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ENCAPSULATION OF MANGOSTEEN PEEL EXTRACT (*GARCINIA MANGOSTANA* L.) AS A NARUTAL INHIBITOR FOR SIWALAN SAP (*BORASSUS FLABELLIFER*)

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ABSTRACT

Mangosteen fruit (Garcinia mangostana L.) is generally only used for its flesh, approximately ¾ of which becomes waste, while the mangosteen peel has benefits as a natural preservative. This study aims to determine the effect of adding the percentage of encapsulation of mangosteen peel extract as a natural inhibitor of Siwalan sap. This study used a Completely Randomized Design (CRD) with 5 treatments repeated three times. The tests carried out included antioxidant activity, pH, shelf life, and organoleptic tests. Analysis of antioxidant activity and pH test data used ANOVA. If a significant difference is found, continue with the Tukey test. Analysis of shelf life test using linear regression, organoleptic analysis using the Friedman test. Based on the results of the study, it showed that the best treatment was obtained in treatment P5 (encapsulation of 10% mangosteen peel waste extract and 500 ml of Siwalan sap).

***Keywords**: Garcinia mangostana* L. *, Borassus flabellifer , Natural inhibitors, Encapsulation, Maltodextrin*

ABSTRAK

Buah Manggis (*Garcinia mangostana* L.) pada umumnya hanya di manfaatkan dagingnya, kurang lebih ¾ bagian menjadi limbah, sedangkan kulit Manggis memiliki manfaatnya sebagai pengawet alami. Penelitian ini bertujuan untuk mengetahui pengaruh penambahan persentase enkapsulasi ekstrak kulit Manggis sebagai inhibitor alami nira Siwalan. Penelitian ini menggunakan Rancangan Acak Lengkap (RAL) dengan 5 perlakuan diulang tiga kali. Uji yang dilakukan meliputi uji aktivitas antioksidan, pH, masa simpan, dan uji organoleptik. Analisa data uji aktivitas antioksidan dan pH menggunakan ANOVA. Apabila ditemukan beda nyata dilanjutkan dengan uji Tukey. Analisa uji masa simpan menggunakan regresi linear, analisa organoleptik menggunakan uji Friedman. Berdasarkan hasil penelitian menunjukkan bahwa perlakuan terbaik diperoleh pada perlakuan P5 (enkapsulasi ekstrak limbah kulit Manggis 10% dan nira Siwalan 500 ml).

Kata Kunci: Kulit Manggis, Nira Siwalan, Inhibitor Alami, Enkapsulasi, Maltodekstrin

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INTRODUCTION

Mangosteen (Garcinia mangostana L.) is one of the fruits that has high economic value and efficacy and has good prospects for development, especially in Mangosteen peel. Mangosteen peel has active compounds that act as antioxidants, anti-inflammatory, anticancer, anti-allergic, antibacterial, antifungal, antiviral, and antimalarial. The main components contained in Mangosteen peel are xanthone, tannin, and flavonoid compounds antioxidants, antiproliferative, and antimicrobials that are rarely found in other fruits (Khairul *et al*., 2022). Actually, the main function of antioxidants is to neutralize per-oxides known as free radicals. Free radicals are unstable molecules due to loss of electrons. To achieve stability, free radicals take electrons from molecules or cells in the body (Srihari *et al*., 2015) Mangosteen rind (Garcinia mangostana L.) contains alkaloids, saponins, triterpenoids, tannins, phenolics, flavonoids, glycosides and steroids. Saponins are active substances that can increase membrane permeability so that cell hemolysis occurs, if saponins interact with pathogenic bacteria, the bacteria will burst or lyse. Flavonoids are a group of phenolic compounds that have a tendency to bind proteins, thus disrupting the metabolic process. Tannins can inhibit the growth of pathogenic bacteria. Mangosteen peel has several properties including antimicrobial, strengthening the immune system, as an antioxidant, and inhibiting the growth of bacteria and fungi, reducing weight (Filianty *et al*., 2022). Encapsulation is a process of directly coating active substances in the form of fine particles of solids, liquid droplets, and dispersed forms. This technique is carried out by forming a thin wall coating around the material to be encapsulated. The encapsulation technique can provide protection to bioactive compounds from physical factors that can interfere with their stability (Iswantini *et al*., 2011). The encapsulation method in the food industry is carried out to protect the organoleptic properties such as color, taste, and odor of the substance to be encapsulated (Asri *et al*., 2021). Nira is a liquid obtained from the tapping of male Siwalan flowers which can be directly consumed as a fresh drink or fermented naturally into a traditional drink commonly called tuak or sopi. Fresh Siwalan sap has a sweet taste and a distinctive odor. The sweet taste of sap is caused by the content of sucrose, glucose, fructose. Siwalan sap contains 10 - 15 g / 100 cc of total sugar. Siwalan sap also contains vitamin C of 13.25 mg / 100 cc and has a pH of around 5-6. Siwalan sap carbohydrates are higher than carbohydrates from coconut sap and sugar cane sap (Falaach *et al*., 2022).

Siwalan sap is very susceptible to damage due to bacterial or microorganism contamination that changes sucrose into alcohol so that it turns into acid due to a decrease in pH in the sap which causes its shelf life to be very short. Some relevant research, one of which was implemented by (Soritua *et al*., 2015) regarding the content of compounds in Mangosteen peel such as alkaloids, saponins, triterpenoids, tannins, phenolics, flavonoids, glycosides, and steroids. One of the active compounds in Mangosteen peel that can damage bacterial cell walls is tannin, because tannin diffuses into the membrane and binds to microbial membrane proteins so that it can disrupt cell permeability. The content of active compounds in Mangosteen fruit can prevent sucrose degradation in the sap so that the total acid does not increase much. Therefore, Mangosteen peel is believed to be able to inhibit bacterial growth in the sap so that it can affect the pH of the sap and extend the shelf life of the sap. It is proven in research conducted by (Utomo, 2016) that natural compounds that can be used to inhibit the growth of S. cerevisiae yeast are chemical components

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that have the potential to be antimicrobials such as tannins and flavonoids found in jackfruit bark so that they can inhibit fermentation and pH can be maintained. S. cerevisiae is one of the yeasts that causes damage to sap. The results of the research that has been carried out show that the active compounds found in jackfruit wood are able to inhibit the growth of S. cerevisiae yeast. Thus, this study aims to determine the effect of chemical characteristics of encapsulation of Mangosteen peel waste extract (Garcinia mangostana L.) in Siwalan sap (Borassus flabellifer) on antioxidant activity, to determine the effect of adding encapsulation of Mangosteen peel waste extract as a natural inhibitor on the shelf life of Siwalan sap (Borassus flabellifer) and to determine the effect of adding encapsulation of Mangosteen peel extract (Garcinia mangostana L.) as a natural inhibitor of Siwalan sap (Borassus flabellifer) on panelist acceptance. With this study, it is expected to be able to produce a formulation of encapsulation of Mangosteen peel waste (Garcinia mangostana L.) as a natural inhibitor applied to Siwalan sap (Borassus flabellifer).

METHODS

The method used in this study was a Completely Randomized Design (CRD) consisting of 5 treatments and 3 replications so that 15 experimental units were obtained, namely: P0: 0% b/v (0 grams of Mangosteen peel encapsulation + 500 ml of Siwalan sap) P1: 3% b/v (15 grams of Mangosteen peel encapsulation + 500 ml of Siwalan sap), P2: 5% b/v (25 grams of Mangosteen peel encapsulation + 500 ml of Siwalan sap), P3: 6% b/v (30 grams of Mangosteen peel encapsulation + 500 ml of Siwalan sap), P4: 7% b/v (35 grams of Mangosteen peel encapsulation + 500 ml of Siwalan sap), P5: 10% b/v (50 grams of Mangosteen peel encapsulation + 500 ml of Siwalan sap). Observations to be carried out include testing the antioxidant activity of Mangosteen peel extract encapsulation using % Inhibition. The application test of Mangosteen peel extract encapsulation on Siwalan sap as a natural inhibitor includes pH test and Siwalan sap shelf life test using the pour plate method. The data obtained using the Minitab 19 software application to analyze variance (ANOVA) with a 95% confidence level ($\alpha = 0.05$) to determine whether there is an effect between treatments. Then if a significant difference is found, a Tukey test will be carried out. While the analysis of the shelf life test uses linear regression and for data analysis from the organoleptic test is calculated using the Friedman test.

RESULTS AND DISCUSSION

3.1 Antioxidant Activity of Mangosteen Peel Waste Extract Encapsulation

In the first stage of the study, the determination of antioxidant activity values in the encapsulation of Mangosteen peel waste extract without Siwalan sap used the DPPH (2,2-diphenyl-1-picrylhydrazyl) method which can

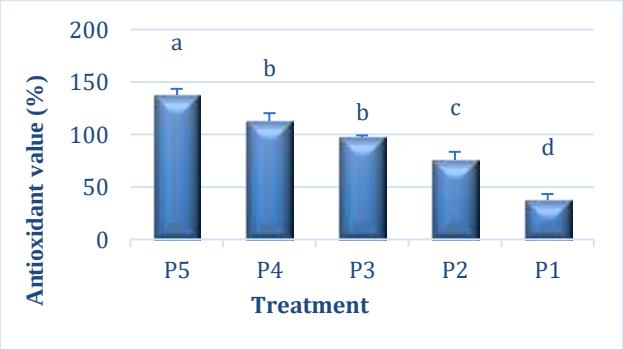

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Figure 1. Histogram of Average Antioxidant Activity

The highest antioxidant activity was obtained in the fifth treatment (P5) with a percentage of 10% encapsulation of Mangosteen peel applied to 500 ml of Siwalan sap. While the lowest antioxidant activity was obtained in the first treatment (P1) with a percentage of 3% encapsulation of Mangosteen peel waste extract applied to 500 ml of Siwalan sap. This is because the tannin and xanthone content in Mangosteen peel has antioxidant activity that is classified as active, so the more the concentration of preservatives used, the higher the antioxidant activity. This is supported by research (Raihanulah et al., 2023) that the more the concentration of temulawak preservative used as a preservative, the greater the antioxidant activity. Supported by research (Rusli et al, 2015) that the higher the addition of antioxidant compounds to the sample, the higher the percentage of inhibition, which means the higher the antioxidant content.

1.2 pH analysis

In the second stage of the study based on the results of the significance calculation (Tukey test) on pH measurements, there was a significant difference between each treatment. The average pH test results that have been sorted from the largest value in the encapsulation of Mangosteen fruit skin applied to Siwalan sap as a natural inhibitor are presented in Figure 2.

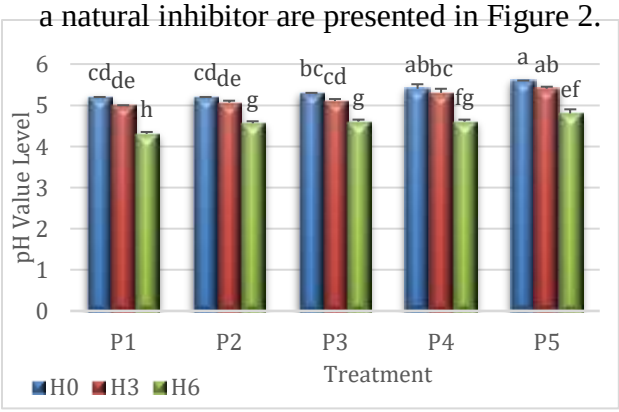

Figure 2. Histogram of the average pH value in the preservation of siwalan sap

Figure 2 shows the Tukey test on the treatment that has the highest pH value, namely treatment 5 (P5) with 10% or 50 grams of Mangosteen peel encapsulation on day 0. It can be seen that the addition of the percentage of encapsulation of Mangosteen peel waste extract has a significant effect on the pH value of Siwalan sap. The pH value in the application of Mangosteen peel encapsulation to Siwalan sap ranges from 4.3 to 5.6. The Mangosteen peel encapsulation treatment showed a higher pH value compared to the control treatment (without treatment). The pH value in the control sap (without treatment) decreased the fastest when compared to the sap that had been added with Mangosteen peel encapsulation. This is because the stability of the pH of Siwalan sap is influenced by the antioxidant activity in the encapsulation of Mangosteen peel waste extract which can neutralize free radicals that cause oxidation and decrease the pH of Siwalan sap. High antioxidant activity can slow down the formation of organic acids that occur during the storage of Siwalan sap, thus preventing a drastic decrease in pH. The encapsulation treatment of 10% Mangosteen peel applied to 500 ml of Siwalan sap obtained a higher pH value of 5.31. This shows that the higher the antioxidant activity in the encapsulation of Mangosteen peel waste extract, the more stable the pH of the Siwalan sap will be, this happens because Mangosteen peel contains active compounds in the form of tannins. The ability to preserve caused by tannin compounds can precipitate proteins and bind metal ions that can inhibit enzyme activity. If the sap is not preserved, the sap will experience the formation of alcohol (tuak) and fermentation will continue to produce acetic acid (Nurlina, et al 2019). The increasing encapsulation of Mangosteen peel in Siwalan

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sap, the pH value will be stable so that it can maintain the shelf life of Siwalan sap. It is suspected that the addition of natural preservatives with high concentrations can inhibit the decrease in pH in the sap. Natural preservative compounds in mangosteen peel can inhibit the conversion of sugar into alcohol and the formation of acetic acid in sap (Suganda et al., 2018). The storage time of sap has a significant effect on pH changes. This is because Siwalan sap undergoes a sugar destruction process that can lower the pH. This is supported by research conducted by (Mahulette et al., 2020) that a pH value below 5 indicates the formation of acetic acid due to the storage process. So, the longer the storage time of the sap, the pH tends to decrease. Mangosteen peel encapsulation can help prevent a rapid decrease in pH. This shows that the release of active compounds from Mangosteen peel can effectively suppress fungal activity in the short term. On the 3rd to 6th day, *S. cerevisiae* activity increased so that the pH continued to decrease. However, the rate of pH decrease in sap was slower than that of sap without treatment. Encapsulation of Mangosteen peel waste extract shows potential in inhibiting fermentation in Siwalan sap, this is because encapsulation of mangosteen peel waste extract contains high antioxidant activity so that it can allow Siwalan sap to be stored longer. The higher the antioxidant activity in the encapsulation of Mangosteen peel waste extract applied to Siwalan sap, the lower the rate of increase in pH in Siwalan sap caused by *S. cerevisiae* fermentation.

3.3 Total Yeast

The results of observations of total yeast in Siwalan sap (*Borassus flabellifer)* which has been preserved by encapsulating Mangosteen peel extract waste (*Garcinia mangostana L.)* using linear regression obtained a high

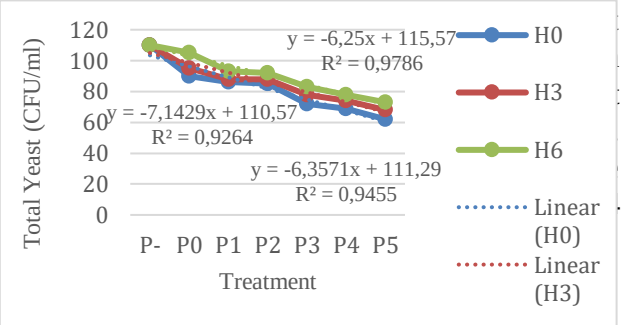

Figure 3 Total Changes in Siwalan Sap Yeast During Storage Based on Different Days

Figure 3 shows that there is a decrease in the total amount of yeast along with the increase in pH caused by the high antioxidant activity of the encapsulation of Mangosteen(*Garcinia mangostana L.*) peel waste extract in the process of inhibiting the activity of *S. cerevisiae* Siwalan sap. The higher the antioxidant activity of the encapsulation of Mangosteen peel waste extract, the more stable the pH of the Siwalan sap will be so that the rate of S. cerevisiae yeast activity will be inhibited. It can be seen that the total yeast during storage of the P5 treatment (10% Mangosteen peel waste extract encapsulation and 500 ml Siwalan sap) tends to be lower. While in the P0 treatment (without treatment) the total yeast tends to be higher and continues to increase along with the storage period. This is due to the high content of antioxidant compounds in the encapsulation of Mangosteen peel waste extract which can reduce yeast activity. Supported by the research of Firdaus et al. (2015) that the more tannin compound extract in coconut fiber substituted into the product, the greater its ability to inhibit the growth rate of microbes, so that it can extend the shelf life. The longer the fermentation that occurs, the more yeast activity will increase so that the carbohydrates that break down into alcohol will be higher (Prawati et al., 2015). The growth of S. cerevisiae yeast can affect the rate of pH, because yeast activity will carry out

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fermentation that produces organic acids, alcohol, and carbon dioxide so that the pH of the sap will be more acidic. Antioxidant compounds in the encapsulation of Mangosteen peel waste extract can affect yeast growth, this is because antioxidant compounds in the encapsulation of Mangosteen peel waste extract have the ability to inhibit yeast growth. That way, less active S. cerevisiae yeast activity, then organic acid production will decrease, which means the rate of pH decline will be slower. Tannin is one of the compounds in Mangosteen peel that can activate reverse transcriptase and DNA topoisomerase enzymes and can bind and interfere with protein transport in the inner layer of cells so that it can inhibit fermentation in sap. S. cerevisiae yeast consumes glucose to grow and reproduce and can convert it into metabolite products such as alcohol, CO2 and organic acids. Excessive sugar concentrations can cause environmental conditions to become hypertonic so that fluid in the cells flows out and causes dehydration and cell shrinkage (Insani et al., 2018).

3.4 Organoleptic Analysis of Appearance

Based on the results of organoleptic analysis conducted on 30 panelists, it shows that the value of the appearance of Siwalan sap that has been added with encapsulation of Mangosteen peel waste as a natural inhibitor ranges from 2.77-3.53, which means between dislike and sufficient. The histogram of the average results of the panelists' level of preference for the

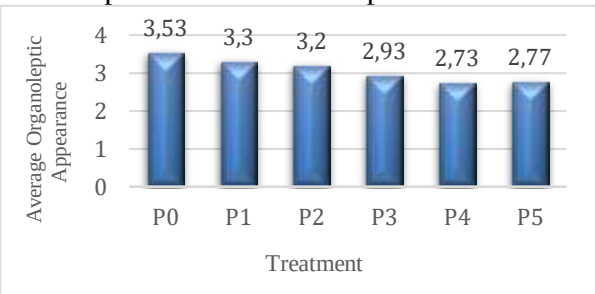

Figure 4 Average Organoleptic Appearance

The average panelist preference value for the Appearance of Siwalan sap that has been added with Mangosteen peel waste encapsulation has the lowest value of 2.73 from the percentage of P4 treatment (encapsulation of 7% Mangosteen peel waste and 500 ml of Siwalan sap) while the highest value is 3.53 from the P0 treatment (encapsulation of 0% Mangosteen peel waste and 500 ml of Siwalan sap). High antioxidant activity can maintain the stability of the pH of Siwalan sap and can inhibit the rate of fermentation caused by S. cerevisiae yeast. However, the application of encapsulation of Mangosteen peel waste extract with a high concentration can change the appearance of Siwalan sap to be cloudy, so that it is less preferred by panelists. Siwalan sap in acidic pH conditions will cause metal ions to precipitate, resulting in the formation of small particles that can reduce the transparency of the sap and can affect the viscosity of Siwalan sap. The results of the Friedman test indicate that the X2 table value is smaller than the calculated X, which means that there is a significant difference between each treatment. According to the panelists' notes, the appearance of Siwalan sap without treatment has fine and clear fibers, while the appearance of Siwalan sap with the addition of Mangosteen peel waste encapsulation treatment is rather cloudy. The encapsulation process can add a little turbidity to the sap caused by the encapsulation particles not being dispersed properly. The addition of encapsulation of Mangosteen peel waste extract contains anthocyanin compounds that give a reddish purple color, but when going through the encapsulation process, the dark color of the Mangosteen peel will be slightly covered. The higher the concentration added as a preservative to Siwalan sap, the more cloudy the appearance of the Siwalan sap will be. Fresh sap is very easily damaged by microbial activity which can

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reduce the quality of the sap which is indicated by changes to foamy and slimy, the longer the storage of sap without treatment, the sap that was originally clear will change to cloudy white (Agussalim et al., 2016). According to Adisetya et al., (2022), fresh sap has a transparent appearance, but during the storage process, the sap will turn cloudy.

3.5 Aroma Organoleptic Analysis

Based on the results of organoleptic analysis conducted on 30 panelists, it shows that the panelist's value for the aroma of Siwalan sap that has been added with encapsulation of Mangosteen fruit peel waste ranges from 4.03-4.33 which means they like it. The histogram of the average results of the panelists' level of preference for Siwalan sap that has been added

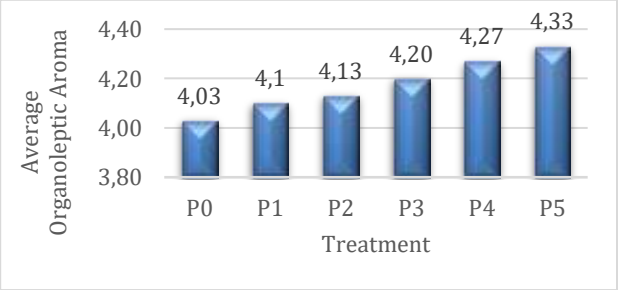

Figure 5. Average Organoleptic Aroma

The average panelist's preference value for the aroma of Siwalan sap has the lowest value of 4.03 from the P0 treatment or without treatment, namely 0% encapsulation of Mangosteen fruit peel waste and 500 ml of sap, while the highest value of 4.33 from the P5 treatment, namely 50% encapsulation of Mangosteen fruit peel waste and 500 ml of Siwalan sap. The aroma of Siwalan sap is influenced by changes in pH during storage. Siwalan sap stored with stable pH conditions will have a fresher aroma. If there is a significant decrease in pH due to fermentation of S. cerevisiae yeast, it can change the aroma to alcoholic and acidic. Based on the results of the Friedman test, it shows that the X2 Table value is greater than the calculated X value, which means there is no significant difference between each treatment. According to the panelist's notes, the aroma produced by Siwalan sap without treatment with Siwalan sap that has been added with encapsulation of Mangosteen fruit peel waste is not much different. The addition of encapsulation of Mangosteen fruit peel waste does not affect the aroma of Siwalan sap. This is because Siwalan sap has a distinctive aroma that is strong enough so that the aroma of encapsulation of Mangosteen fruit peel waste can be covered. The lower the concentration of encapsulation of Mangosteen fruit peel waste, the lower the aroma preference value of the sap. The aroma of Siwalan sap has a distinctive odor thought to be due to the chemical composition in it. The activity of enzymes in the sap such as pectinase and lipase can break down complex components into simpler volatile compounds, so that the aroma of Siwalan sap is easier to smell. Changes in the aroma of the sap are caused by the activity of microbes that can break down a sugar compound into reducing sugar, this causes the sap to have a pungent aroma (Hasanuddin et al, 2013).

3.6 Organoleptic Analysis of Taste

Based on the results of organoleptic analysis conducted on 30 panelists, it shows that the panelist's value for the taste of Siwalan sap that has been added with encapsulation of Mangosteen fruit peel waste ranges from 3.97-4.10 which means between quite-like. The histogram of the average results of the panelists' level of preference for the taste of Siwalan sap that has been added with encapsulation of Mangosteen fruit peel waste is presented in Figure 4.

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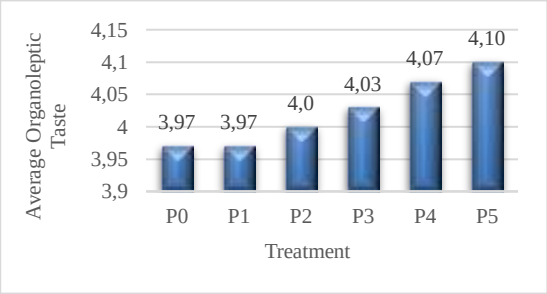

Figure 6. Average Organoleptic Aroma

The average panelist's preference value for the taste of Siwalan sap that has been added with Mangosteen fruit peel waste encapsulation as a natural sap inhibitor has the lowest value of 3.97, namely in the P0 treatment (encapsulation of 0% Mangosteen fruit peel waste extract and 500 ml of Siwalan sap) and P1 (encapsulation of 3% Mangosteen fruit peel waste extract and 500 ml of Siwalan sap), while the highest value of 4.10 from the P5 treatment (encapsulation of 10% Mangosteen fruit peel waste and 500 ml of Siwalan sap). The taste of Siwalan sap can change to sour during the storage process caused by the activity of S. cerevisiae yeast which can change the sugar content in Siwalan sap into ethanol and organic acids so that the pH decreases. In the P5 treatment, the pH of Siwalan sap tends to be more stable during storage, namely 5.60 compared to P0 (without treatment) which experienced a faster decrease. Slow pH decrease during storage of Siwalan sap helps to maintain the sweet taste of the sap and prevents excessive sourness. Prevention of pH decrease can be done by adding antioxidant encapsulation of Mangosteen peel waste extract to the siwalan sap so that it can help stabilize the pH, inhibit yeast activity that can cause excessive sourness, and protect the flavor components from oxidation. The addition of encapsulation of Mangosteen peel waste extract can maintain the pH of the sap to remain stable during storage. The addition of natural preservatives can inhibit hydrolysis by both microorganisms and the influence of acid. If the acidity of the sap can be controlled by adding natural preservatives, the rate of sucrose inversion into glucose can be reduced. If the concentration of natural preservatives is added in small amounts, the pH of the sap will be acidic (Dwi Erwinda et al., 2014). Based on the Friedman test, it shows that the X2 Table value is greater than the X count value, which means there is no significant difference between each treatment. According to panelists' notes in the P0 or untreated and P1 treatments, the taste of Siwalan sap was quite like the taste of Siwalan sap in general, sweet and sour, while in the P5 treatment, Siwalan sap had a sweet and slightly sour taste. Changes in taste in Siwalan sap are caused by microbial activity that breaks down the sugar content in the sap so that the taste of the sap becomes sour so that it can reduce the pH value of the Siwalan sap. The higher the acid content in Siwalan sap, the more sour or tart the taste will be, conversely, the lower the acid content in the sap, the sweeter the taste of the Siwalan sap. Siwalan sap has a high sugar content which occurs due to the saccharification process that takes place optimally, while the decrease in sugar content in Siwalan sap occurs due to an imbalance in the rate of saccharification of the use of sugar by microbes as one of its nutrients (Sukmana et al., 2022).

CONCLUSION

Based on the results of the study and discussion and discussion that are adjusted to the objectives of the study, it can be concluded as follows:

1. The chemical characteristics of the encapsulation of Mangosteen peel waste extract (*Garcinia mangostana L.*) show an increase in antioxidant stability which is influenced by the addition of the

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concentration of each treatment. Antioxidant activity increases with the addition of the encapsulation concentration of Mangosteen peel waste extract of 10% b/v.

2. The addition of the encapsulation concentration of Mangosteen peel waste extract has a significant effect on the pH parameters and shelf life of Siwalan sap.
3. The addition of the encapsulation concentration of Mangosteen peel waste extract (*Garcinia mangostana L.*) as a natural inhibitor of Siwalan sap (*Borassus flabellifer)* has a significant effect on the appearance of the sap. However, there is no significant difference in the taste and aroma of Siwalan sap.

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