



Study on the effect of carboxymethyl cellulose (CMC) concentration on the quality of lacum fruit syrup (*Cayratia trifolia* (L.) Domin)

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ABSTRACT

Background : Syrup made from lacum fruit is one of the efforts to diversify processed products. The use of lacum fruit as a processed product has great potential in society, because the vitamin C content in lacum fruit has properties and benefits for the human body. **Method:** This study used a Randomized Block Design (RAK) with one factor, namely variations in CMC concentration with 5 levels, consisting of CMC 0%, CMC 0.5%, CMC 1%, CMC 1.5% and CMC 2%. **Findings:** CMC administration had a very strong tendency towards the characteristics of total dissolved solids, pH, the L* values obtained tended to increase but the a* (reddish) and b* (yellowish) values tended to decrease. **Conclusion:** The best lacum fruit syrup is syrup with a CMC concentration of 1% which produces an average chemical test in the form of a Total Dissolved Solids test of 45.80o Brix, a pH test of 3.93, an L color of 12.58, a* 2.52 and b* 0.26. The best sensory test results were color 3.81 (like), aroma 3.42 (like), taste 3.77 (like) and viscosity 3.77 (like). **Novelty/Originality of This Study:** This study explores the effect of varying carboxymethyl cellulose (CMC) concentrations on the physicochemical and sensory qualities of lacum fruit syrup. It provides new insights into the optimization of CMC for enhancing the quality of local fruit-based beverages.

KEYWORDS: carboxymethyl cellulose; lacum fruit; potential in society; syrup.

1. Introduction

Lakum (*Cayratia trifolia* (L.) Domin) is a plant that grows abundantly in West Kalimantan, has a lot of potential especially in the health and industrial sectors. This potential is supported by the fruit content which is a source of nutrients such as carbohydrates, proteins, fats, vitamins and minerals (Antarlina, 2009).

The use of lakum fruit as a processed product is very potential in the community, because the vitamin C content in lakum fruit has properties and benefits for the human body. One of the processed food products from lakum fruit is syrup. Syrup is a type of soft drink in the form of a thick solution with various flavors, usually has a sugar content of at least 65% (Satuhu, 1994). In general, stored syrup often experiences sedimentation and decreased quality, prevention can be done by adding ingredients to stabilize the syrup by adding Carboxymethyl Cellulose (CMC). According to Sopandi (1989), the addition of CMC aims to form a liquid with a stable and homogeneous viscosity but does not settle for a

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relatively long time. The use of stabilizers that are too high will cause the solution to become thick (Farikha et al, 2013). This will affect the physical characteristics of the syrup such as viscosity, color and total dissolved solids. The use of the right sweeteners and thickeners will produce syrup with the best physical and chemical characteristics so that it will be preferred by consumers. In the food industry, syrup is a viscous liquid product that is particularly prone to sedimentation and quality degradation during storage. This phenomenon is primarily caused by the instability of components within the syrup, such as sugars, acids, and bioactive compounds, which may precipitate over time. To address this issue, the addition of stabilizing agents such as Carboxymethyl Cellulose (CMC) has become a common strategy to enhance the stability and overall quality of syrup products.

CMC is a hydrophilic derivative of cellulose capable of forming stable colloidal solutions in water. This property allows CMC to increase both the viscosity and homogeneity of syrup, thereby minimizing the risk of sedimentation. A study by Zulfahmi et al. (2024) demonstrated that the incorporation of CMC into Chinese betel and white ginger syrup significantly improved viscosity and was well accepted in sensory evaluations, with an optimal concentration of 0.50%.

Furthermore, research by Duniaji and Budiarti (2015) revealed that a combination of 60% sugar concentration and 1.5% CMC produced purple sweet potato syrup with optimal physical and chemical characteristics, including a viscosity of 11.66 cP and a total soluble solids content of 75.60 °Brix. The addition of CMC also contributed to improved emulsion stability and pH levels, as observed by Agustina et al. (2017) in coconut water syrup.

However, careful consideration must be given to the concentration of CMC used. Excessive CMC can lead to an undesirable increase in viscosity, resulting in syrup that is overly thick and less appealing to consumers. For instance, Rahmaningtyas et al. (2017) found that adding CMC up to 1.25% significantly increased the viscosity of Bali salak syrup but also had the potential to negatively affect sensory acceptance.

In addition to viscosity, CMC influences other important parameters such as pH, total sugar content, and vitamin C levels. A study by Deviarni and Warastuti (2017) on pidada mangrove syrup indicated that both CMC concentration and heating duration had significant effects on viscosity and pH. Similarly, Augustyn (2024) reported that the addition of CMC up to 1.5% in kisar orange syrup resulted in higher total sugar content, increased pH, and improved vitamin C levels.

From a consumer preference standpoint, the appropriate amount of CMC can enhance the sensory qualities of syrup. Research conducted by Waliyurahman et al. (2019) on velva made from jicama tubers showed that adding 0.5% CMC yielded optimal texture and melting characteristics and was well received by panelists.

Overall, the use of CMC as a stabilizing agent in syrup production can significantly improve the physical stability, viscosity, and sensory quality of the final product. Nevertheless, it is essential to determine the optimal concentration of CMC for each type of syrup in order to achieve a balance between stability and consumer acceptance. Further research is recommended to explore the interactions between CMC and other syrup components, as well as their combined effects on the physical, chemical, and sensory properties of the end product.

The addition of CMC in lakum fruit syrup is expected to have a long shelf life and not experience a decrease in quality. However, until now the effect of adding CMC on the quality of lakum fruit syrup has never been studied, further research is needed on the effect of the concentration of stabilizers, namely carboxy methyl cellulose (CMC) on the characteristics of the lakum fruit syrup produced. The purpose of this study was to determine the best amount of CMC addition to the quality of the lakum fruit syrup produced.

2. Methods

This study employed a Randomized Block Design (RBD) with a single factor, namely the variation in Carboxymethyl Cellulose (CMC) concentration. The research involved five levels of treatment and was conducted with five replications for each treatment level. The

treatments were categorized as follows: S0 with 0% CMC concentration, S1 with 0.5%, S2 with 1%, S3 with 1.5%, and S4 with 2% CMC concentration. The research was conducted at the Food Design Laboratory, Faculty of Agriculture, Tanjungpura University, Pontianak for approximately six months.

2.1 Ingredients and tools

The main ingredient used is ripe purple lakum fruit (*Cayratia trifolia* (L.) Domin) obtained from Jungkat Village. The auxiliary materials used are water, granulated sugar, CMC (Carboxy Methyl Cellulose) and chemicals for analysis, namely distilled water and label paper. The tools used in this study are a stove, stirring spoon, cloth filter, frying pan, bowl, analytical scale, thermometer, refractometer, miyako mixer, funnel, dropper, Erlenmeyer flask, porcelain cup, measuring cup, and beaker

2.2 Making lakum fruit syrup

The making of lakum fruit syrup uses the modified method of Susanty (2017) and Fitriani (2020). The fruit is sorted and washed clean then drained. Furthermore, the fruit is boiled in a ratio of 1: 2 for 80°C for 10 minutes. Then the fruit is filtered and mashed using a spoon to produce fruit juice. The lakum fruit juice is then added with 60% granulated sugar (concentration % based on the amount of fruit juice) and CMC according to the treatment. Then it is cooked at a temperature of 65°C for 15 minutes until slightly thickened. After cooking, the lakum fruit syrup is then filtered with a cloth filter. Furthermore, the lakum fruit syrup is put hot into a bottle that has been sterilized beforehand, then the packaged syrup is pasteurized at a temperature of 75°C for 7 minutes. The results of the lakum fruit syrup are then analyzed for total dissolved solids, pH, color and hedonic tests including color, viscosity, taste and aroma.

2.3 Data analysis

The research data were analyzed statistically using the F test (ANOVA) with a test level of 5% to determine the effect of treatment. If it has a real effect ($F_{\text{count}} > F_{\text{table}}$), then it is continued with the DMRT (Duncan's Multiple Range Test), then the determination of the best treatment is carried out using the Effectiveness Index Test (De Garmo et al., 1984). The hedonic test data were analyzed using the Friedman method.

3. Results and Discussion

3.1 Total dissolved solids

Total dissolved solids (TPT) are the total elements or mineral elements dissolved in a solution. TPT is also called total sugar content, because the quality of the sweet taste of the fruit is measured by measuring the sugar content (Rivaldi et al., 2019). The results of the analysis of the total dissolved solids test of lakum fruit syrup at various CMC concentrations showed that lakum fruit syrup at various CMC concentrations had a significant effect on the Anova table so that a further DMRT test was carried out. The average value of TPT can be seen in Table 1.

Based on Table 1, the variation treatment of CMC addition has a significant effect on the TPT value. This is thought to be because the addition of CMC causes the total sugar to increase because the structure of CMC is a polysaccharide and has a polymer chain consisting of cellulose molecular units in the form of a linear chain and has many glucose components, so that with the increase in CMC, the total sugar will increase (Fitriyaningtyas & Widyaningsih, 2015).

Table 1. Average value of total dissolved solids of lakum fruit syrup

CMC Concentration (%)	Average $\pm$ STDEV
0	42.80 $\pm$ 2.77 ^a
0.5	43.40 $\pm$ 3.44 ^{ab}
1	45.80 $\pm$ 2.59 ^{abc}
1.5	46.80 $\pm$ 4.44 ^{bc}
2	47.00 $\pm$ 2.65 ^c

R Squared = 0.655 (Adjusted R Squared = 0.483)

Description : Numbers followed by the same letter are not significantly different based on the DMRT test.

Prabandari (2011) stated that increasing the concentration of stabilizers will be followed by an increase in the total amount of dissolved solids. The addition of stabilizers causes the total dissolved solids to increase because CMC is able to bind sugar, water, organic acids, and other components well. The stability of the solution increases because water, sugar, organic acids, and other components are bound so that the dissolved solids will be higher.

3.2 pH (Potential of Hydrogen)

pH analysis is one of the important parameters because the stable pH value of the solution indicates that the distribution process of the basic ingredients in the preparation is even. This pH value is also associated with the quality of the product related to the processing and preservation of food ingredients (Rienoviar, 2010). The pH analysis of Lakum fruit syrup shows that F Calculation is greater than F Table which shows that the pH value of the syrup has a significant effect on the Anova table so that further DMRT testing is carried out. The average pH value of the syrup can be seen in Table 2.

Based on Table 2, it can be seen that the results of the variation in the addition of CMC have a significant effect on the pH value of lakum fruit syrup with an average value of 3.30-4.23. The results of the study showed that the higher the concentration of CMC added, the higher the pH produced. This is thought to be because CMC is a salt of a strong base and a weak acid so that the solution will be more basic (Apriyantono et al., 1986). The hydrocolloid contained in high CMC causes the pH to increase because the hydrocolloid contains many carboxyl groups that will be hydrolyzed so that the pH value will be high (Manoi, 2006). The CMC concentration of 2% produced the highest average pH value compared to other treatments, this was influenced by the addition of CMC in higher concentrations and could cause an increase in pH in food and beverage products. This is because CMC has a carboxyl group, so the viscosity of the CMC solution is influenced by the pH of the solution (Isniawan et al., 2013). While the control treatment produced the lowest average pH, this was due to the absence of CMC addition in the treatment.

Table 2. Average value of pH test of lakum fruit syrup

CMC Concentration (%)	Average $\pm$ STDEV
0	3.30 $\pm$ 0.11 ^a
0.5	3.71 $\pm$ 0.15 ^b
1	3.93 $\pm$ 0.10 ^c
1.5	4.04 $\pm$ 0.14 ^c
2	4.23 $\pm$ 0.19 ^d

R Squared = 0.960 (Adjusted R Squared = 0.939)

Description : Numbers followed by the same letter are not significantly different based on the DMRT test.

3.3 Color

Color space is a mathematical model that describes how colors are represented in numbers (Rachmat, 2009). One of the color spaces is CIELAB. CIELAB is better known as the

CIEL*a*b color space where L is defined as lightness, which is determined by the Commission Internationale de l'Eclairage (CIE). The L, a * b * color space is modeled after another color theory that states that two colors cannot be red and green at the same time or yellow and blue at the same time (Bansal, 2012).

3.3.1 Color L

Lightness is a color level based on mixing with the White color element as a color element that gives the impression of a light or dark color. The color correction value in Lightness ranges from 0 for black to 100 for white (Putra et al., 2016). The average color value of L lakum fruit syrup is presented in Table 3. Based on table 4, the highest L* color value is found in syrup with a CMC concentration of 2%, which is 13.08, which means it is brighter and the lowest L* color is found in syrup with a CMC concentration of 0.5%, which is 12.34. The more CMC added to the treatment, the higher the color brightness value (L*). Novelina et al. (2007), if xanthan gum is dissolved in water, it will be cream-colored, while for the CMC stabilizer type, if dissolved in water, it will be clear so that the clarity level is higher than xanthan gum.

3.3.2 Color a*

The a* value indicates a red-green color, with a positive a* value (+) meaning red and a negative a* value meaning green. The a* value in the syrup is positive (+), which indicates that the color of the lakum fruit syrup tends to be red. The average a* color value of the lakum fruit syrup is presented in Table 3. Based on the table, the a* color value of the addition of CMC affects the a* color value of the syrup with an average of 1.84-3.90.

The highest value is found in syrup with 0% CMC treatment of 3.90 and the lowest value is found in syrup with 2% CMC treatment of 3.90. This indicates that the more CMC added to the syrup causes a decrease in the red color, this is because CMC can interact with color pigments, especially anthocyanins. This interaction can change the structure or stability of the pigment, so that it can affect the intensity of the red color and cause a decrease in the a* value (Castañeda-Ovando et al., 2009).

3.3.3 Color b*

The b* value indicates blue and yellow colors where b+ is yellow and b- is blue. The b* value is positive (+), which indicates that the color of the lakum fruit syrup tends to be yellow. The average a* color value of the lakum fruit syrup is presented in Table 3. Based on the table, it can be seen that the results of the variation in the addition of CMC to the b* color value of the lakum fruit syrup have no significant effect with an average value of 0.26-0.74. The 0.5% treatment has the highest average value compared to concentrations of 0%, 1%, 1.5% and 2%, namely 0.74. This is because CMC has no color. Tranggono (1990), CMC is a substance with a white or slightly yellowish color, odorless and tasteless, and in the form of fine granules or powder that is hygroscopic.

Table 3. Average color value of lakum fruit syrup

CMC Concentration (%)	Color L	Color a*	Color b*
0	12.70 ± 1.01	3,90 ± 2.54	0.66 ± 1.14
0.5	12.34 ± 1.86	2,28 ± 1.26	0.74 ± 0.37
1	12.58 ± 0.83	2,52 ± 1.21	0.26 ± 0.75
1.5	12.54 ± 1.06	2,68 ± 0.87	0.46 ± 0.88
2	13.08 ± 1.24	1,84 ± 1.99	0.34 ± 0.26

3.4 Organoleptic test of lakum fruit syrup

Organoleptic testing was carried out with the aim of determining the quality value of

color, taste, aroma and viscosity of the syrup using the hedonic test method (preference). The level of preference in the hedonic test is called the hedonic scale (Rahayu, 1998). The hedonic scale uses 5 numeric scales ranging from dislike to very much like (Amriani et al., 2019). The test was carried out by 30 untrained panelists by providing 5 samples that had been given random codes. The results of the hedonic test data were then processed using the Friedman test or better known as "Analysis of Variance on Ranks". The data from the Friedman test on the hedonic lakum fruit syrup can be seen in Table 4.

Table 4. Average organoleptic test value of lakum fruit syrup

CMC Concentration (%)	Average $\pm$ STDEV			
	Color	Flavor	Aroma	Viscosity
0	3.85 $\pm$ 0.92	3.65 $\pm$ 0.78	3.23 $\pm$ 0.97	2.88 $\pm$ 0.91
0.5	3.81 $\pm$ 0.90	3.81 $\pm$ 0.86	3.31 $\pm$ 0.86	3.81 $\pm$ 0.92
1	3.81 $\pm$ 1.06	3.77 $\pm$ 0.77	3.42 $\pm$ 0.95	3.77 $\pm$ 0.83
1.5	3.85 $\pm$ 0.95	3.38 $\pm$ 0.73	3.19 $\pm$ 0.96	3.54 $\pm$ 1.02
2	3.85 $\pm$ 0.93	3.46 $\pm$ 0.99	3.08 $\pm$ 1.07	3.27 $\pm$ 1.26
<i>P</i> (Asymp. Sig)	0.841	0.074	0.335	0.000

Description : If $P < 0.05$ then there is a real effect, if $P > 0.05$ then there is no real effect

Color is a parameter that can be tested directly by the panelist's sense of sight (Shofiati et al., 2014), which determines the level of consumer acceptance of a product (Harun et al., 2013). Visually, the color factor greatly determines the quality and has a role for consumers in a product. Based on the results of the Friedman test ($\alpha = 0.05$) it shows that the P value > 0.05 so that it can be seen that the color of the lakum fruit syrup has no real effect on the addition of CMC.

Taste is a sensation formed from the combination of the composition of ingredients in a food product that is captured by the sense of taste (Hartatie, 2011). Taste is the most important factor in terms of the acceptance of a food product by consumers. Taste testing is done by tasting it with the tongue's sense of taste. The taste of a food ingredient can come from the nature of the ingredient itself or because of other substances added to the processing process so that the original taste is reduced or maybe better (Polnaya and Breemer., 2016). Based on the results of the Friedman test ($\alpha = 0.05$) shows that the P value > 0.05 so that it can be seen that the taste of lakum fruit syrup has no significant effect on the addition of CMC. The addition of various concentrations of carrageenan does not affect the taste because CMC is a Food Additive (BTP) that has no taste. Tranggono (1990), CMC is a substance with a white or slightly yellowish color, odorless and tasteless, and in the form of fine granules or powder that is hygroscopic.

Another additional ingredient that can affect the level of acceptance of the taste of lakum fruit syrup is the added sugar. According to Nicol (1979) the main function of sucrose as a sweetener plays an important role, because it can increase the acceptance of a food by covering up unpleasant tastes. The sweet taste of sucrose is pure because there is no aftertaste, namely a second taste that arises after the first taste.

Aroma is one of the parameters that determines consumer acceptance of a food (Pramitasari, 2010), because the aroma of food often determines the deliciousness of the food (Winarno, 2008). The aroma of a food product is tested by the sense of smell or it can also be done by the sense of taste through the taste that enters through the mouth to feel the aroma. Based on the results of the Friedman test ($\alpha = 0.05$) shows that the P value > 0.05 so it is known that the aroma in the lakum fruit syrup has no significant effect on the addition of CMC. The addition of CMC with various concentrations does not affect the aroma of each syrup produced. This proves that CMC with different concentrations does not affect the taste of the syrup aroma (Istiqomah et al., 2017).

Based on the results of the Friedman Test ($\alpha = 0.05$) shows that the value with Asymp.Sig < 0.05 so it is known that the viscosity of the lakum fruit syrup has a significant effect on the addition of CMC. Ganz (1997) stated that CMC has ionic properties of Na + carboxyl methyl cellulose (CMC) which can attract sediment particles contained in the syrup so that it can form a gel structure and increase viscosity. The addition of sugar to the syrup

can affect the level of viscosity. The higher the sugar concentration given, the higher the viscosity level.

3.5 Determining the best treatment with the effectiveness index

Determination of the best treatment on the results of the research on lakum fruit syrup with the addition of CMC was carried out using the method of De Garmo et al. (1984). The results of the calculation of the best treatment value with the treatment value (NP) are seen in Table 5.

Table 5. Best determination values of lakum fruit syrup

CMC Concentration (%)	Treatment value
0	0.46
0.5	0.51
1	0.57*
1.5	0.55
2	0.54

Description: (*) Best Treatment Value.

Based on table 5, it shows that the highest treatment value of lakum fruit syrup is in syrup with a CMC concentration of 1%. The best treatment value (NP) results in lakum fruit syrup produced an average chemical test in the form of a Total Dissolved Solids test of 45.80° Brix, a pH test of 3.93, color L 12.58, a* 2.52 and b* 0.26. The best sensory test results were color 3.81 (like), aroma 3.42 (like), taste 3.77 (like) and viscosity 3.77 (like).

In evaluating the optimal concentration of Carboxymethyl Cellulose (CMC) in lacum fruit syrup (*Cayratia trifolia*), the Effectiveness Index method serves as a robust analytical tool. This method integrates multiple quality parameters—such as viscosity, pH, total soluble solids (TSS), color attributes, and sensory evaluations—into a singular composite score, facilitating a comprehensive assessment of treatment efficacy.

The Effectiveness Index method's strength lies in its ability to synthesize diverse quality metrics into a single evaluative framework. This holistic assessment is crucial, especially when optimizing food formulations where multiple attributes must be balanced to meet consumer expectations and product stability requirements.

Supporting this approach, Amar et al. (2020) investigated the impact of varying CMC concentrations on red guava syrup's stability and sensory qualities. Their study concluded that a 0.3% CMC concentration effectively maintained suspension stability over six weeks, with viscosity ranging from 1438 to 1516 cP and pH values between 7.51 and 7.73. Sensory evaluations indicated moderate acceptability, with scores around 4.5 for color, flavor, taste, and stability on a 7-point scale (Amar et al., 2020).

These findings underscore the utility of the Effectiveness Index in determining optimal additive concentrations in food products. By providing a comprehensive evaluation of both physicochemical and sensory attributes, this method ensures that the selected formulation delivers on quality, stability, and consumer satisfaction.

4. Conclusions

Based on the results of the study, it can be concluded that the administration of CMC has a very strong tendency towards the characteristics of total dissolved solids, pH, L* values obtained tend to increase but the a* (reddish) and b* (yellowish) values tend to decrease. The sensory characteristics of lakum fruit syrup produce a significant effect on viscosity, but no significant effect on color, taste and aroma.

The best lakum fruit syrup is syrup with a CMC concentration of 1% which produces an average chemical test in the form of a Total Dissolved Solids test of 45.80° Brix, a pH test of 3.93, color L 12.58, a* 2.52 and b* 0.26. The best sensory test results are color 3.81 (like), aroma 3.42 (like), taste 3.77 (like) and viscosity 3.77 (like).

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