture content ($p < 0.05$). Duncan's test confirmed significant differences among treatments, as indicated by different superscript letters.

Table 3. Moisture Content of Tomato Sauce

Treatment	Moisture Content (%) ± SD
P0 ₁ (0% carrageenan)	81.22±0,526 ^a
P0 ₂ (0,25% CMC)	78.34±0,075 ^b
P1 (0,25% carrageenan)	73.46±0,049 ^c
P2 (0,30% carrageenan)	72.21±0,253 ^d
P3 (0,35% carrageenan)	70.63±0,750 ^e

Carrageenan addition reduced the moisture content of tomato sauce, with the lowest value obtained at 0.35% carrageenan (P3). Moisture content is a crucial parameter influencing food deterioration and sauce consistency (Daud, 2019). High moisture levels result in thinner sauces (Hilmy, 2019) and may accelerate quality degradation due to microbial growth (Faizah, 2020). Carrageenan contains sulfate groups that enhance its ability to bind water. These negatively charged sulfate groups are hydrophilic and capable of interacting with water molecules or hydroxyl groups (Nugraha et al., 2022). Lower moisture content is generally associated with higher viscosity (Ikhsani, 2015).

Viscosity of Tomato Sauce

The viscosity of tomato sauce ranged from 12.73 to 15.58 cPs. Table 4 shows that the lowest viscosity occurred in treatment P0₁ (0% carrageenan) at 12.73 ± 0.150 cPs, while the highest viscosity was obtained in treatment P3 (0.35% carrageenan) at 15.58 ± 0.427 cPs. Statistical analysis revealed that carrageenan concentration significantly affected viscosity ($p < 0.05$), and Duncan's test indicated significant differences among treatments.

Table 4. Viscosity of Tomato Sauce

Treatment	Viscosity (cPs) ± SD
P0 ₁ (0% carrageenan)	12.73 ± 0.150 ^a
P0 ₂ (0,25% CMC)	13.79 ± 0.079 ^b
P1 (0,25% carrageenan)	14.70 ± 0.135 ^c
P2 (0,30% carrageenan)	14.92 ± 0.085 ^c
P3 (0,35% carrageenan)	15.58 ± 0.427 ^d

Viscosity represents the thickness level of a product. The higher the concentration of carrageenan added to a product, the higher the viscosity value of the resulting product (Jabeen et al, 2025). The highest viscosity of tomato sauce was found in the treatment with 0.35% carrageenan addition (P3), reaching 15.58 cPs. The average viscosity values of tomato sauce with carrageenan addition in this study were consistent with the viscosity range of tomato sauce reported by Dzhivoderova-Zarcheva et al. (2024), which was 11.76–16.34 cPs. Carrageenan is able to increase viscosity due to the adhesion forces with water and the formation of a gel structure during heating, which causes the product to become thicker.

pH of Tomato Sauce

The pH values of tomato sauce after the addition of carrageenan and CMC as thickening agents ranged from 3.25 to 5.17. Based on the mean results presented in Table 9, the highest pH value was obtained in treatment P0₂ (0.25% CMC), which was 5.17 ± 0.081, while the lowest pH value was found in treatment P3 (0.35% carrageenan), which was 3.25 ± 0.100. The one-way ANOVA statistical test showed that variations in seaweed carrageenan concentration had a significant effect (p-value < 0.05) on the pH of tomato sauce. Duncan’s post hoc test confirmed significant differences among all treatments, as indicated by different superscript letter notations.

Table 5. pH Test Results of Tomato Sauce

Treatment	Mean pH ± SD
P0 ₁ (0% carrageenan)	4.57±0.117 ^a
P0 ₂ (0,25% CMC)	5.17±0.081 ^b
P1 (0,25% carrageenan)	3.63±0.066 ^c
P2 (0,30% carrageenan)	3.50±0.055 ^d
P3 (0,35% carrageenan)	3.25±0.100 ^e

The addition of carrageenan as a thickening agent in tomato sauce affected the pH value of the product. pH is an indicator that represents the level of acidity or alkalinity of a solution (Karangan et al., 2019). Tomato sauce with 0.35% carrageenan addition had a pH of 3.25, while the quality requirement for tomato sauce according to SNI (01-3546-2004) is a pH range of 3–4. Increasing carrageenan concentration in tomato sauce resulted in a decrease in pH because carrageenan is not easily hydrolyzed under low pH conditions and carrageenan is acidic in nature. Therefore, when it is added to a product, it produces a more acidic pH (Saloko et al, 2024). Food products with low pH generally have a longer shelf life because acidic pH is not favorable for microbial growth (Purohit et al, 2023). In contrast, the addition of CMC thickener increased the pH value because CMC is derived from a strong base containing carboxyl groups (Ismayanti, 2024). Rikardo & Rosidah (2025) stated that the higher the concentration of CMC, the more alkaline the resulting solution becomes.

Sensory Characteristics of Tomato Sauce

Organoleptic (sensory) evaluation of tomato sauce was conducted using a scoring method on the physical characteristics of the product, including appearance, aroma, taste, and texture. The mean results are presented in Table 10. Based on the Kruskal–Wallis analysis, seaweed carrageenan concentration had a significant effect (p-value < 0.05) on the texture attribute, but it did not show a significant effect (p-value > 0.05) on appearance, aroma, or taste. The Mann–Whitney post hoc test showed that the highest mean texture score was obtained in treatment P3 with 0.35% carrageenan addition, with a value of 4.286, while the lowest texture score was found in treatment P0₁ without thickener addition, with a value of 1.971. These results indicate that increasing carrageenan concentration mainly plays a role in improving the texture of tomato sauce without significantly altering other sensory attributes.

Table 6. Sensory (Organoleptic) Test Results of Tomato Sauce

Treatment	Average ± SD			
	Appearance	Aroma	Taste	Texture
P0 ₁	4.229±0.731 ^a	4.400±0.604 ^a	3.229±0.490 ^a	1.971±0.453 ^a
P0 ₂	4.143±0.845 ^a	4.371±0.598 ^a	3.314±0.471 ^a	3.314±0.471 ^b
P1	4.029±0.857 ^a	4.429±0.608 ^a	3.286±0.458 ^a	3.657±0.482 ^c
P2	4.057±0.802 ^a	4.343±0.591 ^a	3.429±0.502 ^a	3.914±0.284 ^d
P3	4.200±0.797 ^a	4.486±0.562 ^a	3.314±0.471 ^a	4.286±0.458 ^e

Tomato sauce with carrageenan thickener addition at concentrations of 0.25%–0.35% produced similar organoleptic properties in terms of appearance, aroma, and taste. The

appearance scores ranged from 4.40 to 4.686. Aroma scores ranged from 4.429 to 4.486. Taste scores ranged from 3.286 to 3.314, while texture scores ranged from 3.657 to 4.286. Theoretically, carrageenan does not affect the taste of the product because it does not have a strong flavor that could influence tomato sauce (Afidah et al., 2025). According to Geovani (2023), carrageenan does not significantly affect the appearance of the product because carrageenan does not contain color pigments. Carrageenan also does not have a significant effect on aroma because it has no odor, therefore it cannot influence the aroma of the resulting product. The addition of carrageenan can improve product consistency and viscosity due to its ability to bind water content and the attractive forces between water particles and carrageenan molecules (Saloko et al, 2024).

CONCLUSION

Based on the results of the research that had been conducted regarding the effect of seaweed carrageenan (*Kappaphycus alvarezii*) concentration on the quality of tomato sauce, it could be concluded that the addition of carrageenan as a thickening agent met the required quality standards and was suitable for consumption. The best treatment produced a vitamin C content of 4.00 mg/100 g, a moisture content of 70.63%, a viscosity of 15.58 cPs, and a pH value of 3.25. The optimal carrageenan concentration for increasing vitamin C content, reducing moisture content, improving viscosity, and producing the best texture characteristics was obtained at the highest concentration, namely 0.35%. Further research was recommended to explore variations of other additives in order to enhance the quality of tomato sauce, particularly in terms of appearance, taste, and aroma. Carrageenan from *Kappaphycus alvarezii* has been shown to have potential for application as a natural thickener and stabilizer in tomato sauce to help achieve more uniform viscosity, flowability, and sensory perception. The application of carrageenan in tomato sauce also needs to be accompanied by strict process control, especially regarding pH, temperature and heating time.

REFERENCES

- Afidah, U., Aziz, F. N., dan Hasniah, N. 2025. Effects of Carrageenan and Isolated Soy Protein Addition on the Physicochemical and Sensory Properties of Chicken Sausages. *Journal of Applied Food Technology*, 12(1), 52–56.
- Ali, M. Y., Sina, A. A. I., Khandker, S. S., Neesa, L., Tanvir, E. M., Kabir, A., Khalil, M. I., dan Gan, S. H. 2021. Nutritional Composition and Bioactive Compounds in Tomatoes and Their Impact on Human Health and Disease: A Review. *Foods*, 10(1), 45.
- Association of Official Analytical Chemists. (1995). *Official methods of analysis* (16th ed.). AOAC International.
- Badan Standardisasi Nasional. (2004). *SNI 01-3546-2004: Saus tomat*. Badan Standardisasi Nasional
- Daud, A. 2019. *Kajian Penerapan Faktor yang Mempengaruhi Akurasi Penentuan Kadar Air Metode Thermogravimetri*. *Lutjanus*, 24(2): 11–16.
- Dzhivoderova-Zarcheva, M., Nikovska, K., dan Dimitrova, E. 2024. Effect of Modified Starch/ Non-Starch Thickener Combination on Consistency, Stability and Rheological Properties of Tomato Ketchup. *Carpathian Journal of Food Science and Technology*, 16(3), 68–78.
- Faizah, N. I., dan Haryanti, S. 2020. *Pengaruh lama dan tempat penyimpanan yang berbeda terhadap kandungan gizi umbi jalar (Ipomoea batatas) var. Manohara*. *Jurnal Akademika Biologi*, 9(2), 8–14.
- Fitriani, A., Tamrin, T., Rahmawati, W., & Kuncoro, S. (2022). Pengaruh Suhu Penyimpanan dan Varietas terhadap Mutu Buah Tomat. *Jurnal Agricultural Biosystem Engineering*, 1(4), 549-557.

- Giovani, S., Jameelah, M., & Putri, A. D. (2023). Pengaruh formulasi hidrokoloid iota karaginan terhadap karakteristik kimia dan sensori selai lembaran kacang hijau (*Phaseolus Radiatus* L.). *Jurnal Al-Azhar Indonesia Seri Sains Dan Teknologi*, 8(2), 86-93.
- Halik, A., Sipahelut, S. G., dan Palijama, S. 2022. *Karakteristik Fisikokimia dan Sensori Velve Pisang Tongka Langit (Musa troglodytarum L.) dengan Penambahan CMC*. *Jurnal Sains dan Teknologi Pangan*, 7(6), 5628-5640.
- Haryu, A. S. P., Parnanto, N. H. R., & Nursiwi, A. (2016). Pengaruh penambahan karagenan terhadap karakteristik fisik, kimia dan sensoris *fruit and vegetable leather* berbasis albedo semangka (*Citrullus vulgaris* Schard.) dan labu siam (*Sechium edule*). *Jurnal Teknosains Pangan*, 5(3).
- Herlina, H., Lindriati, T., & Prahasbynar, P. (2016). Penggunaan ekstrak kasar polisakarida larut air dari biji buah durian (*Durio zibethinus* Murr.) pada pembuatan saos tomat. *agriTECH*, 36(3), 286-293.
- Hilmy, H. A., Hintono, A., dan Nurwantoro, N. 2019. *Pengaruh Substitusi Tomat dengan Pepaya terhadap Sifat Kimia dan Kesukaan Saus*. *Jurnal Teknologi Pangan*, 3(1), 86-90.
- Ismayanti, A. P., Wadli, W., & Unzilairrizqi, Y. E. R. (2024). Pengaruh Konsentrasi Carboxy Methyl Cellulose (CMC) Terhadap Kadar Potential of Hydrogen (pH) dan Penilaian Organoleptik Sirup Jahe Merah. *J-CEKI: Jurnal Cendekia Ilmiah*, 3(5), 4106-4116.
- Jabeen, F., Zil-e-Aimen, Ahmad, R., Mir, S., Awwad, N. S., dan Ibrahim, H. A. 2025. Carrageenan: Structure, Properties and Applications with Special Emphasis on Food Science. *RSC Advances*, 15, 22035-22062.
- Jufriadi, Karangan. 2019. *Uji Keasaman Air Dengan Alat Sensor pH di Stt Migas Balikpapan*. *Jurnal Keilmuan Teknik Sipil*, 2(1).
- Martino, J. V., Limbergen, J. V., and Chalisi, L. E. 2017. *The Role of Carrageenan and Carboxymethylcellulose in the Development of Intestinal Inflammation*. *Frontiers in Pediatrics*, 5(96): 1-7.
- Mendes, M., Cotas, J., Gutiérrez, I. B., Gonçalves, A. M. M., Critchley, A. T., Hinaloc, L. A. R., Roleda, M. Y., dan Pereira, L. 2024. Advanced Extraction Techniques and Physicochemical Properties of Carrageenan from a Novel *Kappaphycus alvarezii* Cultivar. *Marine Drugs*, 22(11), 491.
- Mulyana, M., dan Yanti, D. I. W. 2018. *Analisa Mikrobiologi dan Organoleptik Produk Tenggiri Beku (Scomberomorus commersonii)*. *Media Teknologi Hasil Perikanan*, 6(2), 54-64.
- Mulyani, R. I., Utami, R. P., Reski, S., Utami, K. D., dan Sari, R. A. 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 Research*, 9(3), 256-267.
- Mulyani, S., Yuliani, S., & Pranoto, Y. (2020). Effect of carrageenan concentration on physicochemical properties and antioxidant activity of functional beverages. *Food Research*, 4(6), 2150-2156.
- Nugiharti, I., Haryadi, H. 2021. *Pengaruh Konsentrasi dan Jenis Gelling Agent Terhadap Sifat Fisikokimia Jelly Drink Jeruk Bali*. *Jurnal Keteknik Pertanian Tropis dan Biosistem*, 9(3): 272-280.
- Nugraha, W. 2022. *Pengaruh Penambahan Karagenan Terhadap Sifat Fisikokimia dan Sensori Yoghurt Rasa Pisang Ambon*. *Jurnal Agroindustri Berkelanjutan*, 1(2): 253-261.
- Nurhidayati, D. 2021. Moisture Analyzer Sartorius Type Ma 45 Sebagai Alat Uji Kadar Air Gelatin Dari Tulang Kelinci. *Berkala Penelitian Teknologi Kulit, Sepatu, dan Produk Kulit*, 20(2): 161-169.
- Pratiwi, C. L., Lestari, S., dan Widiastuti, I. 2021. *Karakteristik Saus Jeroan Cumi-Cumi dengan*

- Penambahan Karaginan sebagai Stabilizer*. Jurnal Fishtech, 10(2), 120–132.
- Purohit, A., Jain, M., Sarkhel, S. S., Roy, A., dan Mohan, A. 2023. Determination of Quality Kinetics, Microbiology, and Sensory Properties of Shelf-Stable Chicken-Wing Sauce. *Frontiers in Food Science and Technology*, 3, 1204804.
- Rama, B., & Hersoelistryorini, W. (2025). Karakteristik Fisikokimia Dan Sensoris Jelly Drink Selaput Biji Carica (*Carica Pubescens*) Berdasarkan Konsentrasi Karagenan. *Jurnal Pangan dan Gizi*, 15(1), 51-63..
- Rikardo, R., dan Rosidah, U. 2025. The Impact of Carboxymethyl Cellulose Concentration on the Properties of Super Red Dragon (*Hylocereus costaricensis*) Fruit Jam. *Jurnal Ilmu Pertanian Indonesia*, 30(4), 793–800.
- Saloko, S., Cicillia, S., Mulyaningtias, I. D., Irawan, E., Zainuri, Nurbaiti, L., Johansyah, M., Utama, Q. D., dan Unsunnidhal, L. 2024. The Effect of Addition Carrageenan and Citric Acid on the Shelf Life of Moringa Leaf (*Moringa oleifera*) Jelly Drink. *International Journal on Advanced Science, Engineering and Information Technology*, 14(3), 1135–1143.
- Supriyantini, E., Santosa, G. W., & Dermawan, A. (2017). Kualitas ekstrak karaginan dari rumput laut “*Kappaphycus alvarezii*” hasil budidaya di Perairan Pantai Kartini dan Pulau Kemojan Karimunjawa Kabupaten Jepara. *Buletin Oseanografi Marina*, 6(2), 88-93.
- Tambunan, L. O., Hintono, A., & Bintoro, V. P. (2024). Karakteristik fisik saus tomat analog berbahan dasar pepaya (*Carica papaya* L.) dengan penambahan asam sitrat. *Jurnal Teknologi Pangan*, 7(2), 40-47.
- Thalib, M. (2019). Pengaruh penambahan bahan tambahan pangan dalam pengolahan sayur-sayuran menjadi produk saus tomat. *Jurnal Penelitian dan Pengembangan Agrokompleks*, 78–85.
- Wandestri, W., Hamzah, F., & Harun, N. (2016). *Penambahan beberapa konsentrasi xanthan gum terhadap mutu saos tomat (Solanum lycopersicum Lin.)* (Doctoral dissertation, Riau University).