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The Effect Of Adding CMC (*Carboxymethyl Cellulose*) On The Quality Characteristics Of Carrot-Lemon Juice

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ABSTRACT

The combination of carrot and lemon juice has low stability and tends to produce sediment. The addition of a stabilizer, such as CMC (Carboxy Methyl Cellulose), is necessary to improve stability. The objective of this study was to determine the effect of CMC addition and to identify the CMC concentration that yields the best characteristics in carrot-lemon juice. The CMC concentrations used in this study were 0%; 0.1%; 0.2%; 0.3%; and 0.4%. The results were analyzed using a One-Factor Complete Randomized Design (CRD) with 5 levels and 3 replicates. This study employed an ANOVA statistical test with a significance level of 0.05. Duncan's multiple range test was conducted for samples showing significant differences. Based on the results, different CMC concentrations affected the stability, viscosity, pH, total dissolved solids, hedonic viscosity, and viscosity score of the carrot-lemon juice beverage. Based on the best dominant values, the beverage with a 0.3% CMC addition yielded a stability value of 100%, viscosity of 19.28 cP, pH of 4.21, total soluble solids of 11.97°Brix, hedonic color score of 5.2 (liked), color test score of 4.9 (brownish orange), hedonic aroma 4.9 (liked), aroma score 4.8 (not musty), hedonic taste 5.0 (liked), taste score 4.9 (sour), hedonic texture 4.9 (liked), and texture score 4.41 (somewhat thick). The total dissolved solids parameter complies with SNI 3719-2014 regarding fruit juice beverages.

Keywords: *carrot, CMC, fruit juice, lemon, quality*

1. INTRODUCTION

Carrots have the advantage of their antioxidant content, particularly β-carotene, which is a provitamin A and the natural source of the orange color in carrots [1]. β-carotene plays a role in neutralizing free radicals that can trigger degenerative diseases [2]. The β-carotene content in raw carrots is reported to be 34.94% [3]. Various innovations have been developed to process carrots into diverse food products including carrot flour [4], [5], dodol, carrot sticks [6], jelly candies [7], and carrot drinks [8]. However, carrots have a drawback in the form of a musty odor that can reduce consumer acceptance. Therefore, a combination with other ingredients such as lemon, which has a stronger aroma, is required.

Lemon is a fruit rich in vitamin C and possesses high antioxidant activity. Lemon pulp extract has an IC50 value of 76.83 ppm, indicating strong antioxidant activity [9]. Additionally, lemon can help mask the earthy odor and provide a fresh taste to the product. The combination of carrot juice and lemon juice is considered capable of producing a refreshing beverage. Previous studies have shown that lemon juice is effective in reducing off-flavors, such as in aloe vera [10] and purple sweet potato syrup [11]. Therefore, the combination of carrot and lemon holds potential as a delicious and functional health drink.

However, the mixture of carrot and lemon juice has low stability, characterized by the formation of sediment due to settling particles, which makes the product's appearance less appealing and may reduce consumer acceptance. To address this, the addition of a stabilizer such as CMC (*carboxymethyl cellulose*) is necessary. Simanullang et al. (2018) reported the effectiveness of several stabilizers in salak fruit juice, including CMC, gum arabic, and gelatin. CMC is capable of forming a colloidal dispersion system and increasing viscosity so that suspended particles remain dispersed and do not settle quickly [12]. Additionally, CMC improves the color, flavor, and consistency of the product [13], and it is cost-effective and widely used in industry [14]. Based on previous research, the use of CMC at the appropriate concentration can produce beverages with good sensory quality. Therefore, this study aims to determine the optimal concentration of CMC in the production of carrot-lemon juice.

2. LITERATURE REVIEW

Previous studies have extensively explored the utilization of carrots in food products due to their high β-carotene content and antioxidant properties. Carrots are known to contain significant levels of β-carotene, which contributes to their nutritional value and health benefits [3]. The application of carrots in various processed products, such as beverages and fermented products, has shown that carrot addition can improve physicochemical and nutritional characteristics, including increasing water activity, protein content, and acidity [2], [8]. However, the presence of a characteristic musty odor remains a limitation that can affect consumer acceptance.

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The stability of fruit-based beverages is a critical factor affecting product quality and consumer acceptance. The use of stabilizers is necessary to prevent sedimentation and maintain uniformity in the product. Various stabilizers such as CMC, gum arabic, and gelatin have been applied in fruit juice processing [12]. These stabilizers influence physicochemical and sensory properties differently. For instance, gelatin can increase viscosity but may negatively affect sensory acceptance, while gum arabic may alter the pH of the product.

Among these stabilizers, CMC has been widely studied due to its effectiveness in improving beverage stability. CMC is capable of forming a stable colloidal system and increasing viscosity, thereby preventing particle sedimentation [13]. It has also been reported to improve the color, flavor, and consistency of beverages [14]. Several studies have demonstrated that the addition of CMC significantly affects viscosity, pH, total dissolved solids, and sensory characteristics of fruit-based beverages [15]. However, the effectiveness of CMC depends on its concentration, as excessive use may reduce consumer acceptance.

Despite numerous studies on carrot-based products, lemon utilization, and stabilizer application, limited research has focused on the combination of carrot and lemon juice with the addition of CMC at varying concentrations. Therefore, this study aims to evaluate the effect of CMC concentration on the characteristics of carrot-lemon juice and to determine the optimal formulation.

3. METHOD

3.1 Location and Time

The study, which began with the production of carrot-lemon juice with added CMC, followed by physical, chemical, and organoleptic tests, was conducted at the laboratory of PT. X in Depok, West Java. Antioxidant testing was performed at the Bogor Agricultural University (IPB) laboratory. This study was conducted from January 2025 to August 2025.

3.2 Equipment and Materials

The raw materials used in the production of carrot-lemon juice with added CMC were carrots and lemons obtained from the central market in Depok. Sugar and water were obtained from a convenience store, and CMC was obtained from a baking supply store in Depok. The materials used for testing were PCA medium, NaCl solution, 0.01 N iodine solution, kanji indicator, ascorbic acid, DPPH solution, methanol, and distilled water.

The equipment used to prepare the carrot-lemon juice with added CMC included a knife, a blender (Miyako), a strainer, a filter cloth, bottles, and an autoclave (Hirayama). The equipment used for testing included an analytical balance (Sartorius), Erlenmeyer flasks (IWAKI), beakers (IWAKI), measuring cups (IWAKI), volumetric flasks (IWAKI), an Ostwald viscometer (Cannon), a stopwatch (Casio), a bulb, pH meter (Metler Toledo), hand refractometer (ATC), burette (IWAKI), volumetric pipette (IWAKI), spray bottle, petri dish, micropipette (Eppendorf), test tube (IWAKI), test tube rack, incubator (Memmert), laminar air flow cabinet (ESCO), water bath, volumetric pipette (IWAKI), UV-Vis spectrophotometer.

3.3 Preliminary Research

A preliminary study was conducted to determine the optimal formulation of carrot-lemon juice. The carrot-to-water ratio was adjusted to 1:2, while lemon juice was diluted, with the best ratio found to be 10:90 based on hedonic evaluation. The preferred carrot-lemon ratio was 70:30, and 10% sugar was selected as the optimal concentration. The CMC range (0.1%–0.5%) was determined based on previous studies and sensory evaluation.

3.4 Procedure

The production of carrot-lemon juice followed a systematic process. Fresh carrots and lemons were sorted and washed, with carrots peeled and chopped prior to processing. Carrot juice was extracted by blending with water at a 1:2 ratio for 2 minutes and then filtered using cheesecloth, while lemon juice was obtained by squeezing and diluting at a 10:90 ratio. The extracted carrot and lemon juices were then mixed at a ratio of 70:30, followed by the addition of 10% sugar and CMC at varying concentrations (0%–0.4%). The final mixture was packaged in glass bottles and pasteurized at 70°C for 15 minutes.

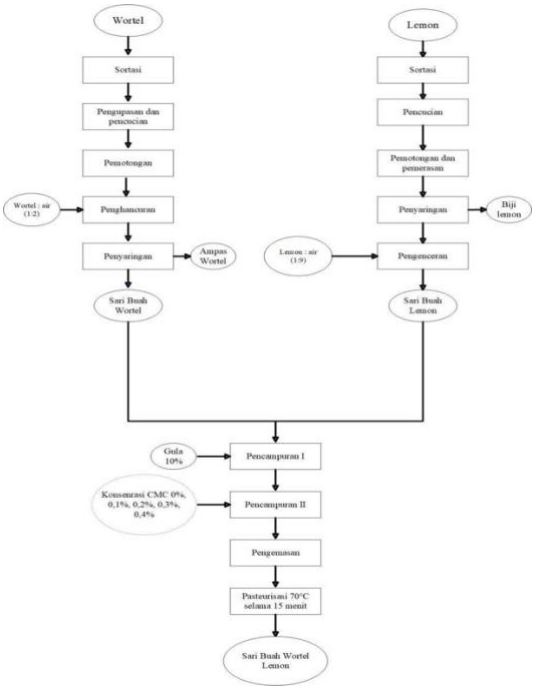


Figure 1. Flowchart of the production of carrot-lemon juice with the addition of CMC

3.5 Observation Parameters

Physical parameters included suspension stability and viscosity (Ostwald). Chemical parameters included pH and total dissolved solids (TDS). Organoleptic tests utilized hedonic and scoring methods (15 panelists). Supporting tests included antioxidant activity (DPPH) and total plate count (TPC).

4. FINDINGS AND DISCUSSION

4.1 Physical Characteristics

4.1.1 Stability Test

CMC is a stabilizer that helps maintain the stability of beverages to prevent sedimentation [15]. In the stability test of carrot-lemon juice with CMC addition, the stability ranged from 85.37% to 100.00%. The most stable samples were those treated with 0.3% and 0.4% CMC, with a stability value of 100%, while the least stable were the samples without added CMC, with a value of 85.37%. CMC concentration exerted a significant influence on the physical properties of the juice. As shown, stability reached its maximum at 0.3%.

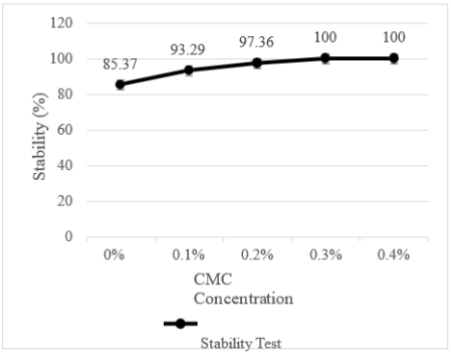


Figure 2. Stability test

4.1.2 Viscosity Test

The viscosity test results for carrot-lemon juice supplemented with CMC at different concentrations ranged from 1.62 cP to 51.83 cP. The highest viscosity value was found in the sample with 0.4% CMC supplementation, at 51.83 cP, while the lowest result was in the sample without CMC supplementation, at 1.62 cP.

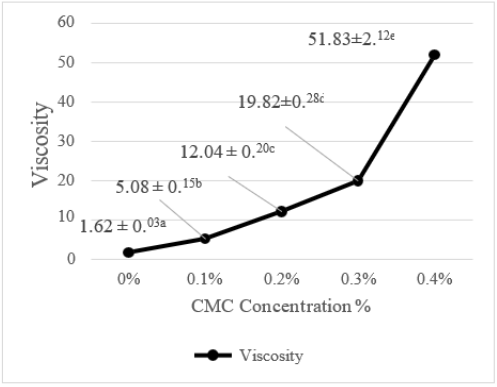


Figure 3. Viscosity test

The increase in stability can be explained by Stokes' law, which states that the settling velocity of particles is inversely proportional to the viscosity of the continuous phase. By increasing the viscosity, CMC reduces the rate at which carrot particles settle, thereby achieving 100% stability at 0.3%.

4.2 Chemical Characteristics

4.2.1 pH Test

pH indicates the concentration of hydrogen ions, which reflects the acidity level of a sample. The higher the acidity, the lower the pH; conversely, if the acidity is low, the pH value will be high [16]. The pH test results for carrot-lemon juice with added CMC at different concentrations ranged from 3.94 to 4.30. The highest pH value was found in the sample with a 0.4% CMC concentration, namely 4.30, while the lowest pH was in the sample without added CMC, namely 3.94. The increase in pH of the carrot-lemon juice beverage is due to CMC containing hydrolyzed carboxyl groups.

This property causes the total acidity to decrease and the concentration of hydrolyzed carboxyl groups to increase as more CMC is added [14]. CMC also has the property of binding components, forming a gel in the sample, which results in a slower decrease in pH when it is added at high concentrations. The best treatment in the pH test results was found in the sample with 0.4% CMC added, with the highest value of 4.30.

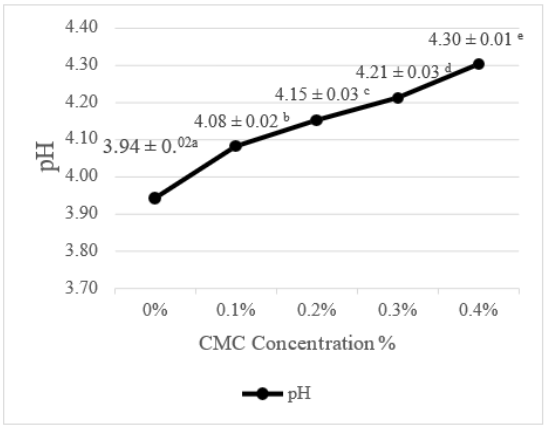


Figure 4. pH test

4.2.2 Total Dissolved Solids Test

The total soluble solids in the carrot-lemon juice with added CMC ranged from 11.47°Brix to 11.97°Brix. The highest total dissolved solids were found in the sample with a 0.4% CMC concentration, at 11.97°Brix, while the lowest total dissolved solids were found in the sample without CMC addition, at 11.47°Brix.

Total dissolved solids increased as the CMC concentration increased; this increased is likely due to the stabilizing agent binding free water, thereby increasing the amount of dissolved material. The more particles bound by the stabilizing agent, the higher the total dissolved solids [17]. The best treatment in the total soluble solids test was found in the sample with 0.4% CMC added, with the highest value of 11.97˚Brix.

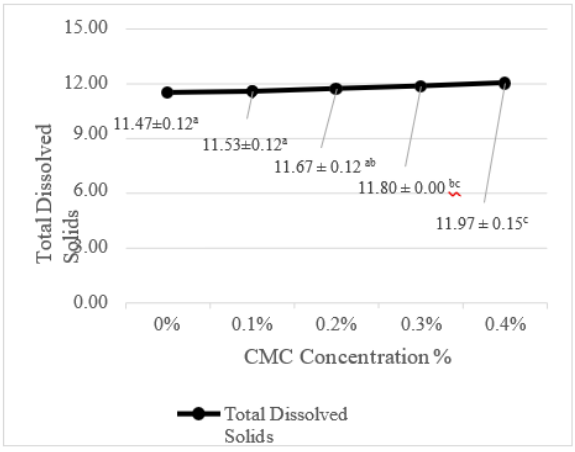


Figure 5. Total Dissolved Solids test graph

4.3 Organoleptic Characteristics

4.3.1 Color

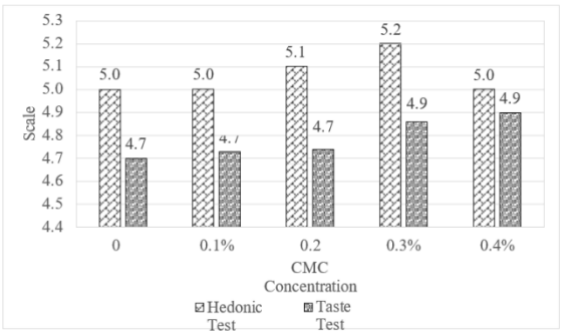


Figure 6. Color Test

The hedonic test results for the color of the carrot-lemon juice ranged from 5.0 to 5.2, with the highest average score of 5.16 (like) observed in the sample with a 0.3% CMC addition. The color score test results ranged from 4.7 to 4.9, with the highest mean value found in the sample with 0.4% CMC addition, namely 4.90 (orange–brownish orange). The ANOVA results indicate ($\alpha > 0.05$), H0 is accepted and H1 is rejected; therefore, it can be concluded that different CMC concentrations do not affect the hedonic scores and color scores of the carrot-lemon juice beverage, so no further tests are necessary.

4.3.2 Aroma

The carrot-lemon juice beverage ranged from 4.7 to 4.9, with the highest average score found in the sample with 0.3% CMC, which was 4.9 (like). The aroma score test results ranged from 4.7 to 4.8, with the highest average score found in the sample with 0.4% CMC added, which was 4.8 (somewhat not bitter–not bitter). As the concentration of added CMC increases, the hedonic values and aroma scores tend to increase.

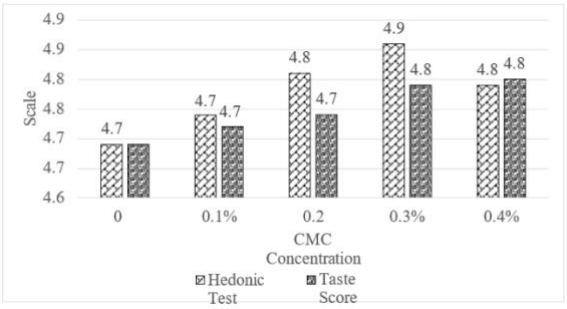


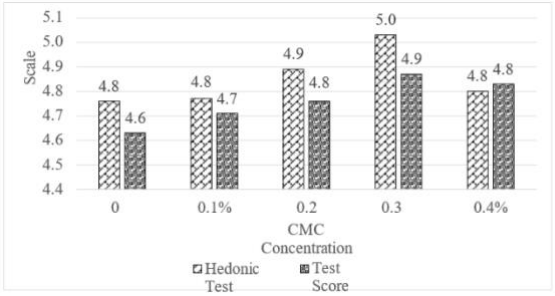
Figure 7 Aroma Test

The ANOVA results indicate ($\alpha > 0.05$) that H0 is accepted and H1 is rejected; therefore, it can be concluded that different concentrations of CMC do not affect the hedonic values and aroma scores of the carrot-lemon juice beverage, so no further tests are necessary. Carrots have a musty aroma because they contain terpenoids and volatile compounds. The characteristic aroma of raw carrots is caused by volatile components largely present in the carrots and the reaction of precursor compounds with flavor-forming enzymes. The best results in the hedonic test and aroma scores were found in samples with 0.3% CMC (4.86, “like”) and 0.4% CMC (4.80, “neither pungent nor non-pungent”).

4.3.2 Taste

The results of the hedonic test for aroma in the carrot-lemon juice beverage ranged from 4.8 to 5.0, with

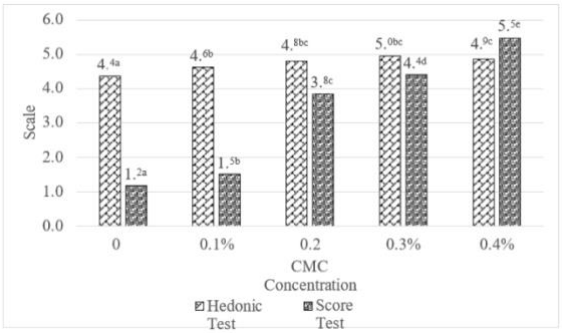
the highest average score found in the sample with 0.3% CMC addition, which was 5.0 (like). The aroma score test results ranged from 4.6 to 4.9, with the highest average score found in the sample with 0.3% CMC addition, which was 4.9 (slightly sour).



The ANOVA results indicate ($\alpha > 0.05$) that H_0 is accepted and H_1 is rejected; therefore, it can be concluded that different CMC concentrations do not affect the hedonic scores or aroma scores of the carrot-lemon juice beverage, so no further tests are necessary. The taste of the carrot-lemon juice beverage tends to be sour, which is due to the citric acid and ascorbic acid content in lemons [18]. The best results in the hedonic test and aroma scores were found in the samples with 0.3% CMC, namely 5.03 (like) and 0.3% CMC, namely 4.87 (slightly sour).

4.3.4 Viscosity

The results of the hedonic test for viscosity in the carrot-lemon juice beverage are shown in Table 23, ranging from 4.4 to 5.0, with the highest average score found in the sample with a 0.3% CMC addition, which was 5.0 (like). The viscosity score test results ranged from 4.4 to 5.5, with the highest average score found in the sample with 0.4% CMC addition, which was 5.5 (thick–very thick).



The results of the ANOVA test for hedonic ratings and viscosity scores indicate ($\alpha < 0.05$), meaning H0 is rejected and H1 is accepted; thus, it can be concluded that different CMC concentrations affect the hedonic ratings and viscosity scores of the carrot-lemon juice beverage. The increase in the viscosity of the carrot-lemon juice with CMC addition is likely due to the stabilizer's ability to form a gel with ions present in the juice, thereby increasing the juice's viscosity, stabilizing the suspension, binding particles or solids together, and exhibiting hydrophilic properties that can absorb water [17].

4.4 Supporting Test

4.4.1 Antioxidant Test

The antioxidant activity of star fruit juice that had undergone a heating process was classified as weak, at 2,650 ppm; this was influenced by the temperature during the processing [19]. The antioxidant activity test result for the carrot-lemon fruit juice was 50,525.72 ppm, classified as weak.

4.4.2 Total Plate Count Test

The Total Plate Count (TPC) test was conducted to determine the microbial contamination present in the best treatment, namely the carrot-lemon juice drink with 0.3% CMC added. The Total Plate Count (TPC) test results show that the TPC in the carrot-lemon juice beverage with added CMC is 5 colonies/mL. Comparing the SNI requirement with the test results obtained, the carrot-lemon juice with added CMC meets the SNI standard for fruit juice. These test results are likely due to the aseptic and hygienic conditions maintained throughout the production process, from juice preparation to packaging. The juice was pasteurized at 70°C for 15 minutes. The addition of CMC can increase viscosity in food products, which hinders the mobility of microorganisms and thereby suppresses their growth [19].

5. CONCLUSIONS

Based on the research results, it can be concluded that different CMC concentrations (0%; 0.1%; 0.2%; 0.3%; 0.4%) affect the stability, viscosity, pH, total dissolved solids (TDS), hedonic viscosity test, and viscosity score test of the carrot-lemon juice beverage. The optimal concentration of the carrot-lemon juice beverage with CMC addition was obtained at a CMC concentration of 0.3%. The best product characteristics were a stability value of 100%, viscosity of 19.83 cP, pH of 4.21, total soluble solids of 11.97°Brix, hedonic color score of 5.2 (like), color test score of 4.9 (brownish orange), hedonic aroma 4.9 (liked), aroma score 4.8 (not musty), hedonic taste 5.0 (liked), taste score 4.9 (sour), hedonic texture 4.9 (liked), and texture score 4.4 (slightly thick). A study was conducted on supporting quality parameters for the 0.3% CMC-added sample, yielding an antioxidant activity of 50,525.72 ppm and a total plate count of 5 colonies/mL. The addition of 0.3% CMC is sufficient because the resulting characteristics are the same as those from 0.4% CMC, making it more economical.

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