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UTILIZATION OF PEDADA MANGROVE FRUITS (*Sonneratia* sp.) IN THE DEVELOPMENT OF FRUIT JUICE DRINKS WITH CARRAGEENAN AS A STABILIZER

Pemanfaatan Buah Mangrove Pedada (*Sonneratia* sp.) dalam Pengembangan Minuman Sari Buah dengan Karagenan Sebagai *Stabilizer*

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ABSTRACT

Pedada mangrove fruits (*Sonneratia* sp.) have high nutritional content, but their utilization remains limited due to their sour taste which is less preferred by consumers. This study aimed to analyze the effect of carrageenan addition as a stabilizer on the chemical characteristics of pedada fruit juice drinks and determine the optimal concentration. The research method used an experimental approach with carrageenan concentration variations of 0%, 0.1%, 0.3%, and 0.5% (w/v). Evaluation included organoleptic tests using 25 semi-trained panelists with a hedonic scale of 1-9 for color, aroma, texture, and taste parameters, as well as chemical analysis including pH, vitamin C, and antioxidant activity (DPPH, ABTS, FRAP). Organoleptic data were analyzed using Friedman test followed by multiple comparison test, while chemical data were analyzed descriptively. Results showed that 0.3% carrageenan addition provided the highest preference level for all organoleptic parameters, particularly texture which increased significantly from 5.48 to 7.08. Chemical analysis revealed that 0.3% carrageenan maintained stable pH at 4, increased vitamin C content from 17.61 mg/100ml to 21.49 mg/100ml, and improved ABTS antioxidant activity with IC_{50} value decreasing from 125.93 ppm to 77.40 ppm. Carrageenan at 0.3% concentration represents the optimal stabilizer concentration for producing high-quality pedada fruit juice drinks with preferred sensory characteristics and maintained nutritional value.

Keywords: Antioxidants, Mangrove, Hedonic, Vitamin C

ABSTRAK

Buah mangrove pedada (*Sonneratia* sp.) memiliki kandungan gizi tinggi namun pemanfaatannya masih terbatas karena rasa asam yang kurang disukai. Penelitian ini bertujuan menganalisis pengaruh penambahan karagenan sebagai stabilizer terhadap karakteristik kimia minuman sari buah pedada dan menentukan konsentrasi optimalnya. Metode penelitian menggunakan pendekatan eksperimental dengan variasi konsentrasi karagenan 0%, 0,1%, 0,3%, dan 0,5% (b/v). Evaluasi meliputi uji organoleptik menggunakan 25 panelis semi terlatih dengan skala hedonik 1-9 untuk parameter warna, aroma, tekstur, dan rasa, serta analisis kimia berupa pH, vitamin C, dan aktivitas antioksidan (DPPH, ABTS, FRAP). Data organoleptik dianalisis menggunakan uji Friedman dilanjutkan uji perbandingan berganda, sedangkan data kimia dianalisis secara deskriptif. Hasil menunjukkan penambahan karagenan 0,3% memberikan tingkat kesukaan tertinggi pada semua parameter organoleptik, khususnya tekstur yang meningkat dari 5,48 menjadi 7,08. Analisis kimia menunjukkan karagenan 0,3% mempertahankan pH stabil pada nilai 4, meningkatkan kandungan vitamin C dari 17,61 mg/100ml menjadi 21,49 mg/100ml, dan memperbaiki aktivitas antioksidan ABTS dengan nilai IC_{50} menurun dari 125,93 ppm menjadi 77,40 ppm. Karagenan 0,3% merupakan konsentrasi optimal sebagai stabilizer untuk menghasilkan minuman sari buah pedada berkualitas terbaik dengan karakteristik sensori yang disukai dan nilai gizi yang terjaga.

Kata Kunci: Antioksidan, Mangrove, Hedonik, Vitamin C

INTRODUCTION

Indonesia possesses globally strategic mangrove forest potential, with mangrove cover reaching 22.8% of the world's total mangrove area, making it the country with the largest mangrove resources in the world (Permana & Andhikawati, 2023). Pangandaran Beach in West Java is one of the areas with a significant mangrove ecosystem, covering an area of 165 hectares, with 10 hectares under rehabilitation (Permana & Andhikawati, 2023). Mangrove forests not only protect the coast from abrasion and provide habitat for various species, but also hold the potential for natural resources with high economic value that have not been optimally utilized.

Mangrove fruits exhibit abundant species diversity with diverse potential uses. The genus Rhizophora sp. is known for its elongated propagules and high tannin content, which are used in the leather tanning industry or as a raw material for charcoal (Alongi, 2002), while Avicennia sp. possesses bioactive compounds with potential as traditional medicinal ingredients (Kathiresan & Bingham, 2001). Pedada fruit (*Sonneratia* sp.) is a type of fruit with very high nutritional content, including vitamin C (56.74 mg/100g), vitamin B2 (7.65 mg/100g), vitamin B (5.04 mg/100g), and vitamin A (221.97 IU/100g) (Manalu *et al.,* 2013). The nutritional advantage of pedada fruit lies in its content of bioactive compounds in the form of steroids, flavonoids, and triterpenoids, which have high antioxidant capacity (Ahmed *et al.,* 2010), potentially acting as natural antioxidants to ward off free radicals and possess antimicrobial activity (Epand *et al.,* 2016; Thimmappa *et al.,* 2014).

Despite its high nutritional and functional potential, the use of pedada fruit is still very limited due to its organoleptic characteristics, namely its predominantly sour taste, which is unpopular with the public. This situation results in most pedada fruit being left to fall in their natural habitat without being processed into value-added products (Rajis *et al.,* 2017). Processing into fruit juice beverages is a promising technological alternative to increase product value and acceptability, while optimizing the use of abundant mangrove resources.

Developing pedada fruit juice beverages faces complex technological challenges, particularly related to product instability during production, distribution, and storage. Beverage stability refers to the product's ability to maintain its physical, chemical, and organoleptic characteristics throughout these periods (Damodaran & Parkin, 2017). Instability in fruit juice beverages can lead to various problems, such as phase separation between liquid and solid phases, sedimentation of fruit particles, color changes due to oxidation, degradation of vitamins and bioactive compounds, and the formation of undesirable sediments (Ashurst, 2016). Pedada fruit juice beverages pose special challenges because they contain fine particles of fruit flesh that tend to settle, coupled with an acidic pH (around 3-4) that can cause protein and polysaccharide instability in the beverage system (Genovese & Lozano, 2001). Without the addition of appropriate stabilizers, pedada fruit juice beverages can experience phase separation within 24-48 hours after production, resulting in decreased visual quality and consumer acceptability (Mirhosseini *et al.,* 2009).

Carrageenan, a hydrocolloid extracted from red seaweed (Rhodophyceae), has been shown to be effective as a stabilizer in various beverage products through its gel-forming mechanism that binds water and other components in fruit juice drinks, thus stabilizing the beverage structure (Imeson, 2009; Necas & Bartosikova, 2013). The advantages of carrageenan as a stabilizer lie in its biodegradable, environmentally friendly nature (Necas & Bartosikova, 2013), and efficiency at low concentrations (0.1-0.5%), unlike other stabilizers such as gum arabic or Carboxymethyl Cellulose (CMC) which require higher concentrations for equivalent effects (Campo *et al.,* 2009). Carrageenan has a synergistic ability to interact with proteins and polysaccharides found in pedada fruit, thereby increasing suspension stability, preventing sedimentation, and maintaining a homogeneous particle distribution during storage (Karbowiak *et al.,* 2006).

Antioxidant activity is a critical aspect in evaluating the quality of mangrove pedada juice, given its significant functional potential for health. Antioxidant activity plays a crucial role in neutralizing free radicals and preventing oxidative stress in the body, contributing to the prevention of various degenerative diseases such as cardiovascular disease, diabetes, and cancer (Nisa *et al.,* 2019). Comprehensive antioxidant activity testing using the 2,2-diphenyl-1-picrylhydrazyl (DPPH), 2,2-azinobis-3-ethylbenzothiazoline-6-sulfonic acid (ABTS), and Ferric Reducing Antioxidant Power (FRAP) methods is necessary to provide a comprehensive overview of the antioxidant activity mechanisms of mangrove pedada juice. The DPPH method measures free radical scavenging capacity, the ABTS method evaluates electron transfer capacity, and the FRAP method analyzes the reducing power of antioxidant components (Thaipong *et al.,* 2006).

This study aims to analyze the effect of adding carrageenan as a stabilizer on the chemical characteristics of mangrove pedada juice and determine the optimal concentration that produces the best quality product. The evaluation included organoleptic parameters (color, aroma, texture, and taste) to determine consumer acceptance, followed by chemical analysis of pH, vitamin C content, and antioxidant activity to provide a comprehensive overview of the effect of carrageenan on product quality. The research results are expected to contribute scientifically to the development of mangrove resource processing technology and serve as a reference for the natural ingredient-based functional beverage industry.

RESEARCH METHODS

Place and Time

This research was conducted in the period December 2024 to May 2025 at the Fisheries Product Processing Laboratory for hedonic testing, as well as the Biogeochemistry Laboratory of the Faculty of Fisheries and Marine Sciences, Padjadjaran University for antioxidant testing (DPPH, ABTS, and FRAP), vitamin C, and pH.

Tools and Materials

The equipment used includes a Miyako BL-101 PL blender, a 3-liter saucepan, a 200-mesh cloth strainer, a knife, a cutting board, a basin, a gas stove, and a digital scale. The ingredients used include 200 grams of fresh pedada fruit from Bojong Salawe Pangandaran, Le Mineral mineral water, House of Organix stevia sugar, and KR 02 carrageenan.

Research Design

The method applied in this study uses an experimental approach, namely the manufacture of pedada fruit juice drinks with different carrageenan concentration variations consisting of 4 treatments with 25 semi-trained panelists as replications to determine the level of panelist acceptance of the resulting product. The research treatments include the addition of 0%, 0.1%, 0.3%, and 0.5% carrageenan based on the volume of the drink (w/v).

Making Pedada Fruit Juice Drink

The manufacturing procedure refers to the modified method of Dari et al. (2021). The steps begin with selecting ripe pedada fruit, washing it thoroughly, peeling it, and cutting it. The fruit flesh is pureed using a blender with water added in a 1:10 ratio, then filtered using a 200-mesh filter cloth. The fruit juice is heated at 80°C for 20 minutes with continuous stirring. Stevia sugar (18% of the fruit weight) is added, then carrageenan according to the treatment variations until a homogeneous mixture is achieved.

Data Analysis

Organoleptic testing was conducted using 25 semi-trained panelists from Fisheries Study Program students using a hedonic scale of 1-9 for color, aroma, texture, and taste. Organoleptic data were analyzed using the Friedman test followed by a multiple comparison test. Data from pH, antioxidant activity, and vitamin C tests were analyzed descriptively and presented in tabular form.

The classification of antioxidant activity strength based on IC50 values refers to Salim (2018): very strong (IC50 < 50 ppm), strong (IC50 50-100 ppm), moderate (IC50 100-150 ppm), weak (IC50 150-200 ppm), and very weak (IC50 > 200 ppm). The lower the IC50 value, the higher the sample's antioxidant activity, as it indicates that even a lower concentration can inhibit 50% of free radicals (Molyneux, 2004).

RESULT

Organoleptic Test

The organoleptic analysis conducted in this study included a hedonic test with parameters of color, aroma, texture, and taste. The results of the hedonic test for various carrageenan addition treatments to the pedada fruit juice drink are presented in Table 1.

Table 1. Hedonic Test Results of Pedada Fruit Juice Drink

Parameter	Carrageenan Addition Treatment			
	0%	0,1%	0,3%	0,5%
Color	$6{,}6^{a}$	$6{,}76^{a}$	$6{,}84^{a}$	$6{,}68^{a}$
Aroma	$6{,}44^{a}$	$6{,}6^{a}$	$6{,}68^{a}$	$5{,}96^{a}$
Texture	$5{,}48^{a}$	$6{,}84^{b}$	$7{,}08^{b}$	$5{,}64^{ab}$
Taste	$6{,}52^{a}$	$7{,}16^{a}$	$7{,}24^{a}$	$6{,}76^{a}$

Description: 1= really dislike; 3= dislike; 5= neutral/normal; 7= like; 9= really like. Averages followed by the same letter indicate no significant difference according to the multiple comparison test at the 5% level/

Chemical Test

Chemical analysis was performed on the control treatment (0%) and the most preferred treatment, the treatment with 0.3% carrageenan added, in the hedonic test. Chemical analysis was conducted to determine the content of the pedada fruit juice drink with the addition of carrageenan. The chemical analysis included pH, vitamin C, and antioxidant (DPPH, ABTS, and FRAP) tests. The results of the chemical analysis on the control pedada fruit juice drink (0%) and the 0.3% carrageenan added drink are presented in Table 2.

Table 2. Chemical Test Results of Pedada Fruit Juice Drink

Parameter	Carrageenan Addition Treatment		Unit
	0%	0,3%	
pH	4	4	-
Vitamin C	17,61	21,49	mg/100ml
DPPH	105,99	104,87	ppm
ABTS	125,93	77,40	ppm
FRAP	128,91	122,90	ppm

DISCUSSION

Organoleptic Test (Hedonic)

Color

The results of the hedonic test showed that the addition of carrageenan at various concentrations did not significantly affect the panelists' preference for the color of the pedada fruit juice drink. All treatments produced an average preference score ranging from 6.6 to 6.84 with a median of 7 (like), indicating that the light brown color of the drink was well accepted by the panelists. The treatment with 0.3% carrageenan gave the highest average score (6.84), while the control treatment without carrageenan gave the lowest score (6.6).

Figure 1. Color of Pedada Fruit Juice Drink with Various Carrageenan Treatments

Good color consistency across all treatments indicates that carrageenan, as a hydrocolloid, does not alter the natural color characteristics of pedada fruit juice. These results align with research (Ningtias *et al.,* 2024), which states that the addition of hydrocolloids does not significantly affect the color quality of the resulting product. Carrageenan functions as a stabilizer without disrupting the product's appearance, thus maintaining the distinctive color of pedada fruit and providing consistent visual appeal.

Aroma

Aroma parameters showed that carrageenan addition did not significantly differ between treatments, with a median score of 7 (liked) for the 0%, 0.1%, and 0.3% treatments, and a median score of 5 (average) for the 0.5% treatment. The highest mean score was achieved in the 0.3% treatment (6.68), while the lowest was in the 0.5% treatment (5.96).

Pedada fruit has a characteristic fruity aroma with a slightly refreshing sourness, derived from volatile compounds such as esters, aldehydes, and terpenoids (Wetwitayaklung *et al.,* 2008). Carrageenan, as a stabilizer, can maintain the distinctive aroma of pedada fruit without introducing undesirable off-flavors. This indicates that carrageenan at concentrations of 0.1-0.3% is able to maintain the sensory quality of the product well, in line with the statement (Gruji *et al.,* 2010) that the addition of hydrocolloids not only improves functional characteristics but also provides beneficial nutritional benefits.

Texture

The hedonic texture test results showed a significant difference between the 0.1% and 0.3% carrageenan addition treatments and the control treatment (0%). The median score for the 0.1% and 0.3% treatments was 7 (liked), while the control and 0.5% treatments were 5 (normal). The 0.3% treatment produced the highest average score (7.08), indicating optimal panelist preference.

The increased preference for texture is due to carrageenan's ability to improve the beverage's textural characteristics by increasing viscosity and forming a gel structure. Carrageenan forms a three-dimensional network that can retain water and provides a more structured sensation in the mouth, resulting in increased body (light viscosity), smoothness, and mouth coating (a thin layer in the mouth), which provides a more pleasant sensory experience (Rastegarpour *et al.,* 2025).

The 0.3% carrageenan concentration provides an optimal balance between increased viscosity and sensory acceptability. The decrease in preference value in the 0.5% treatment shows that excessive carrageenan concentration can produce a texture that is too thick and is less preferred by panelists.

Taste

Taste parameters showed no significant differences between all treatments, with a median score of 7 (liked) for all treatments. The highest average score was achieved in the 0.3% treatment (7.24), while the lowest was in the control treatment (6.52). The pedada fruit juice beverage is characterized by a predominantly sour taste with a slight sweetness and a refreshing sensation.

The lack of significant differences in taste parameters indicates that carrageenan is a hydrocolloid with a neutral taste and does not contribute significantly to the flavor of the beverage. Carrageenan functions as a stabilizer and thickener without altering the basic flavor profile of the pedada fruit juice beverage, in line with research by Zhaki *et al.,* (2018) which stated that carrageenan does not affect the flavor of stabilized beverage products.

The resulting flavor balance comes from a combination of the natural characteristics of pedada fruit with the addition of 18% stevia sugar, which provides sweetness to neutralize some of the sourness, resulting in a harmonious flavor profile acceptable to panelists.

Based on the overall hedonic test results, the 0.3% carrageenan treatment showed the best performance with the highest values for color (6.84), aroma (6.68), texture (7.08), and taste (7.24). Therefore, the 0.3% treatment was selected as the best treatment for further chemical analysis.

Chemical Test

Based on the results of the hedonic test, the 0.3% carrageenan treatment was selected as the best treatment and a chemical analysis comparison was carried out with the control treatment (0%) to evaluate the effect of adding carrageenan on the chemical quality of pedada fruit juice drinks.

Acidity Degree (pH)

The pH test results showed a consistent value of 4 for both treatments, both the control (0%) and the 0.3% carrageenan addition. The pH values obtained met the requirements of SNI 3719:2022 for fruit juice beverages, which requires a minimum pH of 2.5.

The consistency of the pH values indicates that the addition of 0.3% carrageenan did not affect the acidity of the pedada fruit juice beverage. These results align with the research of Wahyu *et al.,* (2022) on pedada fruit juice beverages with the addition of carrageenan, which showed that variations in carrageenan concentration had no significant effect on the product's pH value. This phenomenon can be explained by the chemical characteristics of carrageenan as an anionic sulfated polysaccharide. However, at low concentrations (0.3%) in beverages with buffering capacity, its effect on pH is minimal (Imeson, 2009).

A stable pH at 4 offers dual benefits: first, an acidic pH (<4.6) can inhibit the growth of pathogenic and spoilage microorganisms, thereby increasing product safety and shelf life; Second, the consistent pH indicates that the addition of carrageenan does not disrupt the natural acid-base balance of the product, so that the typical sensory characteristics of pedada fruit are maintained.

Vitamin C Content

The results of the vitamin C test showed an increase in content from the control treatment to the 0.3% carrageenan treatment. Vitamin C content increased from 17.61 mg/100ml in the control treatment to 21.49 mg/100ml in the 0.3% carrageenan treatment. This significant increase indicates that carrageenan plays a role in maintaining vitamin C stability during the processing of pedada fruit juice.

This increase in vitamin C can be explained by the protective mechanism provided by the carrageenan gel matrix. According to Milani & Maleki (2012), carrageenan, as a hydrocolloid, is capable of forming a gel structure that protects sensitive components like vitamin C from oxidative degradation. The three-dimensional structure formed by carrageenan creates a physical barrier that reduces direct contact between vitamin C and oxygen and other environmental factors that can cause degradation.

The protective mechanism of vitamin C by carrageenan is also associated with its ability to control water activity and form complexes with metal ions that can catalyze the vitamin C oxidation reaction (Karbowiak *et al.,* 2006).

Despite the increase, the vitamin C content obtained (17.61-21.49 mg/100ml) was still lower than the vitamin C content of fresh pedada fruit (56.74 mg/100g) reported by Manalu *et al.,* (2013). This decrease was caused by the sensitivity of vitamin C to heat, light, and oxygen during processing, especially during the heating process at 80°C for 20 minutes. However, the addition of 0.3% carrageenan was proven effective in minimizing vitamin C loss and maintaining the nutritional value of the product.

Antioxidant Activity

DPPH method

Test results using the DPPH method showed that the IC50 value decreased from 105.99 ppm in the control treatment (0%) to 104.87 ppm in the 0.3% carrageenan treatment. Although the decrease in IC50 values was relatively small, this indicates an increase in antioxidant activity. Based on the antioxidant strength classification according to Salim (2018), the IC50 values for both treatments fall into the moderate antioxidant category (IC50 100-150 ppm).

DPPH is a stable free radical that is soluble in organic solvents, allowing it to interact with hydrophobic antioxidant components. The ability of antioxidant compounds in pedada fruit to donate electrons or hydrogen atoms to DPPH radicals causes a color change from purple to yellow, indicating antioxidant activity (Molyneux, 2004).

ABTS Method

The ABTS method showed more responsive results to the addition of carrageenan compared to the DPPH method. The IC50 value experienced a more significant decrease from 125.93 ppm in the control treatment to 77.40 ppm in the 0.3% carrageenan treatment. This result indicates a fairly substantial increase in antioxidant activity, where the IC50 value changed from the moderate category (IC50 100-150 ppm) to the strong category (IC50 50-100 ppm) according to the classification (Salim, 2018).

The difference in responsiveness between the DPPH and ABTS methods can be explained by the different characteristics of the radicals. $ABTS^{\bullet+}$ is hydrophilic and can interact with both water- and lipid-soluble antioxidant components. Carrageenan, being hydrophilic and negatively charged (sulfate groups), can interact more strongly with the $ABTS^{\bullet+}$ radical through electrostatic forces, resulting in a more measurable increase in antioxidant activity (Re *et al.,* 1999).

FRAP method

Testing using the FRAP method showed a decrease in the IC50 value from 128.91 ppm in the control treatment to 122.90 ppm in the 0.3% carrageenan treatment. Although there was a downward trend, the increase in antioxidant activity using the FRAP method was relatively smaller than that using the ABTS method. Both values are still in the moderate antioxidant category (IC50 100-150 ppm).

FRAP measures the ability of antioxidants to reduce Fe3+-TPTZ to Fe2+-TPTZ, which does not involve a free radical scavenging mechanism like the DPPH and ABTS methods. This method focuses more on the reducing ability of antioxidant components, where antioxidant compounds act as electron donors to reduce ferric ions to ferrous ions (Benzie & Strain, 1996).

Mechanism of Increasing Antioxidant Activity

The increase in antioxidant activity in the 0.3% carrageenan treatment can be explained by several mechanisms. First, carrageenan protects the antioxidant compounds by forming a three-dimensional gel structure that acts like a "protective shield," trapping and enveloping the antioxidant components, thus protecting them from damage. Second, hydrogen bonds and electrostatic interactions form between the sulfate groups in carrageenan and the hydroxyl groups in phenolic compounds, thus protecting the active compounds from exposure to oxygen, heat, and other damaging factors (Huang *et al.,* 2021).

Third, carrageenan also possesses its own antioxidant properties through its sulfate groups, which can neutralize free radicals (Yuan *et al.,* 2005). (Wang *et al.,* 2021) found that carrageenan and fruit antioxidants can bind to each other to form a more stable and robust complex, providing a synergistic effect on antioxidant activity.

Pedada fruit contains various natural antioxidant compounds such as flavonoids, tannins, saponins, and vitamin C (Jariyah *et al.,* 2015), with phenolic compounds ranging from 30.25 to 45.72 mg GAE/100 g and flavonoids from 2.31 to 4.76 mg QE/100 g, which contribute to antioxidant activity (Sadad *et al.,* 2024). The addition of 0.3% carrageenan helps maintain and increase the effectiveness of these natural antioxidant compounds, especially those measured using the ABTS method.

CONCLUSION

The addition of carrageenan as a stabilizer has been proven to have a positive effect on the chemical characteristics of mangrove pedada fruit juice drinks, with an optimal concentration of 0.3% which produces the best quality product. 0.3% carrageenan increases the level of texture preference from 5.48 to 7.08 without changing the sensory characteristics of color, aroma, and taste, maintains pH stability at a value of 4 according to SNI standards, increases vitamin C content by 22% from 17.61 mg / 100ml to 21.49 mg / 100ml, and improves antioxidant activity especially through the ABTS method with a decrease in IC50 value from 125.93 ppm to 77.40 ppm which changes the antioxidant category from moderate to strong, so that 0.3% carrageenan can be recommended as an effective stabilizer to optimize the utilization of mangrove pedada resources into high-value added functional beverage products.

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