THE DIFFERENCE OF COCONUT VARIETIES AND TEMPERATURE IN CARRAGEENAN EXTRACTION FROM SEAWEED (*EUCHEUMA COTTONII*)

Perbedaan Varietas Kelapa dan Suhu pada Ektraksi Karagenan dari Rumpul Laut (Eucheuma cottonii)

Rista Anggriani, Rizki Khoirun Nisa, Noor Harini*
Program Studi Teknologi Pangan, Universitas Muhammadiyah Malang
Jl. Raya Tlogomas No 246 Malang
*e-mail : harini@umm.ac.id

ABSTRAK

Penggunaan air kelapa sebagai pelarut alami diperlukan dalam ekstraksi karagenan, sebagai alternatif penggunaan KOH sebagai pelarut sintetis. Penelitian ini bertujuan untuk mengkaji pengaruh penggunaan air kelapa dari dua varietas kelapa yang berbeda sebagai pelarut dan suhu ekstraksi yang berbeda dalam mengekstraksi karagenan. Penelitian dilakukan dalam dua tahap. Penelitian tahap pertama adalah mengeskstraksi karagenan dari Eucheuma cottonii dengan pelarut air kelapa, kemudian menganalisis karakteristik fisikokimia dari karagenan yang dihasilkan seperti rendemen, kekuatan gel, viskositas, kadar air dan kadar abu. Tahapan kedua adalah aplikasi penggunaan karagenan untuk pembuatan bakso ayam. Hasil penelitian menunjukkan bahwa karagenan terbaik didapatkan dari ekstraksi dengan pelarut air kelapa hibrida dan suhu 80°C yang menghasilkan rendemen 75,48%, kekuatan gel 579,874 g/cm^2, viskositas 5,1 cps, kadar air 10,85% dan kadar abu 11,32%. Aplikasi karagenan dari perlakuan terbaik menghasilkan bakso ayam dengan tingkat kekenyalan 49,26 N, tingkat kecerahan 73,35, warna nilai a 0,95 dan warna nilai b 11,6. Penggunaan air kelapa dapat digunakan sebagai alternatif pelarut alami dalam mengekstraksi karagenan.

Kata Kunci : karagenan, bakso ayam, air kelapa, pelarut alami, suhu

ABSTRACT

The use of coconut water as a natural solvent is needed in the extraction of carrageenan, as an alternative to the use of KOH as a synthetic solvent. This study aims to examine the effect of using coconut water from two different varieties of coconuts as solvents and different extraction temperature in extracting carrageenan. The study was conducted in 2 steps. Step 1 was extraction carrageenan from Eucheuma cottonii with coconut water solvent, then analyzing the physicochemical characteristics of the carrageenan produced such as yield, gel strength, viscosity, moisture and ash content. Step 2 was the application to chicken meatball. The results showed that the the best carrageenan in this study was carrageenan that was extracted with solvent from hybrid coconut water and temperature of 80°C with a yield of 75.48%, gel strength of 579.874 g/cm^2, viscosity of 5.1 cps, moisture content of 10.85% and ash content 11.32%. Application of the best carrageenan from the best treatment produced chicken meatballs with chewiness of 49.26 N, brightness of 73.35, a value of 0.95 and b value of 11.6. The use of coconut water can be used as an alternative natural solvent in extracting carrageenan.

***Keywords** : carrageenan, chicken meatball, coconut water, natural solvent, temperature*

INTRODUCTION

Carrageenan is a long-chain polysaccharide hydrocolloid compound produced from the extraction of seaweed (Necas and Bartosikova, 2013). Carrageenan as a hydrocolloid is generally used for its functional properties as a gelling agent, an ingredient for texture improvement, thickener and water binder (hydrogel). The factors that must be considered in gelling materials include gel strength, gel formation time, gel formation temperature, and gel melting temperature.

In general, the processing of carrageenan from seaweed requires several stages, namely soaking, extraction, separation of carrageenan with the solvent, then drying. Carageenan from seaweed can be produced by extraction using alkaline solvent. Some researchers use KOH and NaOH as a solvent commonly used to extract carrageenan in seaweed (Distantina et al, 2012; Tunggal and Hendrawati, 2015; Desiana and Hendrawati, 2016; Hudha et al, 2012). However, extraction with KOH solvents is considered dangerous (Utomo, 2012). So a natural solvent containing potassium, such as coconut water, is needed to replace chemical solvents, because coconut water contains high potassium. Previous studies have used Siwalan neera as a natural solvent in carrageenan extraction (Ashfarina et al, 2020). While Berliana et al (2020) using coconut water in the extraction of agar from the seaweed *E.cottoni*. Coconut water contains various minerals, of which potassium is the highest mineral, followed by sodium (Rana et al, 2016). In research of Berliana et al (2020) this study does not examine the different types of coconuts, whereas in Indonesia there are many types of coconuts (Prasetiyo et al, 2021), such as hybrid dan yellow dwarf coconut

Moreover, from the two studies, the effect of extraction temperature has not been studied. Whereas, the extraction of seaweed into carrageenan is influenced by several factors, such as extraction temperature. The solubility level of carrageenan will be greater at higher temperatures. In research of Hudha et al (2012) which extracted carrageenan with NaOH, the extraction temperatures of carrageenan used were 60, 70, 80, and 90°C.

As a gelling agent, carrageenan is often applied to meatball such as tuna, tilapia, and chicken meatballs (Ardianti et al,2014; Candra et al, 2014; Kurniawan et al, 2012). Based on this description, research is needed to examine the effect of using coconut water from two different varieties of coconuts and the extraction temperature on the physicochemical properties of carrageenan produced and the effect of its application on chicken meatball products.

RESEARCH METHODOLOGY

Material

The raw material is dried seaweed (*Eucheuma cottonii*) has red-purple, cylindrical, harvested from the Manggar beach area, Balikpapan, in the age of 45 days. Other materials used are hybrid coconut water purchased from the Segiri Samarinda traditional market and yellow dwarf coconut obtained from private gardens in Manggar Balikpapan area, technical isopropanol 80%, and aquades. The ingredients for chicken meatballs are chicken breast fillets, tapioca flour, salt, pepper, garlic powder, ice cubes, the best carrageenan from this research, and commercial carrageenan.

Equipments

The equipments used in this study were oven (Sanyo MOV-112F-KAV), waterbath (Techne Tempette Junior TE-8J), penetrometer (Koehler K19500), analytical scale (Ohaus Galaxy 400), hotplate, showcase, Ostwald viscometer, texture analyzer, color reader (Konica Minolta), blender (Cosmos CB-171-P).

Research Method

This study used a randomized block design with two factors. The first factor is the difference between the coconuts used (hybrid and yellow dwarf coconut), while the second factor is the extraction temperature (60, 70, 80°C). Statistical analysis was performed using Analysis of Variance (ANOVA). If the treatment significantly affected the observed parameters, then the DMRT α = 5% further test is carried out. Analysis using SPSS 20 software.

Seaweed Pre-treatment

Seaweed pre-treatment was done by referring to the modified method of Distantina (2012). Dried seaweed was soaked in water for 24 hours the water was changed every 4 hours then washed with running water. Then the seaweed was cut approximately 1 cm and dried under the sun for 2 days. After that, the seaweed was weighed for 15 g/ treatment and soaked in distilled water with a ratio of 1: 30 for 15 minutes.

Extraction of Carrageenan

Seaweed pre-treatment was done by referring to the modified method of Distantina (2012). Wet seaweed was put into erlenmeyer containing coconut water solvent according to the treatment (hybrid and yellow dwarf coconut) as much as 1:20 of the weight of dry seaweed then cooked using waterbath at a temperature of 60, 70, 80°C for 120 minutes. After that the filtrate is filtered and collected in a beaker with isopropanol with a ratio of 1: 2 to the filtrate and is deposited for 30 minutes then the solids formed are washed with distilled water then placed on a baking pan then dried for 24 hours at 60°C.

Making of Chicken Meatballs

The making of chicken meatballs refers to the modified method by Kurniawan dkk (2012). The chicken breast fillet was cut about 3x3 cm and then grinded in a blender. The chicken meat was then mixed with other ingredients according to table 1 then it was molded and cooked twice, first was at a temperature of 60-80°C for 10 minutes and then at a temperature of 90-98°C for 10 minutes.

Table 1. Formulation of Meatball Per-Unit of Treatment

Ingredients	Composition (g)		
	Control	N1	N2
Chicken meat	100	100	100
Tapioca flour	15	15	15
Ice cubes	15	15	15
Salt	2	2	2
Pepper	0.2	0.2	0.2
Garlic powder	3	3	3
Carrageenan powder	0	2.5	2.5

N1 = the best carrageenan from the best treatment of this research
N2 = commercial carrageenan

Characteristics Analysis of Carrageenan and Chicken Meatballs

Analysis of carrageenan characteristics includes yield, gel strength, viscosity, moisture content and ash while analysis of meatball characteristics chicken includes chewiness and color.

RESULT AND DISCUSSION

Physical Properties of Carrageenan

Yield, Gel Strength and Viscosity

Based on the analysis of variance, it was known that there was no interaction (p>0.05) between the two factors on the physical properties of carrageenan. However, the extraction temperature significantly affected yield, gel strength and viscosity of carrageenan. The results of the yield value, gel strength and carrageenan viscosity can be seen in Table 2.

The yield of carrageenan in this study ranged from 66.12 - 75.32%. The data show that the yield value of carrageenan extracted with hybrid coconut water solvent is higher than yellow dwarf coconut water. This is because the potassium content in hybrid coconut water is higher than yellow dwarf coconut water. According to research by Hatta et al. (2016) who measured the potassium content (K^+) of young coconut water using atomic absorption spectrophotometry. The yellow dwarf coconut variety has a potassium (K^+) content of 3729.2 mg/L and hybrid coconut is 5162.4 mg/L. Potassium contained in coconut water plays an important role in the carrageenan extraction process because carrageenan is sensitive to K^+ ions which can increase the ionic strength in the carrageenan polymer chain so that the forces between molecules are completely dissolved. Thus, there is a balance between the dissolved ions and the bound ions in the carrageenan structure (Hakim. 2011).

Based on table 2. it is known that the carrageenan yield increases with the increasing of extraction temperature. It is because the higher the extraction temperature of the extracting solution, the more active the solvent is so that more carrageenan is released from the cell walls of the seaweed. The higher the extraction temperature

Table 2. Yield, Gel Strength and Viscosity of Carrageenan

Treatments	Yield (%)	Gel Strength (g/cm²)	Viscosity (cps)
Hybrid coconut	69.36^a	539.638^a	6.0^a
Yellow dwarf coconut	66.12^a	525.469^a	6.4^a
60°C	57.88^a	507.533^a	7.0^c
70°C	70.02^b	523.678^a	6.2^b
80°C	75.32^b	566.448^b	5.4^a

causes an increase in the kinetic energy of the solution so that the diffusion of the solvent into the cell increases as well (Hudha et al, 2012)

The gel strength produced in the extracted carrageenan ranged from 507.533 - 566.448 g / cm². The data showed that the gel strength of carrageenan extracted using hybrid coconut water was higher than yellow dwarf coconut water which was 539.638 g/cm^2. The difference in the value of the gel strength is because hybrid coconut water contains more potassium ions (K^+) than yellow dwarf coconut water. This is suitable with the research by Distantina et al. (2012) that the higher the KOH concentration, the higher the gel strength value. The higher the KOH concentration (0.1–0.3 N) with the extraction time of 60 minutes increased the gel strength. The ability of carrageenan to form gel is indicated by the presence of 3.6-anhydro-galactose groups. The alkaline treatment in carrageenan extraction can improve the gel strength. The increase of gel strength was due to the formation of anhydrogalactose. The anhydrogalactose group formation can also be indicated based on the reduction of the sulfate content in the resulting carrageenan. If the sulfate content in carrageenan is high, the three-dimensional structure that was formed absorbs a lot of water.

The results showed that the higher the extraction temperature, the higher the gel strength value. The increase in the value of the gel strength was because the higher the extraction temperature, the more anhydrogalactose bonds would be formed. Kappa carrageenan is consist of α (1.3) -D-galactose-4- sulfate and β (1.4) -3.6-anhydro-D-galactose. Carrageenan also contains D-galactose-6-sulfate ester and 3.6 -anhidroD-galactose-2-sulfate ester. The presence of 6-sulfate groups can reduce the gelation power of carrageenan. But with the addition of alkaline, it can cause transelimination of 6-sulfate groups by K^+ ions which results in 3.6-anhydro-D-galactose. Thus the degree of molecular uniformity increases and the gel strength value also increases (Fathmawati et al., 2014).

The viscosity of carrageenan extracted with yellow dwarf coconut water was higher than hybrid coconut water. This because the higher number of K^+ ions in hybrid coconut water. Even though it is not in line with Prasetyo et al(2021) which states that yellow dwarf coconut has 266.13 mg K, while hybrid coconut only has 216.81 mg. Nevertheless, according to Bunga et al. (2013) the presence of K^+ ions can reduce the charge along the polymer chain. By means of the transformation between the sulfate groups that attached to the galactose group to form a K_2SO_4 salt. This salt can reduce the charge along the polymer chain and reduce the repulsion between the sulfate groups which results in weakening hydrophilic properties and decreasing viscosity value.

The research data showed that the viscosity of carrageenan decreased with the increasing of extraction temperature. According to Webber et al (2012), carrageenan crude extract solution viscosity increased when the extraction temperature reached 60 °C, and at higher temperatures this parameter decreased. This is suitable with the results of research by Pacheco (2007) where carrageenan extracted at a temperature of 80. 90. 100°C resulted in an agar viscosity of 63.40; 53.10; and 38.30 cps. The decrease in viscosity value is due to the easy degradation of carrageenan which is a long-chain polymer. The higher the extraction temperature, the longer chains degraded into short chains causing viscosity to decrease.

Chemical Properties of Carrageenan
Moisture Content and Ash Content

Based on the analysis of variance. it was known that there was no interaction ($p>0.05$) between the solvent from coconut varieties and the extraction temperature on the moisture content and ash of carrageenan. However. the extraction temperature has a significant effect on the moisture content of carrageenan. The results of the average moisture content and ash content of carrageenan can be seen in Table 3.

The results showed that the moisture content of carrageenan ranged from 9.86 - 11.70%. The moisture content of carrageenan extracted with hybrid coconut water was higher than yellow dwarf coconut water. This moisture content value is suitable with the standards set by FAO which is not more than 12%. However, this is not suitable with the statement of Gerung et al. (2019) who said that the alkaline solvent has the ability to extract and inhibit the increase in water in the *Kappaphycus alvarezii* seaweed molecule so that the moisture content is reduced. The moisture content of carrageenan extracted with hybrid coconut water should be lower considering that there is more K^+ ion

Table 3. Moisture and Ash Content of Carrageenan

Treatments	Moisture content (%)	Ash (%)
Hybrid coconut	10.33^a	11.62^a
Yellow dwarf coconut	9.86^a	11.0^a
60°C	8.07^a	11.48^a
70°C	11.70^b	11.21^a
80°C	10.52^b	11.24^a

in hybrid coconut water. Unsuitable moisture content could be due to the drying process or the deposition process that wasn't done properly. The moisture content calculated in the drying process was the bound water because the free water was assumed to be evaporated in the dehydration process. which is deposition using isopropyl alcohol.

The moisture content of carrageenan increases as the increasing of extraction temperature. This is suitable with the research of Hasan et al. (2019) where carrageenan was extracted at temperatures of 50. 60. and 70°C and had a moisture content of 4.50; 7.0; and 14.58%. Extraction at high temperatures can cause the seaweed cell walls to become softer so that carrageenan is easier to dissolve in alkaline solvents. This process made the filtrate being thicker and the carrageenan that form clumps. The clumped carrageenan fibers will affect the moisture content of the sample when oven-dried.

The research data showed that the carrageenan ash content from the extraction ranged from 10.61-11.81%. The overall value of carrageenan ash content has met FAO standards where the maximum carrageenan ash content is 40%. Carrageenan extracted using hybrid coconut water solvent has higher ash content than yellow dwarf coconut water. This is because the number of K^+ ions in hybrid coconut water is higher than yellow dwarf coconut water. This is suitable with the research of Tunggal and Hendrawati (2015) where the addition of KOH concentration increases the amount of ash content in carrageenan. Carrageenan extracted with KOH 0.5 N produces carrageenan with an ash content of 31.5% and at a KOH concentration of 0.9 N an ash content of 37% was obtained. The increase in the KOH concentration causes the value of the ash content to also increase.

The extraction temperature used had no significant effect on the value of carrageenan ash content. Ash content in carrageenan according to Wenno et al. (2012) influenced by the age of seaweed when being harvested and the growing conditions of seaweed. The salinity of the coastal waters of Balikpapan was known to be 35.5%. Waters with high salinity cause seaweed to contain a lot of mineral salts. A study by Supriyantini et al. (2017) reported that carrageenan from seaweed extracted from waters with a salinity of 30-33% has an ash content of 19.45%. The value of the ash content of the research results should be greater. this can be due to differences in cultivation locations in the middle of the sea and on the coast where the waters are at risk of being contaminated by local household waste.

Chicken Meatballs Characteristics

Chewiness and Color of Chicken Meatballs

Based on the analysis of variance. it is known that the addition of the best treatment of carrageenan and commercial carrageenan has no significant effect ($p > 0.050$) on the chewiness of the meatballs. The average value of the chewiness of

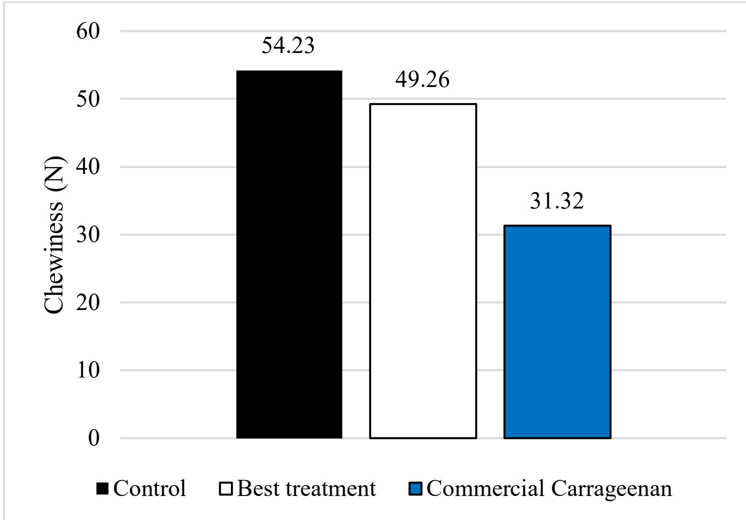

Figure 1. Chewiness of Chicken Meatballs

chicken meatballs by the addition of carrageenan can be seen in Figure 1.

Based on the data. it is known that the addition of carrageenan can increase the chewiness of chicken meatball products. Chicken meatballs without the addition of carrageenan had a chewiness value of 54.23 N while chicken meatballs with the addition of carrageenan. The best treatment and commercial ones were 49.26 N and 31.32 N. According to Akbar et al. (2019) the addition of carrageenan will help gel formation. Carrageenan will bind to protein from chicken meat and water, so that the meatballs have the strength to withstand pressure from outside. In the research of Kurniawan et al (2012) who made chicken meatballs with the addition of carrageenan extracted with KOH solvent, showed that meatballs with carrageenan addition had more water holding capacity than meatballs without carrageenan. This is due to the ability of carrageenan to form a three-dimensional gel matrix that can trap the water. Thus, the meatball with the addition of carrageenan will increase the chewiness.

Chicken meatballs with the addition of commercial carrageenan was more chewy than chicken meatballs with the addition of carrageenan from the best treatment. This is because the gel strength of commercial carrageenan is higher when compared to carrageenan from the best treatment. In addition, the commercial carrageenan that is sold in the market is considered as Semi Refined Carrageenan (SRC). While the best treated carrageenan is classified as crude carrageenan. Crude carrageenan is one of the carrageenan products with a lower purity level compared to pure carrageenan (Jaya et al.. 2019). Crude carrageenan contains a small amount of cellulose which also precipitates with the carrageenan on the process of depositioning. The gel strength indicates the ability of carrageenan to form a gel in the presence of heat. Based on this research, the best treated carrageenan had gel strength of 579.874 g/cm², while there is no clear information about type of seaweed and its extraction process in commercial carrageenan. If commercial carrageenan is assumed that derived from *Kappaphycus alvarezii* which uses KOH as solvent in its extraction has low gel strength, around 208.96 g/cm² (Khalil et al, 2018). Whereas, carrageenan is able to form a three-dimensional structure that can trap water and cause the chewiness to increase along with the strength of the carrageenan gel (Kurniawanet al, 2012). Therefore, chicken meatball with the addition of commercial carrageenan has a more chewy texture.

The results showed that the addition of the carrageenan from the best treatment and commercial carrageenan had no significant effect ($p>0.050$) on the color of the meatballs. However. the addition of the carrageenan from the best treatment and commercial carrageenan has a significant effect on the redness of chicken meatballs. The average lightness and yellowness value of chicken meatballs by the addition of carrageenan can be seen in Figure 2.

The L represents the lightness level. from 0 for black and 100 for white. The high level of brightness in chicken meatballs is due to the use of chicken breast that is lighter in color than the other parts of the chicken carcass. According to Bianchi et al (2007), the lightness of chicken breast meat is about 52-54. Based on the research results, the addition of carrageenan caused the brightness level of chicken meatballs to decrease. According to Cahayanti (2019) carrageenan will form a continuous three-dimensional structure so that it will reduce the hollow of the structure. This structure can reduce the lightness intensity of food products because the color of the product becomes darker. The addition of more carrageenan can also cause the appearance of the product to become cloudy (Wijana et al.. 2014). In addition, a non-enzymatic browning reaction occurs. namely the maillard reaction between the protein in chicken meat and the reducing sugar found in starch which contains glucose.

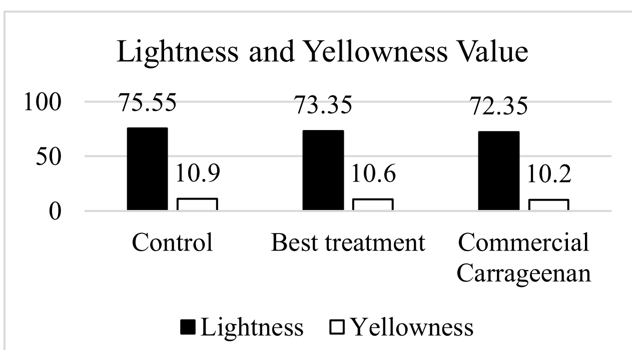

Figure 2. Lightness and Yellowness Value of Chicken Meatballs

The b represents the color of blue - yellow. The value of b^+ has a yellow color. while if the value of b^- has a blue color. According to Suharto (2018) the yellowish color of the meatballs can be due to the Maillard reaction between amino acids from meat and reducing sugars from flour. The yellowish value of the chicken meatballs with the addition of carrageenan from the best treatment was higher than the chicken meatballs with the addition of commercial carrageenan. namely 10.6. This is because the best treated carrageenan was extracted from red Eucheuma cottonii seaweed without any bleaching process. The carrageenan from the best treatment was also classified as crude carrageenan which still contains a small amount of cellulose. Cellulose is the main component of plant cell walls. Cellulose is a glucose polymer with β-1.4 glucoside bonds in a straight chain (Grevitara et al, 2018). The presence of glucose polymers in cellulose will cause a non-enzymatic browning reaction.

The results showed that the addition of carrageenan had a significant effect ($p < 0.050$) on the “a” value or the redness color of chicken meatballs. The average value of chicken meatball redness is presented in Table 3.

The a value represents the color green - red. The value of a^+ has a red color. while the value of a^- has a green color. Chicken meatballs have a yellowish white color. The results showed that the redness value increased with the addition of carrageenan. According to Wiguna et al. (2016) Carrageenan contains about 25-30% sulfate and consists of galactose groups which will react with the amino acid, especially non-enzymatic browning which will be detected as a reddish color. Chicken meatballs with the addition of carrageenan with the best treatment had a^+ value higher than chicken meatballs with the addition of commercial carrageenan. This is because the carrageenan from the best treatment has a yellowish brown color because it does not go through a bleaching process so that it is detected as a reddish color on the color reader.

CONCLUSION

Based on this research, it shows that carrageenan extracted with natural solvents from coconut water has good quality. The best treatment

Table 3. Redness Value of Chicken Meatballs

Treatments	Redness
Control	0.11^a
Best Treatment	0.95^c
Commercial Carrageenan	0.55^b

in this study was extraction with hybrid coconut water used extraction temperature of 80°C. This best treatment obtained a value almost close to the FAO standard with a yield of 75.48 %, gel strength of 579.874 g/cm^2, viscosity of 5.1 cps, moisture content of 10.85 % and 11.32 % ash content. The addition of the carrageenan from the best treatment to chicken meatballs can increase the chewiness of chicken meatballs. The characteristic chicken meatballs with the addition of carrageenan from the best treatment had the chewiness of 49.26 N, lightness of 73.35, a value (redness) of 0.95, and b value (yellowish) 11.6.

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