

Antioxidant Activity, Physical Quality and Sensory Properties of Watermelon Albedo Yogurt with the addition of Carboxy Methyl Cellulose

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Abstract: This research aims to determine the effect of adding Carboxy Methyl Cellulose (CMC) and watermelon albedo juice. on antioxidant activity, physical properties and organoleptic properties of watermelon albedo yogurt. This study uses Completely Randomized Design (CRD) with the first factor was CMC concentration (0%, 0.2%) and the second factors was Watermelon albedo juice concentration (0%; 20% and 30%). with triplicate. Parameters to be observed include antioxidant activity, pH, viscosity, syneresis and sensory test (aroma, taste and texture). Observational data were tested by ANOVA at a 5% and continued using the Honestly Significant Difference (HSD) at a significant level of 5%. The best yogurt was the addition of 0.2% CMC and 30% watermelon albedo juice concentration which produces of antioxidant activity 29.67%, pH value 4, 21, syneresis 12.37% and viscosity 3759.33 cP. The sensory resulted in a slightly sweet taste and strong watermelon aroma preferred by the panelists.

Keywords: Antioxidant, Carboxy Methyl Cellulose, Watermelon, Yogurt.

I. Introduction

Watermelon consumption in Indonesia is quite high, so it can produce quite high amounts of watermelon rind waste. According to the results of the Central Statistics Agency's Susenas in 2020, watermelon commodity consumption in 2021 reached 1,250 kg/capita/year. Data on watermelon consumption among households in Indonesia is likely to continue to increase every year. Watermelon abedo is the thickest and most white part of skin that contains nutrients such as vitamins, citrulline, mineral, pectin and enzym. When consuming watermelon, usually the only part consumed is the red flesh, while the albedo of the watermelon is discarded and not used so it becomes useless waste. Eventhough the albedo of watermelon still has quite high nutritional content and can be beneficial for the human body. According to Agustina [1], albedo watermelon is rich in vitamins, minerals, enzymes and chlorophyll. The vitamins found in albedo watermelon include vitamin A, vitamin C, vitamin E, and vitamin B. Albedo watermelon also contains amino acids, phenolics, beta-carotene, citrulline, and lycopene which can be used as antioxidants. Apart from these contents, watermelon albedo contains pectin compounds. Pectin is widely used in the food industry, for example pectin can be used as an adhesive and stabilizer to prevent sediment from forming in protein drinks [5]. Watermelon albedo has great potential considering its pectin content reaches 13% while watermelon biomass consists of 30% watermelon rind [2]. The results of research showed that the yield of pectin resulting from enzymatic extraction with *Aspergillus niger* was 15.26%. in watermelon albedo [33]. Meanwhile, according to Tyas [30], in research on the quality of sheet jam using a combination of watermelon albedo and super red dragon fruit, the analysis results showed that the watermelon albedo pectin content was 0.68% of 300 g of watermelon albedo.

The prevalence of degenerative diseases is increasing from year to year. WHO estimates that around 8.2 million deaths due to cancer in 2012 will continue to increase in the next two decades. The cause of degenerative diseases is caused by free radicals. In the body, free radicals will be neutralized by antioxidants, but if the levels exceed the capacity of intracellular antioxidants, they have the potential to cause oxidative stress. One way to prevent this can be done through intake of antioxidants. Antioxidants can also be interpreted as natural nutrients found in vegetables and fruit whose nutrients contain antioxidants.

Based on the results of research conducted by Ismayanti *et al* [11], the antioxidant content in the albedo of a round watermelon weighing 1.4 kg and a volume of 915 ml was 214,369 ppm and an oval watermelon weighing 1.9 kg and a volume of 1220 ml was 376,266 ppm. According to Maulida [15] this antioxidant content can reduce free radicals which trigger the growth of cancer cells. Albedo watermelon contains more Citrulline than the flesh of the fruit. The citrulline content in watermelon albedo is around 24.7 mg/dwt g, while in the flesh it is around 16.7 mg/dwt g. Citrulline can be used to treat hypertension, widen blood

vessels and remove ammonia from the liver. According to research conducted by Novi [17], the highest levels of vitamin C in watermelon rind fruitghurt were in the treatment of 100 ml of watermelon rind fruitghurt with the addition of 5% palm sugar and 15 ml of secang wood which had an ascorbic acid content of 15.987 mg. Meanwhile, from the results of research conducted by Tyas, et al. [30] showed that the lycopene isolate in watermelon albedo was 0.018%, with a lycopene content of 0.502% and the antioxidant activity test showed an IC50 value of 55.84 μ g/mL. Yogurt is a popular food product that was introduced centuries ago. Since its discovery, extensive research has been carried out to understand and improve the texture, taste, and the health properties associated with yogurt. Yogurt consumption has been associated with an array of health benefits including improved intestinal health and immune system [6]. With the increasing awareness about the health benefits associated with yogurt consumption, the popularity and trade of yogurt has increased globally. The advances and innovations in product development of yogurt have maintained the interest of consumers. Yogurt is a fermented processed product which is usually made using fresh milk by utilizing lactic acid bacteria to convert lactose into lactic acid, so that yogurt is more easily digested by the body when compared to pure milk [31]. The acid contained in yogurt is the result of fermentation by lactic acid bacteria (LAB) which converts lactose into lactic acid.

Generally, when making yogurt, a stabilizer is added in the form of CarboxyMethyl Cellulose (CMC). According to Zahro [33], CMC is easily soluble in hot and cold water and can stabilize protein drinks at low pH. Fermentation causes the formation of acids which will cause the protein to clump in the milk. The CMC-protein complex will increase protein stability in fermented milk beverage products so that it will stabilize yogurt. Apart from having benefits as a stabilizer, CMC can have negative impacts in the long term if not used according to the permitted doses, use of CMC can cause cancer or kidney damage. The use of CMC in Indonesia as a stabilizer, thickener, developer, emulsifier and gel-former in food products is permitted by the Indonesian Minister of Health, regulated according to PP. No. 235/ MENKES/ PER/ VI/ 1979 is 1-2%. The addition of watermelon albedo juice can be done to improve the nutritional value of yogurt. Therefore, this study examined the effect of the combination of Carboxy Methyl Cellulose (CMC) and watermelon albedo juice on the activity of antioxidant, physical and organoleptic properties of yogurt.

II. Material and Methods

The manufacturing stages are as follows. The albedo of the watermelon used is in good condition then peeled to separate the albedo from the outer skin and the flesh of the fruit. Albedo that has been peeled is then cut into several parts, washed and crushed until the pulp and juice are separated automatically.

Making yogurt starts from mixing fresh cow's milk and watermelon albedo juice according to the treatment (0%, 20% and 30%) adding 8% skim milk, 7% sugar and Carboxy Methyl Cellulose (CMC) according to the treatment (0% and 0, 2%) then homogenized using a blender [31]. After the homogenization process is carried out, it is poured into a pan. Standardized milk is pasteurized (90°C–95°C for 10–20 min) to kill all the pathogenic and almost all the spoilage-causing organisms. After heat treatment, milk is quickly cooled to 42°C followed by the addition of yogurt starter culture at 2% level. After inoculation, milk is incubated at 42°C for 4–6 h or up to a period until the pH reaches 4.6, followed by cooling to stop the fermentation [28]. The inoculation process by adding a yogurt starter containing of 5% of the bacteria *Streptococcus thermophilus*, *Lactobacillus bulgaricus*, *Lactobacillus acidophilus* and Bifidobacterium. The incubation process was carried out at room temperature (37°C) and incubation was carried out for 15 hours [12,13,19].

Experimental Design and Data Analysis. Completely Randomized Design (CRD) with a factorial pattern (2x3) consisting of two factors, the concentration of CMC (C), and the concentration of watermelon albedo (A) in yogurt which consists of 2 levels, namely: The concentration factor of the CMC stabilizer (C) consists of 2 levels, namely: C1= CMC Usage 0%: C2= CMC Usage 0.2%. Watermelon albedo juice concentration factor (A) consists of 3 levels, A1 = addition of 0% albedo watermelon juice (control)

A2 = addition of 20% watermelon albedo essence and A3 = addition of 30% watermelon albedo essence

Each level of the two factors is combined to obtain 6 combinations (C1A1, C1A2, C1A3, C2A1, C2A2, and C2A3). The observation was analyzed by Analysis of Variance at a 5% level using Co-stat software., then continued by using the Honestly Significant Difference Test (BNJ) at the same level of 5%. Parameters to be observed include chemical parameters, namely antioxidant activity [19,22] and pH, physical parameters include viscosity and syneresis testing, organoleptic parameters include taste, aroma and texture [23,24,26]. Antioxidant activity. The sample was tested using a 1,1-diphenyl-2-picryl hydrazyl (DPPH) technique. A total of 24 milligrams of DPPH were dissolved in 100 mL of methanol for making the stock solution. Filtration of DPPH stock solution using methanol yielded a usable mixture with an absorbance of around 0.973 at 517 nm. In a test tube, 3 mL DPPH workable solutions were combined with 100 μ L of leaf extract. Three milliliters of solution containing DPPH in 100 μ L of

methanol is often given as a standard. After that, the tubes were kept in complete darkness for 30 min. The absorbance was therefore determined at 517 nm. The following formula was used to compute the percentage of antioxidants % of antioxidant activity= $[(Ac-As) \div Ac] \times 100$ where: Ac—Control reaction absorbance; As—Testing specimen absorbance.

Syneresis Measurement. Syneresis index of different yogurt samples was determined according to the methodology proposed by Parnsworth et al. [18] with modifications. Yogurt (20 g) was prepared in centrifuge cups and centrifuged at $350 \times g$ (model K-24; Sigma Laborzentrifugen GmbH, Osterode am Harz, Germany) for 10 min at $4^{\circ} C$. The clear BioMed Research International 3 supernatant was collected and weighed and syneresis was calculated according to the following equation [18]: Syneresis(%) = weight of supernatant (g) weight of yogurt sample (g) $\times 100\%$..

Sensory Evaluation. Twenty trained panelists who are trained to use their senses to evaluate characteristic of yogurt including aroma, taste and texture. The ratings were presented on a 5-point hedonic scale ranging from 5 (“like extremely”) to 1 (“dislike extremely”). Yogurt sensory parameters were evaluated by viscosity, finished flavor, and taste quality. To minimize bias, all groups were three digits coded. The yogurts were served to panelists after the cooling process. Result was given on averages of the three trials for each type of yogurt [20].

III. Results and Discussion

Antioxidant Activity are chemical compounds that can inhibit or stop the oxidation process and can give one or more electrons to free radical molecules so that they can break chain reactions and free radicals [27]. Antioxidants function to prevent various types of diseases caused by free radicals such as cancer and coronary heart disease [3]. The treatment with the addition of CMC had no significantly different effect, while the treatment with the addition of albedo watermelon juice to yogurt had a significant effect on the antioxidant activity of yogurt. The relationship between the effect of adding watermelon albedo on the antioxidant activity of yogurt (Fig.1).

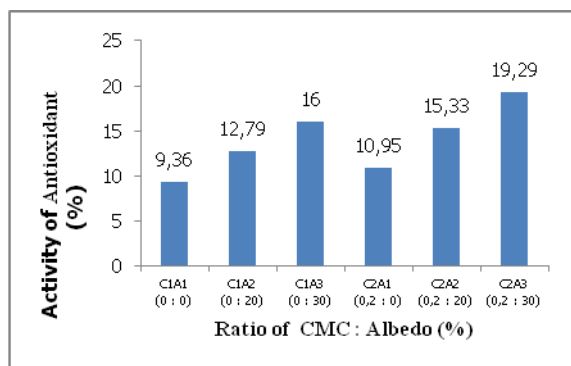


Figure 1. The Effect of Adding CMC and Watermelon Albedo Juice on the Activity of Antioxidant of Yogurt.

It shows that the interaction of CMC concentration and watermelon albedo juice concentration does not have a significantly different effect on the antioxidant activity of yogurt. This is because the watermelon albedo juice used has the same concentration so that the antioxidant levels produced are relatively the same. The treatment of adding CMC to yogurt did not have a significantly different effect. This is because CMC is a cellulose ester type solid substance, a derivative of cellulose which is often used in the food industry to get a good texture ([18,32]. The treatment of adding watermelon albedo juice to yogurt had a significantly different effect on the antioxidant activity of yogurt. Based on Figure 1, it shows that the more watermelon albedo is added, the higher the antioxidant activity contained in yogurt. The types of antioxidants contained in albedo watermelon include phenol, lycopene and citrulline. The phytochemical content in the white part of watermelon albedo contains phenolic compounds in the form of flavonoids and tannins which can influence the antioxidant activity value of watermelon rind [30]. The watermelon rind antioxidant activity test showed an IC_{50} value of $55.84 \mu g/mL$. With an antioxidant content in the form of lycopene of 0.502%, the watermelon albedo isolate is 0.018%. Meanwhile, according to research conducted by Ismayanti [11], the antioxidant activity of round watermelon albedo juice was obtained with an IC_{50} of 214,369 ppm. Based on the IC_{50} value, it can be said that the antioxidant activity of watermelon albedo is classified as a weak antioxidant. In a study of the phenolic content and antioxidant activity of watermelon albedo juice, it was found that the total phenolic content in round watermelon albedo juice volume of 915 ml had a total phenolic content of 351.571 mg/L, equivalent to 18.702 mg/g. According to research conducted by Campbell [5], the watermelon albedo contains citrulline of around 24.7 mg/dwt g, while the flesh of the fruit is around 16.7

mg/dwt g. Albedo watermelon also contains citrulline compounds which can provide antioxidant effects so that they can protect the body from damage caused by free radicals.

Test pH

Yogurt is fermented milk made through a fermentation process using lactic acid bacteria, namely *Streptococcus thermophilus* and *Lactobacillus bulgaricus*. These bacteria will change lactose, into lactic acid. So, by increasing the amount of lactic acid during the fermentation process, the pH decreases, and the yogurt becomes sour. According to Tammime and Robinson [29], carbohydrate fermentation by *Streptococcus thermophilus* and *Lactobacillus bulgaricus* is carried out through the conversion of carbohydrates to glucose, then the glucose is fermented through the hexose diphosphate pathway to produce lactic acid as the main product. Based on the results of observations and analysis results, the addition of watermelon albedo had a significantly different effect on the pH of yogurt. The relationship between the effect of adding CMC and watermelon albedo juice on the pH of yogurt (Fig.2). Based on the results of observations and analysis results, the treatment of adding CMC did not have a significant effect on the pH value of watermelon albedo yogurt, so no further tests were carried out on the factor of adding CMC. It is suspected that this is due to the difference in CMC concentration used not being sufficient to produce a significantly different pH of the yogurt. The addition of watermelon albedo juice with various concentrations has a significant influence on the pH level of yogurt so that further tests need to be carried out. Further test results showed that the more watermelon albedo juice added, the higher the pH level of the yogurt. The highest pH level was obtained in the treatment with the addition of 30% watermelon albedo with a pH level of 4.21-4.24, while the lowest pH level was obtained in the treatment without the addition of watermelon albedo juice.

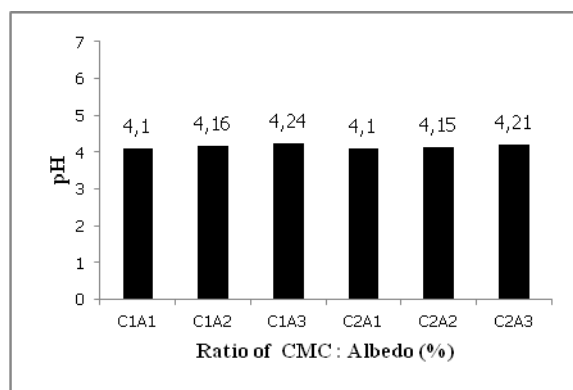


Figure 2. The Effect of Adding CMC and Watermelon albedo Juice on the pH of Yogurt.

In the C1A1 and C2A1 treatments or without adding watermelon albedo, a pH level range of 4.1 was obtained. According to SNI (1998), fresh milk has a degree of acidity (pH) ranging between 6-7. The albedo of watermelon has a pH that tends to be neutral, namely around 6.5 [28].

Syneresis Test

Syneresis states the gel's ability to retain water during storage [6]. Syneresis provides an illustration of the ability of the paste or gel to trap water and shows the stability of the paste [7]. Syneresis causes changes in the physical quality of a beverage product. Therefore, one of the efforts that can be made is by adding stabilizers from hydrocolloids such as gelatin, carrageenan, xanthan and CMC. The effect of adding CMC and watermelon albedo juice at various concentrations on yogurt syneresis can be seen in Figure 3. The average syneresis observation results show that the addition of CMC and Albedo watermelon juice has a significantly different effect on yogurt syneresis. The higher the concentration of CMC and watermelon Albedo Juice given, the lower the yoghurt syneresis. From this graph it can be seen that the syneresis of yogurt with the higher watermelon albedo concentration given, where the addition of 30% watermelon albedo juice has the lowest syneresis both with the addition of CMC and without the addition of CMC. The decrease in syneresis value is caused by watermelon having a sugar content of 6.2 gr/100 g. The sugar content in watermelon albedo has the ability to bind water so that syneresis can be reduced [31]. In principle, the formation of hydrocollid gel occurs due to the presence of a three-dimensional mesh or network which is formed which then traps a certain amount of water within it. The existence of this three-dimensional mesh causes solvent molecules to be trapped between them, immobilization of solvent molecules occurs and a rigid and tough structure is formed that is resistant to any force or pressure [31]. Therefore, the amount of water that comes out of the gel structure is less when CMC is added to the yogurt, as indicated by the decreasing syneresis value.

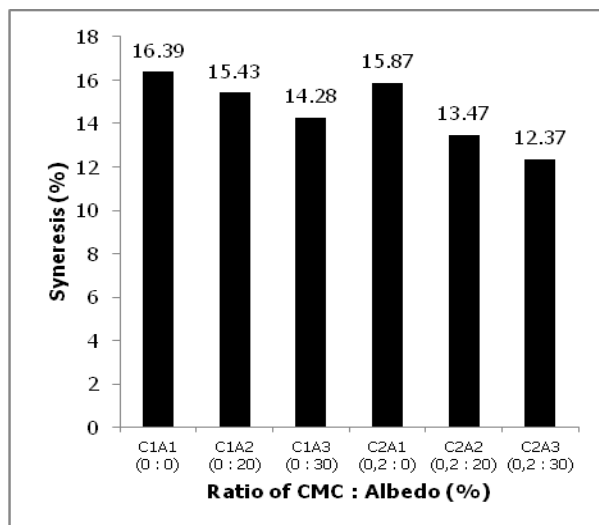


Figure 3. The Effect of Adding CMC and Watermelon Albedo Juice on Yogurt Syneresis Value

Viscosity Test

Viscosity shows the level of thickness of a product. The higher the product viscosity value, the thicker the product [9]. Viscosity measurements are used to determine changes in the viscosity of the yogurt product produced [12]. According to Koeswara [13] stated that the viscosity level parameter is very important for liquid products. A graph of the relationship between treatment and viscosity (Fig.4). The results of the diversity analysis showed that the addition of CMC and various watermelon albedo juice concentrations had significantly different effects on yogurt viscosity. Data on the influence of CMC concentration and watermelon juice albedo on yoghurt viscosity can be seen in Figure 4. The lowest viscosity of yoghurt was found in the C1A1 (CMC 0%: Albedo 0%) and C2A1 (CMC 20%: Albedo 0%) treatments, namely in the range 2511-3120 cP and the highest viscosity was found in the C1A3 (CMC 0%: Albedo 30%) and C2A3 (CMC 20%: Albedo 30%) treatments ranging from 3563-3759 cP. It can be seen that the treatment of adding various concentrations of CMC and watermelon albedo juice has a significantly different effect on the viscosity of the yogurt, where the higher the concentration of CMC and watermelon albedo juice used, the more the viscosity or thickness of the dough increases. The results of the diversity analysis showed that the addition of CMC and various watermelon albedo juice concentrations had significantly different effects on yogurt viscosity.

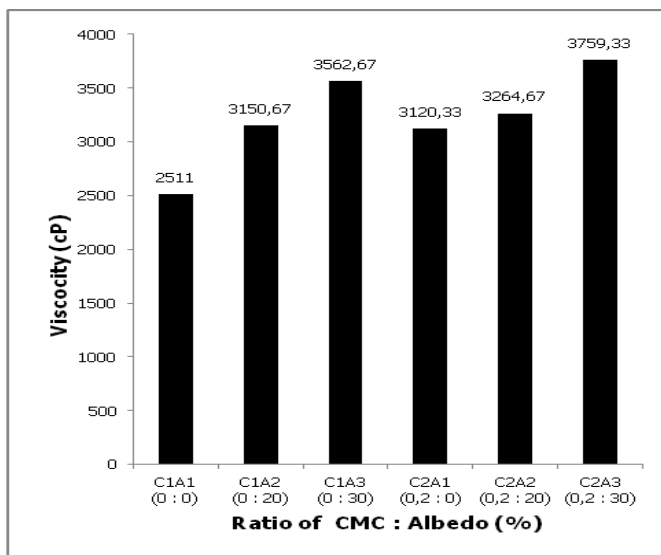


Figure 4. The Effect of Adding CMC and Watermelon Albedo Juice on Yogurt Viscosity Values.

As an emulsifier, CMC is very well used to improve the texture appearance of products with high sugar content. As a thickener, CMC is able to bind water so that water molecules are trapped in the gel structure formed by CMC ([7]. The amount of CMC required maintaining product stability depends on the viscosity level before consumption. Products containing large amounts of viscous solids require the addition of only small amounts of CMC. According to research [10], the use of CMC with a concentration of 0.2% added to pineapple juice probiotic drinks gives the best results because it has good stability and characteristics. According to Tyas [30], CMC is easily soluble in hot and cold water and can stabilize protein drinks at low pH. Fermentation causes the formation of acids which will cause the protein to clump in the milk. The CMC-protein complex will increase protein stability in fermented milk beverage products so that it will produce fruit-flavored probiotic drinks and stabilize yogurt. Na-CMC will be dispersed in water, then the hydrophilic Na-CMC grains will absorb water and swell. Water that was previously outside the granules and free to move, can no longer move freely so that the solution state is more stable [32]. This will cause particles to be trapped in the system and slow down the deposition process due to the influence of gravitational forces [18]. According to Dibiyanti [7], stabilizers have properties as emulsifiers which are characterized by the presence of polar (hydrophilic) and non-polar (hydrophobic) groups. When mixed with liquid food, the polar groups will bond with water and the texture of the food will become firm. Apart from that, watermelon albedo has fiber in the form of pectin, where the more watermelon albedo is added, the higher the pectin content of the yogurt. According to research conducted by Novitasari [17] on the quality of sheet jam using a combination of watermelon albedo and super red dragon fruit, from the extraction of watermelon albedo pectin, a pectin content of 0.88% was obtained. Meanwhile, the pectin content in sheet jam from a combination of watermelon albedo and super red dragon fruit. When treated with 300 gr of watermelon albedo without the addition of dragon fruit, the pectin content was 0.68%. According to Setianto, et al.,[22] stated that pectin is useful in gel formation and functions as a stabilizer. The higher the viscosity value, the syneresis value decreases, so the stability of the yogurt is better.

Aroma

Aroma is also one of the determinants of food quality so that it can be accepted by consumers [10]. The addition of watermelon albedo juice to yogurt had a significantly different effect on aroma parameters in the hedonic test results and aroma scoring test results. The effect of adding CMC and Watermelon Albedo Juice at various concentrations on the aroma of yogurt (Fig. 5). The contribution of LAB to the formation of yogurt aroma depends on their intrinsic potential to produce aroma compounds and on the way that this potential is (or is not) revealed during the fermentation process. Although much has been done for increasing the intrinsic potential for flavour enhancement of LAB, there are still some conundrums hindering the possible application in yogurt-making [7].

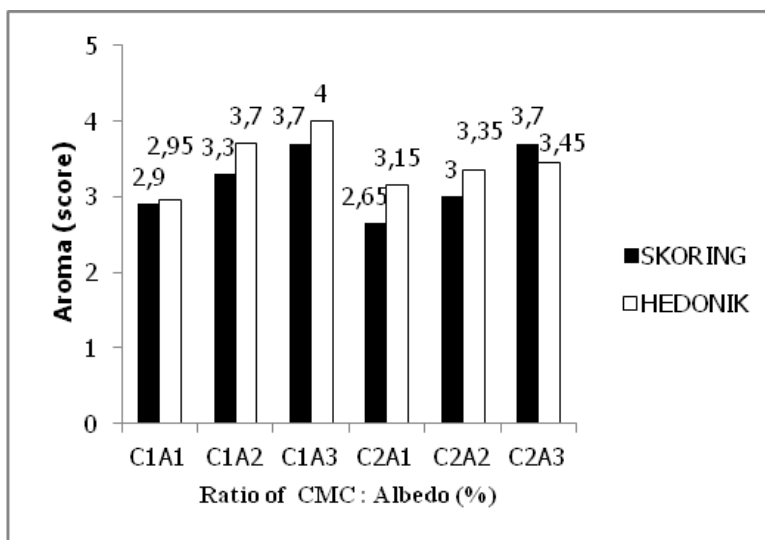


Figure 5. Effect of Adding CMC and Watermelon Albedo Juice on Yogurt Aroma

Analysis of the scoring test showed that the addition of CMC and Watermelon Albedo Juice gave a score of 2.65-3.7, which means that the panelists stated that yogurt did not have a typical watermelon aroma to a slight watermelon aroma. The hedonic test showed a value of 2.95-4, which means the panelists did not like or liked the yogurt product. This is thought to be because the strength of the aroma of watermelon albedo also increases with increasing watermelon albedo. The strong aroma is caused because the material contains volatile compounds that evaporate easily and are easily oxidized [10]. According to Harwanti [10],

aroma is a sensation that is formed from the combination of forming ingredients and their composition in a food which is captured by the sense of smell. Therefore, the aroma of a food is greatly influenced by the composition of the formula ingredients in the food. A product can be accepted by consumers if it has the desired aroma. Therefore, aroma is a sensory attribute that really determines consumer acceptance.

Taste

Taste is a very important parameter to determine the quality of a product according to consumer preferences. The taste is greatly influenced by the formulation and composition of the yogurt, the resulting taste is a combination of the distinctive taste of watermelon albedo and a slight sweet taste from the milk and sugar used. Based on the results of observations and treatment analysis results, adding watermelon albedo to yogurt had a significantly different effect on the results of the hedonic test and taste scoring. The relationship between the influence of adding CMC and watermelon albedo juice on the taste of yogurt (Fig. 6).

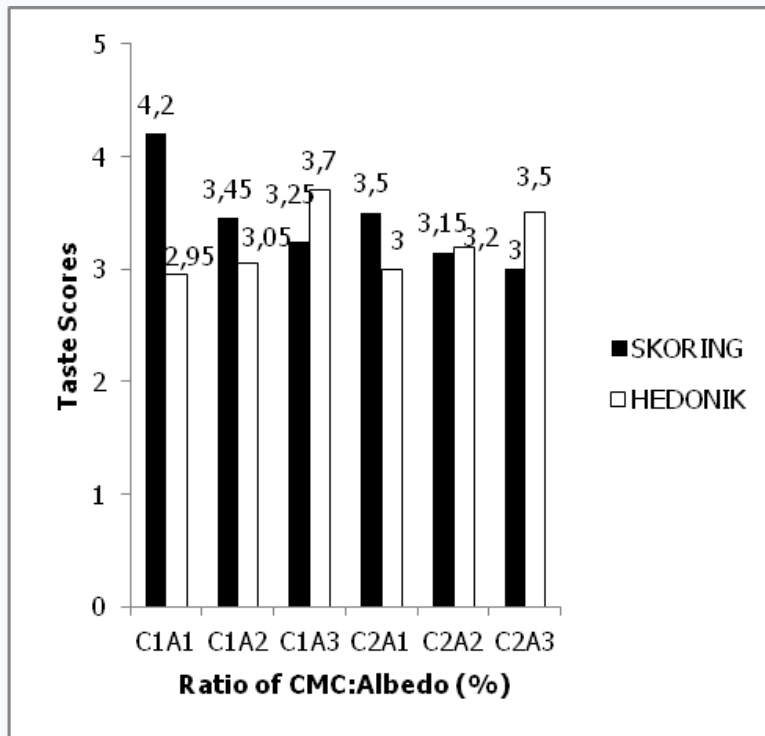


Figure 6. The Effect of Adding CMC and Albedo Watermelon Juice on Yogurt Taste.

On average, the panelists gave a score between 3-4.2 with the criteria being slightly sour to acidic. so that the amount of watermelon albedo juice affects the taste of the yogurt, where the watermelon albedo gives a slightly sweet taste. The albedo of watermelon has a pH that tends to be neutral of around 6.5 [30]. According to Potter [18], the characteristics of the stabilizer used are that it is odorless, and not solid. Many researchers reported that the exopolysaccharide could improve the texture of yogurt, because exopolysaccharide produced by LAB interacts with the free water in the gellike structure. The ingredients that make up yogurt are sugar and milk, where sugar functions as a sweet taste enhancer and milk can break down glucose into lactic acid [8]. Taste can be used as a reference for whether the product is suitable for consumption or not and as a determinant of product damage. According to Saleh [20], damage to the taste of yogurt can be categorized based on the cause, namely because the taste is not as the original taste of the ingredients, the typical taste of yogurt is sour with a slight sweet taste. This is caused by using acidic ingredients or due to the formation of lactic acid in the dough.

Texture

The results of the diversity analysis showed that the treatment of adding various concentrations of CMC and Watermelon Albedo Juice had significantly different effects on the organoleptic texture of yogurt.

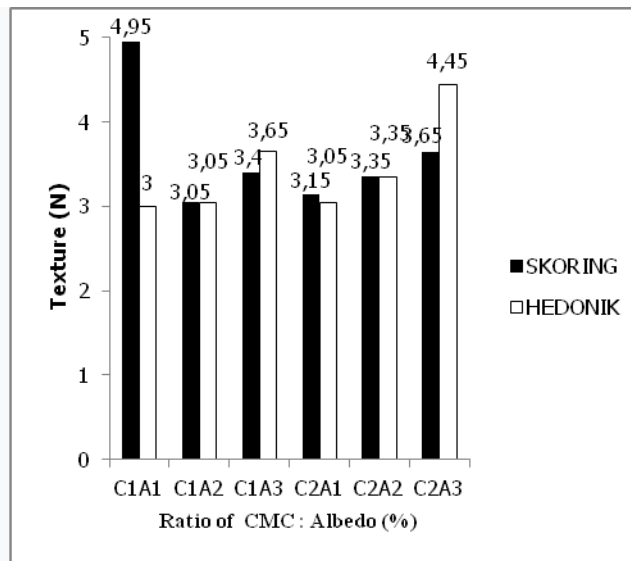


Figure 7. The Effect of Adding CMC and Watermelon Albedo Juice on Yogurt Texture.

On average, the panelists gave a score between 3.05-4.95 with the criteria being slightly thick to thick. By adding watermelon albedo, the texture of the yogurt is influenced by the water content in the mixture. In this research, it can be seen that the more watermelon albedo added, the thicker the yogurt texture. This is because albedo watermelon contains pectin which can act as a stabilizer. According to Zahro, *etal.*[33], stabilizers can reduce the concentration of free water in the dough by absorbing water and increasing the smoothness of the resulting texture [16].

IV. Conclusions

Based on the research results, it can be concluded that the addition of CMC at various concentrations has a significant influence on antioxidant activity, syneresis and yoghurt viscosity.

The addition of albedo watermelon juice at various concentrations had a significant effect on chemical parameters (antioxidant activity and pH) as well as physical parameters (syneresis and viscosity).

The organoleptic parameters added with CMC and albedo watermelon juice at various concentrations, including aroma, taste and texture in hedonic testing and scoring testing, had a significant influence.

The treatment with the addition of 0.2% CMC and 30% albedo watermelon juice (C2A3) was the best treatment with antioxidant activity of 29.67%, pH 4.21, syneresis 12.37%, and viscosity 3759.33 cP, as well as organoleptic analysis which included aroma with a liking level of somewhat liking (somewhat typical watermelon aroma), taste analysis with a liking level of somewhat liking (slightly sour) and viscosity analysis with a liking level of slightly liking (thick).

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