HAYYAN JOURNAL
Vol. 2 No. 2, June 2025, page. 61-65
ISSN: 3046-6679

HAYYAN JOURNAL

Extraction of Carrageenan from Seaweed *Eucheuma cottonii* Using Sonication Method

Muhammad Arham Yunus[1*], A. Miftah Alya Patrisya[1], Athiyah Nur Artanti[1], Indriantika Pagayang[1], Nur Ainun Aswa[1], Fiqry Maulana Aras[1]

[1]Department of Chemical Engineering, Politeknik Negeri Ujung Pandang, Makassar

*Corresponding Address: arhamyunus21@poliupg.ac.id

Received: April 27, 2025 *Accepted: May 17, 2025* *Online Published: June 05, 2025*

ABSTRACT

This study aimed to extract carrageenan from the red seaweed *Eucheuma cottonii* using potassium hydroxide (KOH) as solvent with the sonication method. Extraction was performed at 80°C for 60 minutes with a seaweed-to-solvent ratio of 1:30 (w/v) at an ultrasonic frequency of 40 kHz. The optimized extraction conditions yielded a carrageenan yield of 21.08%. Quality parameters evaluated included moisture content, ash content, viscosity, and gel strength. Moisture content (0.07%), ash content (0.37%), and viscosity (34.2 cP) all met FCC and FAO standards. However, the gel strength of 14.361 g/cm² did not meet the commercial standard.

Keywords: Carrageenan, *Eucheuma cottonii*, KOH, sonication, quality parameters

I. INTRODUCTION

Seaweed is one of the most strategically and economically valuable aquatic commodities. As an archipelagic nation with the second-longest coastline in the world, Indonesia holds enormous potential for developing the seaweed industry. Indonesia's seaweed production has been steadily increasing, positioning the country as one of the world's leading producers (Yusuf et al., 2024). One of the most valuable seaweed-derived products is carrageenan, a sulfated polysaccharide extracted from red algae (Rhodophyceae). The primary carrageenan-producing species is *Eucheuma cottonii* (synonym *Kappaphycopsis cottonii*), which yields kappa-carrageenan (Ferdiansyah et al., 2023).

Carrageenan is widely used as a thickener, gelling agent, stabilizer, and emulsifier in the food industry (milk, jelly, candy, syrup, pudding) as well as in non-food industries (cosmetics, textiles, pharmaceuticals, and animal feed). Saputra et al. (2021) stated that the quality of carrageenan is significantly influenced by the type of solvent, temperature, and extraction method used. The use of KOH as an alkaline solvent has been proven effective in improving carrageenan gel strength by accelerating the conversion of 6-sulfate groups into 3,6-anhydrogalactose (Ega et al., 2016).

Conventional extraction techniques require long processing times, large solvent volumes, and carry the risk of thermal degradation of active components. As an alternative, sonication-assisted extraction has been shown to significantly improve extraction efficiency. Martín-del-Campo et al. (2021) reported that ultrasound-assisted extraction increased carrageenan yield by 41–45% compared to conventional methods. The working principle of ultrasonic extraction involves acoustic cavitation effects that disrupt cell walls and enhance solvent penetration into plant tissue, thereby accelerating mass transfer (Murdiningsih & Hasan, 2018). This study optimized extraction temperature (80°C) and contact time (60 minutes) for sonication-assisted extraction of carrageenan from *E. cottonii* using KOH solvent, and evaluated the influence of these conditions on the quality parameters of the resulting carrageenan.

II. METHODS

Materials and Equipment

Equipment used in this study are erlenmeyer flask (Pyrex), beaker glass (Pyrex), spatula, Petri dish, crucible, funnel, stirring rod, furnace (Thermo Scientific), analytical balance (Ohaus), tray, oven (Thermo Scientific), desiccator, volumetric flask (Pyrex), hot plate, and Brookfield Viscometer (AMETEK). Materials used in this study are *Eucheuma cottonii* seaweed, calcium hypochlorite $Ca(ClO_2)$, potassium hydroxide (KOH), potassium chloride (KCl), ethanol, and distilled water.

Experimental Procedure

Raw Material Preparation

Seaweed was cleaned to remove impurities, then bleached by soaking in a 1% $Ca(ClO_2)$ solution for 1 hour. The seaweed was subsequently sun-dried for 5 days, then soaked in water with a volume 30 times the weight of the dry seaweed (pH 8.5–9, adjusted with KOH addition) for 12 hours to soften the material prior to extraction.

Sonication Extraction

Extraction was carried out at a seaweed-to-solvent ratio of 1:2 (w/w) using KOH 1N at pH 8.5–9 for 1 hour at 80°C. The extract was filtered through a 150-mesh filter cloth. The filtrate was precipitated by pouring it into ethanol with continuous stirring for 15 minutes. The precipitate was dried in an oven at 50°C for 10 hours and milled to obtain carrageenan powder.

Moisture Content Analysis (AOAC, 1984)

1 gram sample was placed into a pre-weighed porcelain crucible and dried in an oven at 105°C for 1 hour. The crucible was cooled in a desiccator for 15 minutes before reweighing. Moisture content was calculated based on the difference in weight before and after drying.

Ash Content Analysis (AOAC, 2005)

The porcelain crucible was pre-heated in an oven at 100–105°C for 30 minutes, cooled in a desiccator, and weighed. A 1-gram sample was placed in the crucible, oven-dried for 30 minutes at 105°C, then ashed in a furnace at 600–800°C for 2 hours. After cooling in a desiccator, the residue was weighed to determine ash content.

Viscosity Analysis (AOAC, 1984; FMC Corp., 1977)

A 35 mL solution of 66.67% carrageenan and 0.16% KCl was heated with constant stirring to 80°C, then measured using a Brookfield Viscometer with an appropriate spindle.

Gel Strength Analysis (AOAC, 1984; FMC Corp., 1977)

A solution of 66.67% carrageenan and 0.16% KCl was heated to 80°C, poured into 4 cm diameter molds, and stored at 10°C for 18 hours. Gel strength was measured using the TAXT2i Texture Analyzer with the plugger centered on the gel surface.

III. RESULTS AND DISCUSSION

Carrageenan Yield

Extraction at 80°C for 60 minutes using ultrasonic waves at 40 kHz produced a carrageenan yield of 21.08%. Elevated temperature increases molecular activity, thereby accelerating the extraction process; however, excessive temperatures must be avoided to prevent degradation of active components. Azis & Mahyati (2019) reported that optimizing temperature and time in ultrasonic extraction of *Kappaphycus alvarezii* significantly increased carrageenan yield. In general, ultrasonic-assisted extraction is more efficient than conventional methods due to acoustic cavitation effects that disrupt cell walls and accelerate solvent mass transfer into seaweed tissue (Martín-del-Campo et al., 2021). Karim et al. (2024) further reported that a sequential ultrasonic-microwave extraction combination can yield carrageenan up to 61.25% in a considerably shorter time than conventional methods.

Carrageenan Quality Parameters

The quality parameters of the extracted carrageenan were evaluated and compared against FCC, FAO, and commercial standards. The results are summarized in Table 1.

Table 1. Summary of Carrageenan Quality Test Results

Parameter	Result	Description	FCC Std. (%)	FAO Std. (%)	Commercial Std.
Ash Content	0.37%	Meets FCC, FAO standard	15–40	Max. 35	18.06 ± 0.22
Moisture Content	0.07%	Meets FCC, FAO standard	Max. 12	Max. 12	14.34 ± 0.25
Viscosity	34.2 cP	Meets FCC, FAO standard	Min. 5	Min. 5	—
Gel Strength	14.361 g/cm²	Does not meet commercial standard	—	—	685 ± 13.43

Moisture Content

The moisture content of the carrageenan obtained by sonication extraction was 0.07%, well below the maximum limit of 12% set by FCC, EEC, and FAO standards. Longer extraction times cause greater water evaporation, resulting in lower moisture content. Hermanto (2021) stated that higher alkali concentrations yield carrageenan with lower moisture content, as the alkaline properties act as inhibitors within the carrageenan molecular structure. This result is consistent with the findings of Djurumudi et al. (2022), which reported moisture content of *E. cottonii* carrageenan ranging from 9–14% depending on the extraction method and solvent used.

Ash Content

The ash content of the extracted carrageenan was 0.37%, satisfying the FAO maximum limit of 15% for food-grade applications. Gerung et al. (2019) reported that solvent concentration and extraction duration significantly affect carrageenan ash content, where higher alkali concentrations and longer extraction times result in greater mineral dissolution into the extract. Saputra et al. (2021) noted that low ash content reflects the quality of the raw material and the effectiveness of the seaweed washing process prior to extraction.

Viscosity

The measured carrageenan viscosity was 34.2 cP, exceeding the minimum FCC and FAO standard of 5 cP. Ferdiansyah et al. (2023) explained that KOH-based extraction produces higher carrageenan swelling capacity compared to NaOH and $Ca(OH)_2$, contributing to higher viscosity values. Increasing alkali concentration increases carrageenan viscosity due to greater formation of 3,6-anhydrogalactose resulting from sulfate group elimination (Ega et al., 2016). Although the viscosity value in this study is below the optimal range reported by Ha et al. (2022) for high-quality carrageenan, it meets international standard requirements.

Gel Strength

The gel strength obtained was 14.361 g/cm², which does not meet the commercial standard minimum of 685 g/cm². The low gel strength is attributed to the negatively charged sulfate groups in the carrageenan molecule, which interact with water molecules and interfere with gel network formation, reducing the gel's resistance to external pressure. Asikin & Kusumaningrum (2019) stated that seaweed harvest age significantly affects the gel strength of the resulting carrageenan. Karim et al. (2024) reported that the highest gel strength of 588.03 g/cm² was achievable through sequential ultrasonic-microwave extraction, demonstrating that further optimization of extraction methods and parameters is essential to enhance gel formation.

IV. CONCLUSION

Sonication-assisted extraction of *Eucheuma cottonii* seaweed at 40 kHz, 80°C, and 60 minutes yielded 21.08% carrageenan. Quality evaluation showed that moisture content (0.07%) and ash content (0.37%) met FCC and FAO standards; viscosity (34.2 cP) exceeded the minimum FCC and FAO requirement (min. 5 cP). However, gel strength (14.361 g/cm²) did not meet the commercial standard, indicating that further optimization of extraction conditions is required

V. REFERENCES

Asikin, A.N., & Kusumaningrum, I. (2019). Physicochemical characteristics of carrageenan based on different harvest ages from Bontang waters, East Kalimantan. Jurnal Ilmu dan Teknologi Kelautan Tropis, 22(1), 136–142.

Azis, A., & Mahyati. (2019). Optimization of temperature and time in carrageenan extraction of seaweed (Kappaphycus alvarezii) using ultrasonic wave extraction methods. IOP Conference Series: Earth and Environmental Science, 370, 012076.

Desiana, E., & Hendrawati, T.Y. (2015). Production of carrageenan from Eucheuma cottonii with KOH extraction using variable extraction time. Prosiding Semnastek FT UMJ, TK-007, 1–7.

Djurumudi, S., et al. (2022). Quality of carrageenan using different solvents and extraction methods. Media Teknologi Hasil Perikanan, 10(2), 80–85.

Ega, L., Lopulalan, C.G.C., & Meiyasa, F. (2016). Quality assessment of carrageenan from Eucheuma cottonii based on physicochemical properties at different potassium hydroxide (KOH) concentrations. Jurnal Aplikasi Teknologi Pangan, 5(2), 38–44.

Ferdiansyah, R., Abdassah, M., Zainuddin, A., Rachmaniar, R., & Chaerunisaa, A.Y. (2023). Effects of alkaline solvent type and pH on solid physical properties of carrageenan from Eucheuma cottonii. Gels, 9(5), 397. https://doi.org/10.3390/gels9050397

Gerung, M.S., Montolalu, R.I., Lohoo, H.J., Dotulong, V., Taher, N., Mentang, F., & Sanger, G. (2019). Effect of solvent concentration and extraction time on carrageenan production. Media Teknologi Hasil Perikanan, 7(1), 25–31.

Ha, H.T., Cuong, D.X., Thuy, L.H., Thuan, P.T., Tuyen, D.T.T., Mo, V.T., & Dong, D.H. (2022). Carrageenan of red algae Eucheuma gelatinae: Extraction, antioxidant activity, rheology characteristics, and physicochemistry characterization. Molecules, 27(4), 1268. https://doi.org/10.3390/molecules27041268

Hermanto, K.P. (2021). Effect of different alkali solution ($Ca(OH)_2$) concentrations on the quality of carrageenan powder produced from Eucheuma cottonii. Jurnal Akuatek, 2(1), 51–57.

Karim, A.A., Sankar, A.J., & Gokhale, J.S. (2024). Optimization of sequential ultrasound-microwave assisted extraction of polysaccharide from red seaweed (Kappaphycus alvarezii). Journal of Applied Phycology, 36, 3675–3689.

Martín-del-Campo, A., Fermín-Jiménez, J.A., Fernández-Escamilla, V.V., Escalante-García, Z.Y., Macías-Rodríguez, M.E., & Estrada-Girón, Y. (2021). Improved extraction of carrageenan from red seaweed (Chondracantus canaliculatus) using ultrasound-assisted methods and evaluation of the yield, physicochemical properties and functional groups. Food Science and Biotechnology, 30, 901–910.

Mendes, M., Cotas, J., Gutiérrez, I.B., Gonçalves, A.M.M., Critchley, A.T., Hinaloc, L.A.R., Roleda, M.Y., & Pereira, L. (2024). Advanced extraction techniques and physicochemical properties of carrageenan from a novel Kappaphycus alvarezii cultivar. Marine Drugs, 22(11), 491. https://doi.org/10.3390/md22110491

Momo, A.N., Amalo, D., Mauboy, R.S., Boro, T.L., Danong, M.T., & Asa, J.C. (2023). Quality of carrageenan extract from Eucheuma cottonii seaweed in Tablolong waters, Kupang, NTT. Jurnal Biotropikal Sains, 20(2), 7–13.

Murdiningsih, H., & Hasan, B. (2018). Extraction of carrageenan from Eucheuma cottonii seaweed using ultrasonic waves. Prosiding Seminar Nasional Hasil Penelitian (SNP2M) 2018. Makassar: Politeknik Negeri Ujung Pandang.

Nur, F., et al. (2023). Physicochemical characteristics of carrageenan flour by immersion method using Eucheuma cottonii seaweed from Takalar waters of South Sulawesi. The 6th International Conference on Agriculture, Environment and Food Security. Makassar: Universitas Hasanuddin.

Saputra, S.A., Yulian, M., & Nisahi, K. (2021). Characteristics and quality of seaweed carrageenan in Indonesia. Lantanida Journal, 9(1), 1–92.

Yusuf, M., Liu, K., Hurtado, A.Q., & Mostaert, A.S. (2024). Current biodiversity status, distribution, and prospects of seaweed in Indonesia: A systematic review. Heliyon, 10(10), e31073.