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The Effect of Low Methoxyl Pectin and Sugar Concentration on Characteristics of Coconut (*Cocos nucifera* L.) Jam

Melanie Cornelia[1*], Ivana[1], Djohan Sofia[1], Candra Yulius Tahya[2]

[1]Food Technology Study Program, Universitas Pelita Harapan, Indonesia
[2]Chemistry Education Study Program, Universitas Pelita Harapan, Indonesia
* E-mail: melanie.cornelia@uph.edu

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ABSTRACT

Coconut is one of many kinds of fruit that grow in Indonesia. Coconut is well known as a nutritional and beneficial fruit, especially for health. Many consumers like coconut because it's delicious, cheap, and consists of many vitamins and minerals. The application of coconut on food product such as jam was suitable because freshly opened coconut with presence of oxygen became very easily damaged and usually contaminated by spoilage microorganism. Coconut jam was made by gelling agent low methoxyl pectin. Gelling properties in low methoxyl pectin are dependent on concentration low methoxyl pectin and sugar, so the effect concentration of low methoxyl pectin and the concentration of sugar were investigated. The concentration of low methoxyl pectin (0%, 0.5%, 1%, and 1.5%) and the concentration of sugar (0%, 10%, 20%, and 30%) were used in this research. And the result of this research could be concluded that increasing concentration of low methoxyl pectin and sugar, increased viscosity and consistency and decreased syneresis, whiteness, and a_w of coconut jam. The best jam formulation choosen was formulation with addition of 1 % of low methoxyl pectin and 20 % of sugar.

Keywords: coconut, jam, low methoxyl pectin, sugar

INTRODUCTION

Coconut (*Cocos nucifera* L.) is a plant that grow in various climates, especially countries with tropical climates. Indonesia is one of the largest coconut producing countries in the world (Shahbandeh, 2024). Processed coconut products are well known to the public such as soy sauce, *nata de coco*, coconut milk, copra, coconut oil, dry grated coconut, and various types of cookies (Moreno et al., 2020). Various kinds of food innovation products can be produced using coconut as the basic ingredient. Coconut flesh can also be processed into coconut jam. The main purpose of making coconut jam is to use coconut meat so that it does not spoil easily and has a long shelf life. Apart from that, the process of processing coconuts into coconut jam can be an alternative for consuming jam made from coconuts in the community (Moreno et al., 2020).

The process of making coconut jam is traditionally done by heating coconut meat with sugar until it reaches a certain level of viscosity. This processing process generally has various weaknesses that can affect the physical and chemical properties of coconut jam. Therefore, processing coconuts using thickening agents such as pectin is expected to improve the physical and chemical

properties of coconut jam products. Jam is a semi-wet food that can be spread which is made from processing fruit, sugar with or without the addition of other food ingredients and permitted food additives (Zhang et al., 2020). The fruit that is generally used as a basic ingredient for making jam is fruit with a high acid and pectin content. However, fruit with low acid and pectin content can also be processed into jam products by adding thickening agents such as pectin (Tafese, 2021).

The main purpose of this research was making jam from coconut of a certain age by adding the right amount of low methoxyl pectin (LMP) and sugar to produce jam with a good consistency.

MATERIALS AND METHODS

Materials and Tools

The materials used in the research were 8 month old and 10 month old coconuts from Rangkas Bitung, Banten. Commercial Low Methoxy Pectin (LMP) brand *KELCO GENUPECTINE LM-104 AS* , granulated sugar *GULAKU*, potassium sorbate preservative. The solutions used for analysis were H_2O_2, H_2SO_4, boric acid, selenium, potassium sulfate, NaOH (0.2 N, 10%), HCl (0.2 N, 37%), pp indicators, methylene blue and methyl red, petroleum bezene, glacial acetic acid, chloroform, saturated KI, $Na_2S_2O_3$, 1% starch, and Fehling's solution.
The equipment used in the research were ovens, desiccators, furnaces, magnetic stirrers, heaters, hand refractometers, pH meters, Aw meters, viscometers, consistometers, chromameters, Soxhlet for fat extraction, stopwatches, Buchner funnels, analytical scales, blenders, ash cup.

Raw Material Analysis

Raw material analysis done for proximate analysis of 8 month and 10 month old coconuts and determining the calcium and magnesium content and also total sugar in the best flesh and water of the coconut.

Determining Coconut Jam with the Best Aged Coconut

The ages of the coconuts used were 8 months and 10 months. The preference level test was carried out organoleptically by 70 panelists which included parameters of aroma, taste, color, texture, spreadability and overall characteristics. The best coconut jam will be selected as the basic ingredient for making coconut jam.

Determination of Formulation

The formulation was determined by variation of the composition of coconut flesh, coconut water, granulated sugar, and LMP, which will be used in the process of making coconut jam, and was carried out using the trial and error method for each parameter. The composition of fruit flesh and coconut water used is 1:1, 3:4, and 4:3 made in 1 coconut jam formulation. Organoleptic assessment which includes viscosity and spreadability parameters. The concentration of coconut flesh and water was chosen based on a physical assessment of the jam, namely jam that is not too runny but has good viscosity and spreadability on the surface of the bread. The sugar concentrations used are 10%, 30% and 65%. Organoleptic assessment of coconut aroma and taste parameters and sweetness level. The granulated sugar concentration chosen is a sugar concentration with an acceptable level of sweetness and a strong coconut aroma and taste. The LMP concentrations used were 0.5% and 2% with organoleptic assessment of the level of viscosity and spreadability. The LMP concentration chosen is based on a physical assessment of the jam, namely jam that is not too runny but has good viscosity and spreadability on the surface of the bread.

Coconut Jam Production

Coconut jam was made by weighing coconut meat and coconut water and mixing using a blender for 1 minute. The mixture was put into a beaker and 70 mg of calcium citrate per gram of pectin was added. The mixture was heated in a heater to a temperature of 80°C. Potassium sorbate preservative 300 ppm was mixed into coconut jam. Put the coconut jam in a sterile jam bottle and store it at refrigerator temperature (4°C)(Mayliana, 2010).

Analysis of Coconut Jam (AOAC, 2005)

Proximate analysis of coconut jam includes water content using the oven method, protein analysis using the Kjeldahl method, ash content using the furnace method, fat and carbohydrates (by difference). Physical analysis of total dissolved solids, level of syneresis, measurement of consistency, color and viscosity. Chemical analysis consists of pH measurements, aw measurements, quantitative analysis of carbohydrates, free fatty acid content, peroxide value content. Organoleptic testing with hedonic tests and scoring tests.

RESULTS AND DISCUSSION

Raw Material Analysis

The results of proximate analysis and data from the literature can be seen in Table 1. Coconuts aged 8 months have a higher water content than coconuts aged 10 months. The range of water content for coconuts aged 8 months is 85.26% to 87.24% and aged 10 months is 62.26% to 66.24% (Barlina et al., 2022).

Fat content is the second largest composition of coconuts. For 10 month old coconuts have a higher fat composition compared to 8 month old coconuts. Based on Table 1, it can be seen that there are differences between the results of the proximate analysis carried out and the literature. This can be caused by differences in environmental conditions for growing coconuts and differences in analytical tools, resulting in coconuts with different compositions.

The best raw material is 8 month old coconut which was selected based on organoleptic testing. Calcium and magnesium content analysis is carried out to determine the amount of divalent ions contained in the raw material. The divalent ion content is needed to help LMP work in gel formation. Gel formation in LMP requires the presence of divalent ions that bind to the carboxyl group (Sriamornsak, 2011). Test results and literature can be seen in Table 2.

The sufficient divalent ion content in jam can produce a strong gel structure without the presence of acid. Based on the results of the analysis, 8 month old coconut meat contains the most magnesium than calcium. The divalent ions needed to form the gel structure generally come from calcium (Sriamornsak, 2011). Therefore, based on the results of the previous analysis, the calcium content in coconuts is not large enough to form a gel, so it is necessary to add divalent ions to the coconut jam formulation so that the gel structure is better.

Testing the total sugar content of 8 month old coconut raw materials. The method used is the Lane Eynon method. The results of the analysis of total sugar content can be seen in Table 3.

The total sugar of meat and water from 8 month old coconuts is calculated as simple sugars such as glucose and fructose. Based on the data in Table 3, the total sugar in coconut water is higher than coconut meat, namely 15.58% from 100 grams of coconut water. The total sugar in 8 month old coconut meat is 10.09% of 100 grams of coconut meat. The sugar content in coconut water will decrease with increasing age of the fruit. The results of the analysis showed that the simple sugar levels contained in the water and meat

of 8 month old coconuts were quite high. Therefore, the use of sweeteners in making jam from 8 month old coconut can be reduced to obtain sensory characteristics that are preferred by the panelists.

Determining Coconut Jam with the Best Aged Coconut

Organoleptic preference level testing of 70 panelists which included parameters of aroma, taste, color, texture, spreadability and overall characteristics. The coconut jam with the highest level of preference is the best coconut jam that will be used in the main research. The organoleptic test results for coconut jam aged 8 months and 10 months can be seen in Table 4. Coconut jam from 8 months coconut and from 10 months one are differed significantly in the parameters of aroma, taste, texture and overall acceptability and did not differ significantly in the parameters of color and spreadability. Determining the best coconut age is done by looking at the average value for each parameter. A high average value indicates the best coconut jam based on the organoleptic assessment of the panelists. Based on Table 4, coconut jam from 8 months coconut has a higher average value compared to coconut jam of 10 months. Therefore, the jam chosen was coconut jam of 8 months (Uresti, R., López-Arias, N., Ramírez de León, J., Vázquez, M., 2003).

Determination of Formulation

Determining the formulation of coconut jam using the trial-and-error method aims to determine the best composition of coconut meat and water, granulated sugar and LMP to be used in the process of making coconut jam. The ratio of meat and coconut water in the experiment consisted of 3:4, 1:1, and 4:3. Coconut jam made with a ratio of 3:4 results in a semi-solid and slightly liquid jam texture. Coconut jam with a ratio of 1:1 and 4:3 results in a dense texture and is difficult to spread. The sugar concentrations used are 10%, 30%, and 65%. When making coconut jam with a sugar concentration of 65%, a strong sugar aroma and taste is obtained and the coconut aroma and taste is lost. Therefore, experiments with sugar concentrations of 10% and 30% were used. Making coconut jam with 10% sugar provides a strong coconut taste and aroma, while 30% sugar provides a coconut taste and aroma which starts to disappear and gives rise to a strong sugar aroma and taste. Therefore, the sugar concentration used as a factor is 0%, 10%, 20%, and 30%.

The concentration of LMP pectin which is generally used in the jam making process ranges from 0.5% to 1.5%. Experiments were carried out by making jam with LMP concentrations of 0.5% and 2%. At a concentration of 0.5%, the result was jam that was too runny, while at a pectin concentration of 2% the result was jam that was too hard. Therefore, the LMP concentrations used are 0%, 0.5%, 1%, and 1.5%.

Coconut Jam Analysis

From Figure 1a, it can be seen that the addition of LMP affects the total dissolved solids of the jam. Based on Figure 1b, it can be seen that the higher the LMP concentration, the whiteness degree increases. At sugar concentrations of 10%, 20% and 30%, the higher the pectin concentration, the higher the white degree value. At a sugar concentration of 0%, there was an increase in the white degree value at an LMP concentration of 1% and 1.5%. Therefore, according to research results, the higher LMP concentration will affect the color of coconut jam. Overall, it can be seen that in the overall sugar concentration, the higher the sugar concentration, the lower the white degree value. According to Buckle et al (1987), continuous heating of sucrose can change the color of the solution to brown.

Therefore, an increase in sugar concentration causes a brown color in coconut jam.

Based on Figure 1c, it can be seen that the higher the LMP concentration, the lower the consistency value of coconut jam. The consistency value of jam is influenced by the ability of pectin to form gel. The stronger the gel formed, the lower the consistency value. The higher the sugar concentration, the consistency value obtained tends to decrease. The consistency of jam is influenced by the gel-forming ability of LMP. The higher sugar concentration will increase the total dissolved solids which can increase the ability of LMP to form gel. In addition, a higher sugar concentration will increase the viscosity of the solution, thereby increasing the consistency of coconut jam.

Based on Figure 1d, it can be seen that increasing the LMP concentration, the pH value tends not to increase or decrease. The pH value measures the number of protons (H^+) which are acidic and hydroxide (OH^-) which are basic in a solution. The main difference is in the LMP concentration of 0% and the sugar concentration of 0%.

Based on Figure 1e, it can be seen that the higher the LMP concentration, the lower the syneresis level. The highest syneresis was found at an LMP concentration of 0.5% and a sugar concentration of 0%. Syneresis is strongly influenced by the ability of pectin to form gel. At certain LMP concentrations supported by sufficient sugar and calcium content, syneresis can be avoided. Syneresis generally occurs when the gel structure experiences mechanical damage. However, LMP has the ability to form a gel again if mechanical damage has occurred. Based on research, the higher the LMP concentration, the lower the syneresis percentage. The high percentage of syneresis at a concentration of 0.5% and 0% sugar could be due to the lack of total dissolved solids required by LMP so that the gel structure formed is not perfect and causes syneresis (Liang, Y., 2017).

Based on Figure 1e, it can be seen that the higher the sugar concentration, the lower the syneresis level of coconut jam. Therefore, a sugar concentration of 0% has a higher level of syneresis compared to concentrations of 10%, 20% and 30%. Increasing sugar concentration can reduce the percentage of syneresis in coconut jam.

Based on Figure 1f, it can be seen that the higher the LMP concentration, the higher the viscosity of coconut jam. LMP has a hard gel texture (Liang et al., 2017). Optimal gel formation in LMP occurs at a concentration of 1% or more (Rodriguez et al., 2008; Uresti et al., 2003). Optimal gel formation will increase the viscosity of the jam. The research results show results that are in accordance with the literature, namely the higher the LMP concentration, the higher the viscosity. The highest viscosity was found in a combination of 1% LMP concentration and 10% sugar concentration. Too much monovalent ion content can affect pectin's ability to form gel. Monovalent ions bind to the carboxyl group on the pectin molecule and affect the binding of the monovalent ion to the carboxyl group (Sriamornsak, 2011). Therefore, at the same LMP concentration it is possible to obtain different viscosity results due to the influence of monovalent ions from coconut meat and water. The higher the sugar concentration, the more dissolved solids there are in the solution, thereby increasing the intermolecular friction in the solution.

Based on Figure 1g, there is no significant difference between the LMP concentration and the aw value. The higher the LMP concentration, the lower the aw value. This is because pectin binds the free water present, thereby reducing the aw value. The aw value of jam products ranges from 0.8 to 0.9. In this range of aw values, it allows the growth of mold but minimizes the growth of mycotoxins. Therefore, based on the a_w value of jam with an LMP concentration of 1.5%, it is the most optimal concentration in

inhibiting the growth of destructive microorganisms. The difference in a_w values is found at a sugar concentration of 0% and a sugar concentration of 30%. The most optimal sugar concentration reduces the a_w value by 30%.

Based on Figure 2, it can be seen that the higher the LMP concentration, the better the spreadability. Spreadability is influenced by consistency. Jam that is too runny and has a high consistency value will be difficult to spread. On the other hand, jam that is too thick and has a low consistency value will also be difficult to spread.

Best Five Sample Scoring Test

Based on Figure 3, there is a significant difference between LMP concentration and sugar concentration on aroma, coconut taste and spreadability. The jam formulation that has the best coconut aroma, coconut taste and spreadability is jam with a concentration of 1% LMP and 20% sugar.

There is a significant difference between LMP concentration and sugar concentration on the color of coconut jam. The higher the LMP concentration and sugar concentration, the lower the white color assessment. There was no significant difference between LMP concentration and sugar concentration on the gritty texture of coconut jam. The jam formulation that has the lowest gritty (undesirable) texture is jam with an LMP concentration of 0.5% and 10% sugar. The gritty texture of jam products can be caused by the calcium content not being completely dissolved. Therefore, the gritty texture of coconut jam products can be caused by too much calcium citrate concentration being added and the heating process not being optimal in dissolving the calcium citrate. The jam formulation that was best accepted by the panelists was jam with an LMP concentration of 1% and a sugar concentration of 20%.

Analysis of Free Fatty Acids and Peroxide Number

Analysis of free fatty acids and peroxide value was carried out on the jam with the best level of preference. From the results of the analysis, there was no free fatty acid content and peroxide value on days 0 to 7 of storage. On day 10 of storage, there was a free fatty acid content of 0.7% which was calculated as oleic acid, but there was no free fatty acid content. Peroxide (Liang, Y., Guo, B., Zhou, A., Xiao, S., Liu, X., 2017). According to Nielsen (2010), the free fatty acid content indicates the breakdown of fat components due to poor storage, causing rancidity. The free fatty acid content of coconut samples stored until the 10th day was 0.7%, possibly originating from the breakdown of fat components. However, organoleptically, no rancid aroma was detected in the coconut jam.

CONCLUSION

Coconuts aged 8 months and 10 months can be used as a basic ingredient for making coconut jam. Coconut jam made using different aged coconuts produces different sensory characteristics. Coconuts aged 8 months have a higher level of preference in terms of aroma, taste, texture and overall characteristics. Differences in LMP concentration (0 %, 0.5 %, 1 % and 1.5 %) and sugar concentration (0 %, 10 %, 20 % and 30 %) have an effect on total dissolved solids, whiteness, consistency, pH value, syneresis percentage, viscosity, aw value, and organoleptic testing. Increasing the concentration of LMP and sugar increases viscosity and consistency and decreases the syneresis value, whiteness degree, and aw value. From the organoleptic test results, the coconut jam with the best acceptance was coconut jam with an LMP concentration of 1% and a sugar concentration of 20%. This best formulated jam has a nutritional content of 72.23% water content, 0.1% ash content,

0.24% protein content, 7.63% fat content and 19.8% carbohydrate content.

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Table 1. Comparison of Proximate Analysis Results for Coconut Fruit

Parameter	Research Analysis Data (% wet basis))		Research Analysis Data (%) Barlina *et al.* (2004)	
	Coconut meat (8 months)	Coconut meat (10 months)	Coconut meat (8 months)	Coconut meat (10 months)
Water Content	93.93	62.66	85.26 – 87.24	62.26 – 66.24
Ash Content	0.48	0.10	0.51 – 2.64	-
Protein Content	0.94	0.36	1.29 – 1.70	8.09 – 9.55
Fat Content	4.27	20.10	5.59 – 7.86	34.60 – 45.60
Carbohydrate Content	0.38	16.78	3.39 – 6.67	33.61 – 43.33

Table 2. Calcium and Magnesium Analysis Results

Parameter		Analysis (mg/100g) 8 month old coconut
Calcium content (Ca)	Coconut meat	34.00
	Coconut water	16.25
Magnesium content (Mg)	Coconut meat	258.20
	Coconut water	5.35

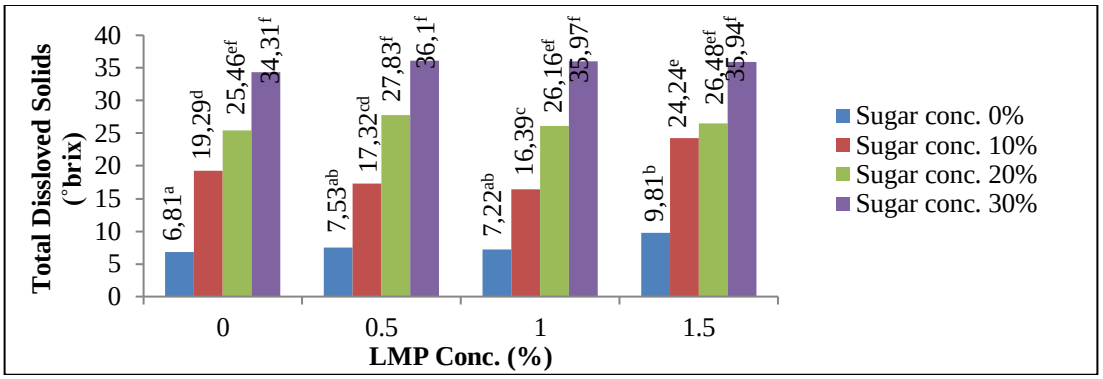
Table 3. Results of Total Sugar Analysis

Sample	Total sugar (%)
Coconut meat	10.09
Coconut water	15.58

Table 4. Organoleptic Data for Coconut Jam Aged 8 months and 10 months

Parameter	Coconut Jam (8 months of coconut)	Coconut Jam (10 months of coconut)
Aroma	3.59^{a}	2.56^{b}
Taste	3.26^{a}	2.37^{b}
Color	2.77^{a}	2.50^{a}
Texture	2.83^{a}	2.13^{b}
Spreadability	3.10^{a}	2.79^{a}
Overall	3.30^{a}	2.46^{b}

Note: Values with the same letter are not significantly different $\alpha = 0.05$


Total Dissloved Solids (°brix)
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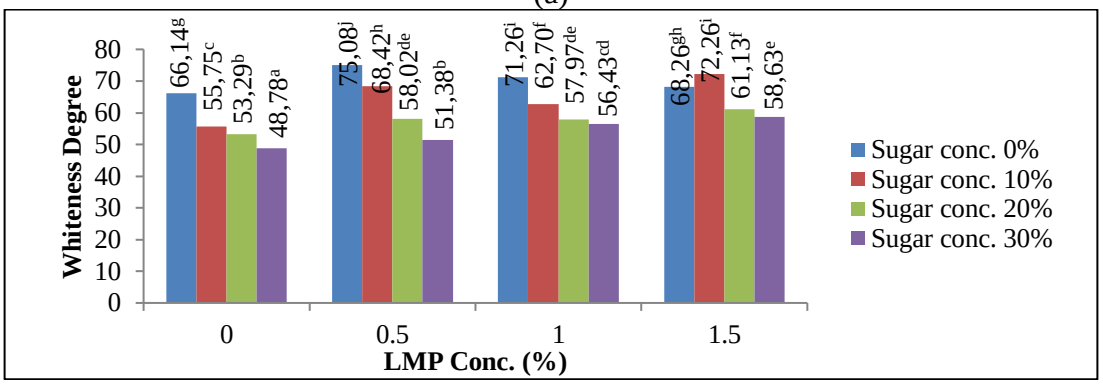
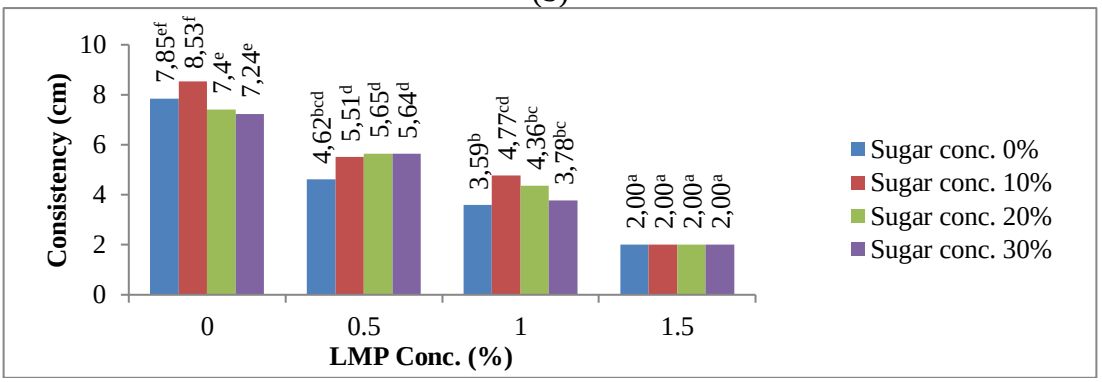
35
30
25
20
15
10
5
0
6,81a
19,29d
25,46ef
34,31f
7,53ab
17,32cd
27,83f
36,1f
7,22ab
16,39c
26,16ef
35,97f
9,81b
24,24e
26,48ef
35,94f
0
0.5
1
1.5
LMP Conc. (%)
Sugar conc. 0%
Sugar conc. 10%
Sugar conc. 20%
Sugar conc. 30%

(a)


Whiteness Degree
80
70
60
50
40
30
20
10
0
66,14g
55,75c
53,29b
48,78a
75,08j
68,42h
58,02de
51,38b
71,26i
62,70f
57,97de
56,43cd
68,26gh
72,26i
61,13f
58,63e
0
0.5
1
1.5
LMP Conc. (%)
Sugar conc. 0%
Sugar conc. 10%
Sugar conc. 20%
Sugar conc. 30%

(b)


Consistency (cm)
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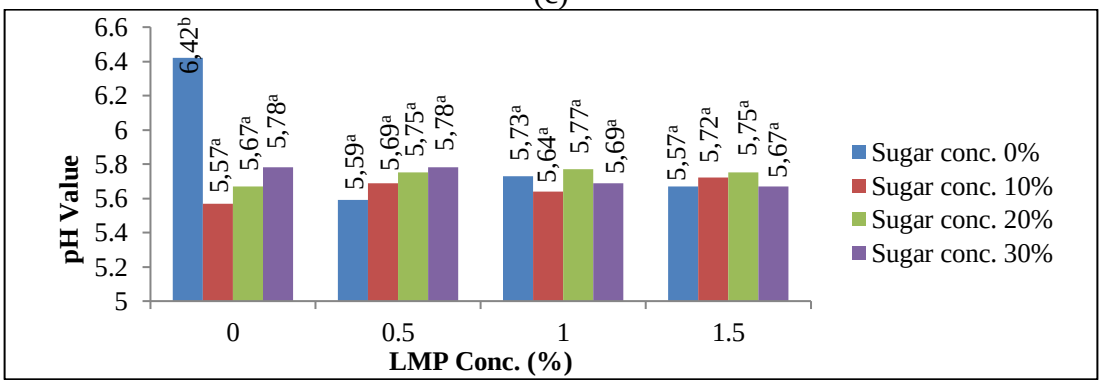
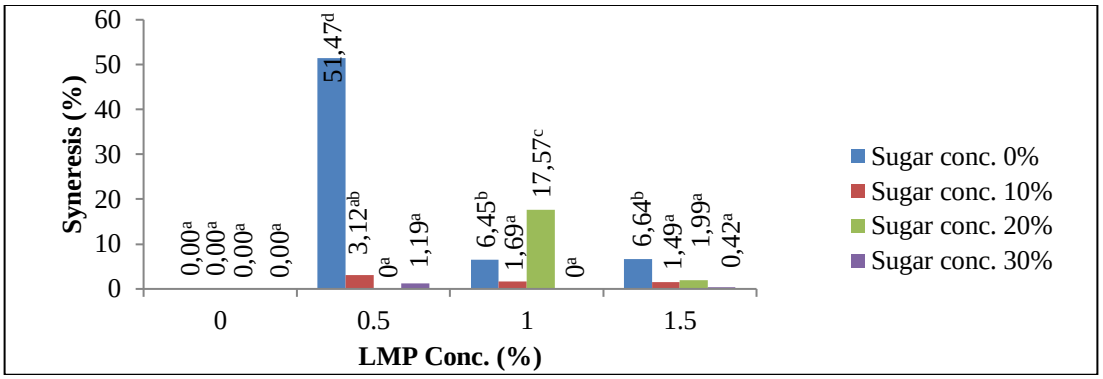
8
6
4
2
0
7,85ef
8,53f
7,4e
7,24e
4,62bcd
5,51d
5,65d
5,64d
3,59b
4,77cd
4,36bc
3,78bc
2,00a
2,00a
2,00a
2,00a
0
0.5
1
1.5
LMP Conc. (%)
Sugar conc. 0%
Sugar conc. 10%
Sugar conc. 20%
Sugar conc. 30%

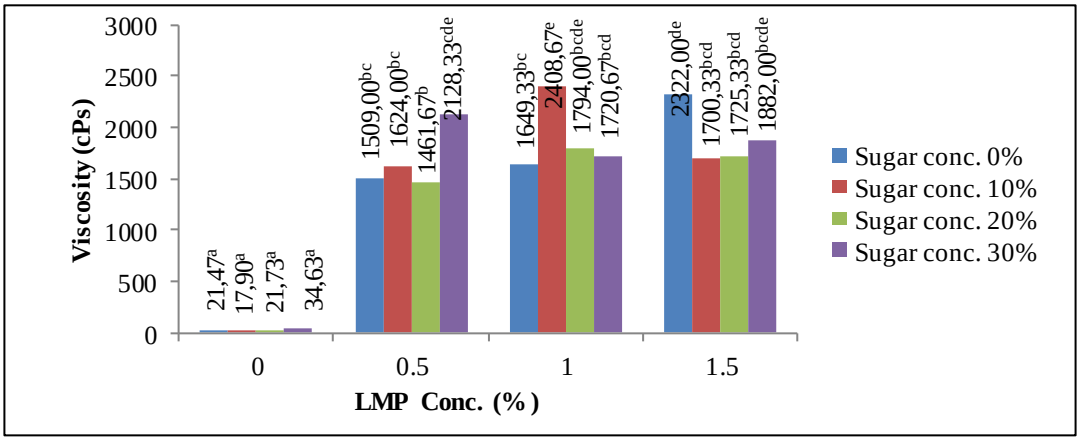
(c)


pH Value
6.6
6.4
6.2
6
5.8
5.6
5.4
5.2
5
6,42b
5,57a
5,67a
5,78a
5,59a
5,69a
5,75a
5,78a
5,73a
5,64a
5,77a
5,69a
5,57a
5,72a
5,75a
5,67a
0
0.5
1
1.5
LMP Conc. (%)
Sugar conc. 0%
Sugar conc. 10%
Sugar conc. 20%
Sugar conc. 30%

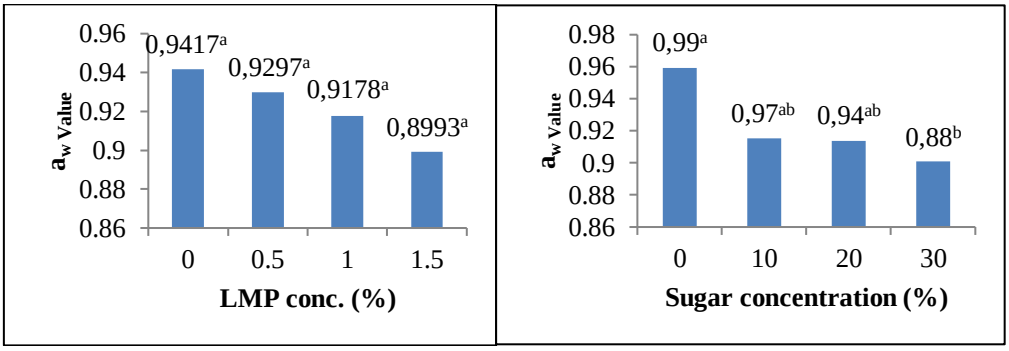
(d)



(e)



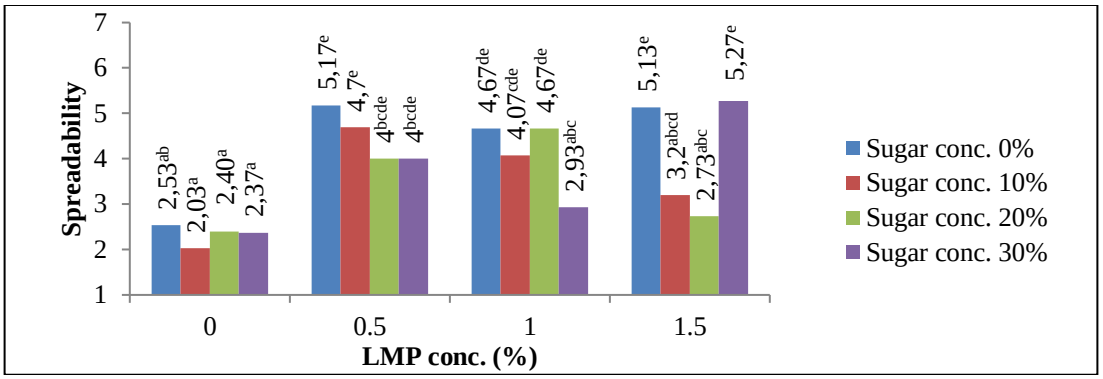
(f)



(g)

Note: Different notations for each concentration in each parameter show that they are significantly different (sig <0.05)

Figure 1. Average Value of Coconut Jam Analysis Parameters (a) total dissolved solids, (b) degree of whiteness, (c) consistency, (d) pH value, (e) syneresis, (f) viscosity, and (g) value a_w at LMP Pectin concentration (0%, 0.5 %, 1 %, and 1.5 %) and sugar concentration (0%, 10 %, 20 %, 30 %)



Note: Different notations for each concentration in each parameter show that they are significantly different (sig <0.05).

Figure 2. Average Value of Coconut Jam Analysis Spreadability Parameters at LMP concentration (0%, 0.5%, 1%, and 1.5%) and sugar concentration (0%, 10%, 20%, 30%)