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Mangosteen (*Garcinia mangostana* L.) trunk bark as palm sap preservative

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Abstract

The present study aimed to prove the effectiveness of mangosteen trunk bark on the shelf life of palm sap based on its taste, odour, and colour. The palm sap preservation was performed using 10 g, 20 g, and 30 g of mangosteen trunk barks in 2 L of palm sap to investigate the effectiveness of the bark as a preservative. The palm sap was sterilized by cooking the sap and mixing it with the mangosteen trunk bark. Following the sterilization was storing the palm sap was for 48 hrs to identify the preservation results. The sugar content and pH of the sap were measured throughout this process. The results showed that mangosteen trunk bark in the preserved sap was effective as its quality improved. On top of that, the preserved sap's sugar and pH content were higher than those without preservatives. The more mangosteen trunk bark was used, the longer the sugar content and pH of the sap last. The sensory test results on 13 volunteers revealed that sap with mangosteen trunk bark had a darker colour, sweeter taste, and a fainter odour than sap without preservatives.

1. Introduction

Sugar, one of the most-consumed ingredients in daily diet, can be found in almost every food, e.g., rice, bread, corn, honey, and fruit. This nutrient is a simple carbohydrate that dissolves in water; it is absorbed and processed by the human body into energy (Darwin, 2013). Sugar has been incorporated into the daily diet in Indonesia, one of the most populous countries in the world. This notion signifies that the country is among the largest sugar consumers. The national sugar demand of Indonesia is 3.2 million tons per year, yet the domestic sugar production is only around 2 million tons (Mardianto *et al*., 2005). Such data confirms that meeting the national sugar demand by increasing domestic sugar production is necessary. One approach to achieving such a target is using Arrenata pinanga, a plant species commonly found in Indonesia. Arrenata pinanga has long been renowned for its sap called *nira*, the ingredient of palm sugar. This kind of sugar is produced by cooking the sap until evaporates, resulting in a thick liquid before being processed into a sugar cube (Pontoh *et al*., 2016).

Nira aren (henceforth, palm sap) requires specific treatments to ensure the sweet taste of the sugar. Palm sap contains a high level of sucrose, with relatively low glucose and fructose contents. For this reason, palm sap is prone to microbe, and it has an acidic taste of sugar. Palm sap contains yeast (*Saccharomyces cerevisiae*) and *Zymomonas mobilis*, which change glucose to ethanol efficiently (Lantemona, 2013). Both bacteria should not be in the sap in producing palm sugar.

Many traditional farmers in Java use *Millettia sericea* sp. root in preserving the sap, slow the fermentation process, and prevent the palm sugar from becoming acid. Another preservative is mangosteen bark (Fitry *et al*., 2006). The bark of the palm tree has been used by farmers in Tomohon, North Sulawesi, as a preservative to slow the fermentation process. The mangosteen bark has phytochemical components with anti-bacterial, anti-inflammatory, anti-fungal, anti-oxidant, and other biological activities (Dharmaratne *et al*., 2005).

Acidity due to the fermentation of palm sap may hinder palm sugar production. Using a refractometer, Lantemona (2013) finds that the sugar content in fresh palm sap made by Masarang Palm Sugar Factory in Tomohon ranges from 12 to 17%. The percentage of the range value becomes the factory's standard of sugar content in palm sap. In maintaining the standard, the palm sap should be preserved to keep the sweet taste and inhibit fermentation. Otherwise, producing palm sugar

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would be a rough road.

Therefore, this study intends to examine the advantage of using mangosteen bark on the shelf life of palm sap. It focused on how the bark keeps the quality of the sap before being processed into palm sugar as the palm sap is central to sugar production and fermentation prevention.

Mangosteen trees have been cultivated for centuries in tropical parts of the world. Some of the species of mangosteen are from Southeast Asia or Indonesia, and others are from the Malay peninsula, Myanmar, Thailand, Cambodia, Vietnam, and the Moluccas (Akao *et al*., 2008). The mangosteen tree is dark brown with a hard and dense texture. Its inner bark has a yellowish colour, and the petiole is short and thick. The flower diameter is 5 cm and is separated into four parts. Seeds of mangosteen are broad and attached to the flesh of the reddish-white fruit (Anthony, 2002 as cited in Sar, 2013).

The part of the mangosteen tree used as a preservative for palm sap is the bark due to the purplish pigment within the mangosteen (Akao *et al.,* 2008). The purplish pigment will change the colour of the sap itself during the preservation process. For this reason, the bark of the mangosteen tree is a better alternative preservative rather than the fruit skin.

According to the data in the above table, mangosteen bark has a significant amount of three phytochemicals, including alkaloids, flavonoids, and glycosides. The bark also contains triterpenoids and steroids, with a composition less than the previous phytochemicals. According to Cowan (1999) as cited in Fitry *et al*. (2006), the components of alkaloids, flavonoids, and triterpenoids are anti-microbial. Flavonoids also serve as enzyme inhibitors since they can form complexes with enzymes (Harbourne, 1987 as cited in Fitry *et al.,* 2006).

Palm sap is one of the products of the male flower of a palm tree. The sap serves as the sugar ingredient, with sugar content ranging from 10 to 15% (Lantemona, 2013). In addition, the sap contains sucrose and a small amount of glucose and fructose. A study reported that the chemical composition of palm sap involves 86% of sucrose, 4% of glucose, 2% of polysaccharides, and 3% of non-carbohydrates, i.e., protein and ash (Pontoh, 2009, as cited in Lantemona 2013). Another research has reported that the chemical composition of palm sap is not that different from palm sap of other palm trees species, such as Nipah, siwalan (lontar), coconut, and others (Wijaya, 2004). Table 1 provides the comparison of the content of palm sap from Arrenga pinata species and other species of palm trees (Marzuki, 1987).

2. Materials and methods

This experimental research was conducted at the Industrial Engineering Laboratory, Faculty of Industrial Technology, Minaesa Institute of Technology, Tomohon, from November 2020 to February 2021. The tools involved a refractometer, pH meter, thermometer, electric stove, cooking pot, gallon for the sap, funnel, kettle (volume meter), filter, dropper, watch glass, knife, spoon, analytical balance, tissue, plastic jar, and glass. Research materials involved palm sap water, mangosteen bark, and pH 4 and 6.86 calibration powder.

The preservation treatment comprises four groups, i.e., unpreserved palm sap and palm sap with the addition of 10 g, 20 g, and 30 g of mangosteen barks. All treatments were heated at an average temperature of 83° C for 20 minutes, as shown in Table 2.

Each treatment comprised three experiments and observations. The storage life of sap was observed 12 times, every two hrs for the first 12 hrs. Then, the sample was monitored every 6 hrs for the next 36 hrs. Thus, the total time is 48 hrs of storage and inspection of each sap sample.

All data were collected through direct observation, interviews, documentation, and information from stakeholders that understand the problem. Data analysis was done statistically using the CRD (Completely Randomized Design) method in this study. CRD is the most straightforward design among other experimental designs. In CRD, the treatment is applied completely and randomly to the experimental units or vice versa. This pattern is known as complete randomization or unrestricted randomization. The application of a one-factor experiment in CRD is preferred if the condition of the experimental units is relatively homogenous (Muhammad *et al.*, 2014).

The data from the CRD table was inputted into the

Table 1. Comparison of nipah palm sap and other palms (%)

Types of Palm	Water content	Sugar content	Protein	Ash
Arenga pinnata 1	88.85	10.52	0.23	0.23
Arenga pinnata 2	87.82	12.04	0.36	0.21
Lontar (Asian palmyra palm)	87.78	10.96	0.28	0.10
Nipa palm	87.78	20.32	0.21	0.43

Source: Marzuki (1987) as cited in Wijaya (2004)

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Table 2. The process of heating sap of each sample

Sap Heating	Sap Volume (L)	Mangosteen Bark Weight (g)	Heating Temperature (°C)	Heating Time (mins)
Sample A	2	10	83	20
Sample B	2	20	83	20
Sample C	2	30	83	20

ANOVA (Analysis of Variance) table by calculating the number of squares using the following formula:

$$FK = \frac{y_{..}^2}{ab}$$

$$JKT = \sum_{i=1}^{a}\sum_{j=1}^{b} y_{ij}^2 - FK$$

$$JKP = \sum_{i=1}^{a} \frac{y_{i.}^2}{b} - FK$$

$$JKG = \sum_{i=1}^{a}\sum_{j=1}^{b} y_{ij}^2 - \sum_{i=1}^{a} \frac{y_{i.}^2}{b}$$

Hypothesis:

H0 : τ1=… τ4=0, treatment does not affect the observed response.

H1 : There is at least one i where τi ≠ 0

Test level : α = 5% = 0.05

Test criteria : Reject H0 if the value of F count > F table $_{(\alpha=0.05)}$ or sig. < α

Decision: H0 is rejected or H0 is accepted

Conclusion: There is at least one effect of the treatment of using mangosteen bark on the shelf life of the palm sap which was observed / the treatment does not affect the shelf life of the palm sap.

The next test employed least significant difference (LSD) with the following formula:

$$LSD\alpha = t_{table}(\alpha; dbG) \times \sqrt{\frac{2 \times KTG}{n}}$$

The difference test in three sensory variables was carried out involving thirteen volunteers. A rating scale was employed for the sensory test of unpreserved sap: a score of 1 represents a highly disliked attribute or characteristic, a score of 2 represents something that is disliked, a score of 3 indicates that the attribute or characteristic is quite favoured, a score of 4 shows that it is favoured and a score of 5 indicates that the attribute or characteristic is highly favoured. This rating system provides a clear and concise way to assess various attributes or characteristics and allows for an objective evaluation of their degree of favourability.

3. Results and discussion

3.1 The preservation of palm sap

The purpose of periodic reviews is to see how much the sugar content and pH of the sap with preservatives and without preservatives have decreased in a specific time scale. The results are shown in Figure 1 as follows.

Figure 1 shows the results of the sugar content of sap after 48 hrs of storage, indicating that the preserved sap is of better quality. Thus, the pH of the sap has significant survivability after 48 hrs of storage, as shown in Figure 2 .

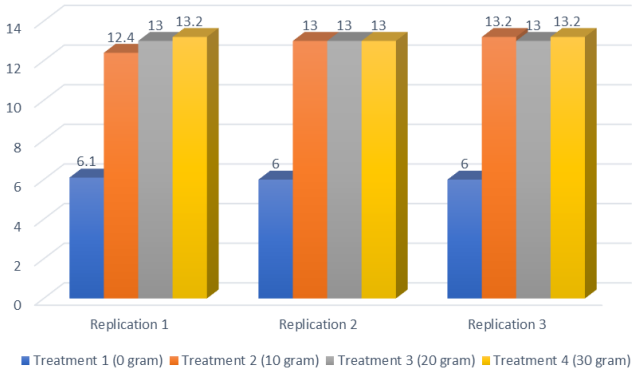

Figure 1. Sugar content of sap

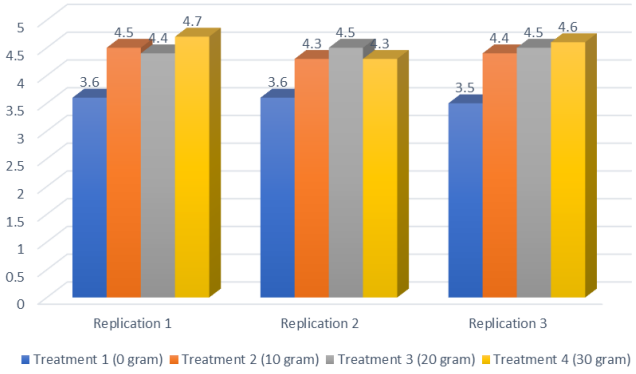

Figure 2. pH level of sap

The test results indicated that the mangosteen bark preservative is effective in slowing the decrease in sugar content and pH of sap during storage as it can survive at better concentrations for 48 hrs. This is directly proportional to the pH of the sap which has a higher concentration than the sap without preservatives. Moreover, the finding proves the effectiveness of mangosteen barks in preventing a fall in the pH of the palm sap and maintaining its sugar content. This evidence aligns with the research results, which utilize the mangosteen bark or fruit to fresh sap as a preservative and slow down the fermentation (Fitry *et al*., 2006).

3.2 Effect of use of mangosteen bark towards the change of taste, odour, and colour of palm sap

After 48 hrs of storage of sap, it turns out that there

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are differences in colour, odour, and taste between sap with mangosteen barks and without preservatives.

The results showed that the research volunteers favour the colour of the sap with or without preservatives. However, the odour and taste of sap with preservatives are preferable to sap without preservatives. Some volunteers, however, claim to have no problems with the odour and taste of sap without preservatives (Table 3, Table 4, Figure 3, Figure 4, and Figure 5). This finding confirms the idea that palm sap is a promising material because it produces bioethanol and sugar with a low glycemic index (Haagen and Lantican, 2015).

3.3 Completely randomized design

The study employed a completely randomized design to analyze the preservation results of palm sap by adding mangosteen bark. Based on the data on sugar content and pH level of palm sap, the study formulated a completely randomized design table model as shown in the following Table 5.

The results of the completely randomized design analysis of the sugar content of the sap are the correction factor = 1521.00083; total square = 109.68917; total treatment square = 109.30917; and total squared error = 0.38 (Table 6).

The results of the completely randomized design analysis of the pH of sap are the correction factor = 215.900833; total square = 1.969167; total treatment square = 1.849167; and total squared error = 0.12. This analysis has been used in a study on fish seeds (Adinugraha and Wijayaningrum, 2017).

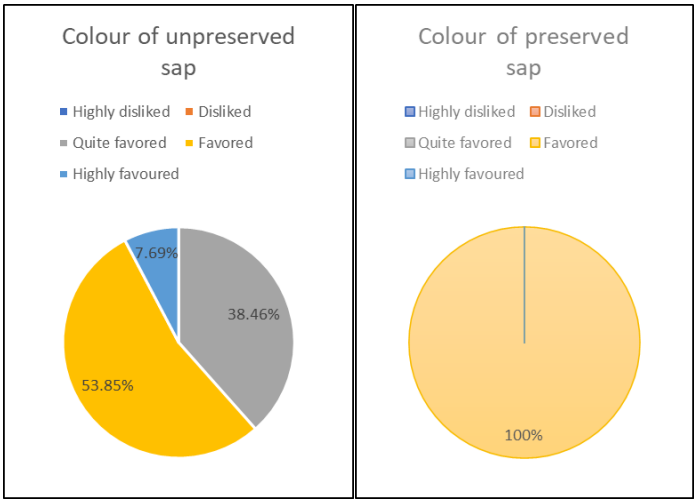

Figure 3. Percentage of colour of unpreserved sap and preserved sap

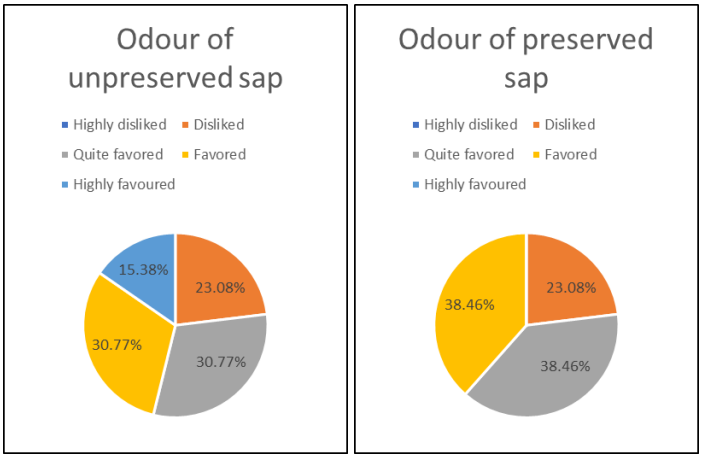

Figure 4. Percentage of odour of unpreserved sap and preserved sap

3.4 Analysis of variance

After compiling the data of treatments and replications of palm sap to the CRD table, each square of the data was calculated. An ANOVA table was

Table 3. Sensory test of preserved sap

Table Volunteer	Sensory Variable														
	Colour					Odour					Taste				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Principal Supervisor:				√				√						√	
Co-Supervisor:				√					√						√
Head of Department of Industry				√					√					√	
Student 1				√					√					√	
Student 2				√			√					√			
Student 3				√				√						√	
Student 4				√				√				√			
Student 5				√					√						√
Student 6				√			√						√		
Student 7				√			√						√		
Student 8				√				√					√		
Student 9				√					√				√		
Student 10				√				√						√	
Average Point			4					3.15					3.54		

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Table 4. Sensory test of unpreserved sap

Volunteer	Sensory Variable														
	Colour					Odour					Taste				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Principal Supervisor:				√			√					√			
Co-Supervisor:				√			√					√			
Head of Department of Industry				√				√				√			
Student 1			√					√				√			
Student 2				√					√				√		
Student 3				√					√					√	
Student 4			√						√				√		
Student 5					√				√				√		
Student 6				√								√			
Student 7			√									√			
Student 8				√				√						√	
Student 9			√					√						√	
Student 10			√				√					√			
Average Point			3.69					3.38					2.69		

Table 5. Completely randomized design of sugar content of sap

Replication	Treatment				Total	Average
	P1 (0)	P2 (10)	P3 (20)	P4 (30)		
1	6.1	12.4	13	13.2	44.7	11.18
2	6	13	13	13	45	11.25
3	6	13.2	13	13.2	45.4	11.35
Total Treatment (Yi…)	18.1	38.6	39	39.4	135.1	33.78

Table 6. Completely randomized design of pH level of palm sap

Replication	Treatment				Total	Average
	P1 (0)	P2 (10)	P3 (20)	P4 (30)		
1	3.6	4.5	4.4	4.7	17.2	4.3
2	3.6	4.3	4.5	4.3	16.7	4.18
3	3.5	4.4	4.5	4.6	17	4.25
Total Treatment (Yi…)	10.7	13.2	13.4	13.6	50.9	12.73

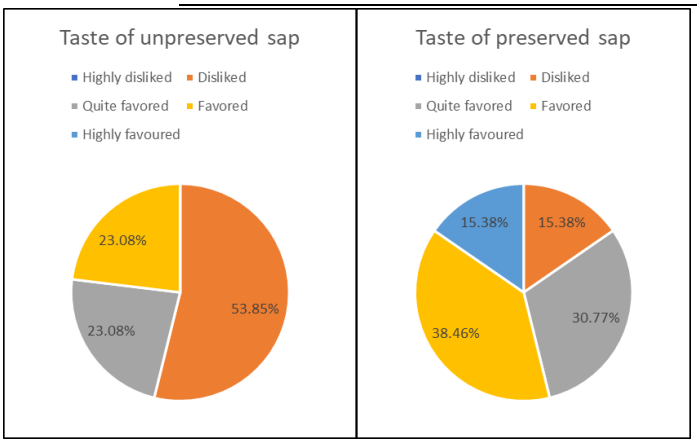

Figure 5. Percentage of taste of unpreserved sap and preserved sap

formulated to see whether the H0 is accepted or denied. Based on the calculation of the sum of squares, the model of the ANOVA table for Brix content and pH level of palm sap is presented as follows (Table 7 and Table 8).

H0 : τ1=… τ4=0, the treatment of mangosteen bark does not affect the shelf life of palm sap. H1: At least one treatment has an effect, where τi ≠ 0. Degree of significance: α = 5% = 0.05. Testing criteria: H0 is rejected if F-count> F-table$_{(\alpha=0,05)}$ or sig. < α. Decision: Based on the ANOVA table, palm sap's brix content and pH level yielded a higher F-count value than the F-table value; therefore, H0 is denied. Conclusion: At least one treatment affects the shelf life of palm sap.

3.5 Least significance difference

As the H0 is denied, this proves that the mangosteen bark affects the enhanced quality of sugar content and pH level of palm sap, which prolongs the shelf life of preserved palm sap compared to the unpreserved sap. In this regard, a further test was conducted to identify which treatment caused the H0 to be denied and which treatment yielded the most significant effect. The other test employed the least significant method. The

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Table 7. Analysis of variance table of sugar content

Source of Variance	Degree of Freedom	Sum of Squares	Median Square	F-count	F-table
Treatment	3	109.30917	36.43639	767.081895	4.07
Error	8	0.38	0.0475		
Total	11	109.68917			

Table 8. Analysis of variance of pH content of the sap

Source of Variance	Degree of Freedom	Sum of Squares	Median Square	F-count	F-table
Treatment	3	1.849167	0.616389	41.0926	4.07
Error	8	0,12	0.015		
Total	11	1.969167			

following formula was applied in the least significant of the brix content:

$$BN t\alpha = \text{ttable}(\alpha; dbG) \times \sqrt{\frac{2 \times KTG}{n}}$$

$$= 2.306 \times \sqrt{\frac{2 \times 0.0475}{3}}$$

$$= 2.306 \times \sqrt{\frac{0.095}{3}}$$

$$= 2.306 \times \sqrt{0.03166667}$$

$$= 2.306 \times 0.17795131$$

$$= 0.41$$

For the least significance in the pH level, the following formula was employed:

$$BN t\alpha = \text{ttable}(\alpha; dbG) \times \sqrt{\frac{2 \times KTG}{n}}$$

$$= 2.306 \times \sqrt{\frac{2 \times 0.015}{3}}$$

$$= 2.306 \times \sqrt{\frac{0.03}{3}}$$

$$= 2.306 \times \sqrt{0.01}$$

$$= 2.306 \times 0.0001$$

$$= 0.0002$$

After identifying the least significant value of both the Brix content and the pH level, the notation Table 9 was formulated.

Based on the table of least significance notation for Brix content, a significant difference is discovered between each treatment; thus, different notations are given for each treatment. The rejection of H0 in the ANOVA table of Brix content is due to the different concentrations of mangosteen bark in each preservation treatment. The notation table also shows that the increased use of mangosteen bark will yield better palm sap, with 30 grams treatment being the most optimal treatment. The notation table of palm sap's least significant pH level is shown in Table 10.

The previous notation table shows that each treatment yields a different notation (Haagen and Lantican, 2015; Adinugraha and Wijayaningrum, 2017). Therefore, the rejection of H0 in the ANOVA table of pH content is caused by different mangosteen bark usage in each treatment. The notation table also shows that using higher concentrations of mangosteen bark will result in better preservation results, with the most optimum pH level at the treatment of 30 g of mangosteen bark.

Table 9. Notation of least significance difference of sugar content

Treatment	Average of Total Treatment (Yi…)	Least Significance Notation
0 g	6.03	a
10 g	12.87	b
20 g	13	c
30 g	13.13	d

Table 10. Least significance difference notation of pH level

Treatment	Average of Total Treatment (Yi…)	Least Significance Notation
0 g	3.57	a
10 g	4.4	b
20 g	4.47	c
30 g	4.53	d

4. Conclusion

The study concluded that the use of mangosteen barks effectively maintained the sugar content and pH of palm sap compared to sap without preservatives. It showed that the shelf life of sap with preservatives could last longer (48 hrs). Further, the least significant difference method test showed a difference in the resistance of sugar content and pH of the sap between the use of 10 g, 20 g, and 30 g of mangosteen bark. The more mangosteen bark was used, the longer the sugar content and pH of the sap could last. Moreover, sap with preservatives and without preservatives had a different taste, odour, and colour. Sensory test results on 13 volunteers showed that the juice with preservatives had a

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darker colour, a sweeter taste, and a fainter scent than those without preservatives. Further studies are recommended to analyze the effect of other preservation methods to discover more effective preservation techniques/methods.

Conflict of interest

The authors declare no conflict of interest.

References

Adinugraha, B.S. and Wijayaningrum, T.N. (2017). Rancangan Acak Lengkap dan Rancangan Acak Kelompok Pada Bibit Ikan, presented at Seminar Nasional Pendidikan, Sains dan Teknologi, Fakultas Matematika dan Ilmu Pengetahuan Alam, Semarang, 2017. Semarang: Universitas Muhammadiyah Semarang. [In Bahasa Indonesia].

Akao, Y., Nakagawa, Y. and Nozawa, Y. (2008). Anti-Cancer Effects of Xanthones from Pericarps of Mangosteen. *International Journal of Molecular Sciences*, 9(3), 355-370. https://doi.org/10.3390/ijms9030355

Darwin, P. (2013). Menikmati Gula Tanpa Rasa Takut. Yogyakarta: Sinar Ilmu. [In Bahasa Indonesia].

Dharmaratne, H.R.W., Piyasena, K.G.N.P. and Tennakoon, S.B. (2005). A Geranylated biphenyl derivative from Garcinia mangostana. *Natural Product Research*, 19(3), 239 – 243. https://doi.org/10.1080/14786410410001710582

Fitry, F., Raharja, S. and Suryadarma, P. (2006). Perubahan Kualitas Nira Tebu (*Saccharum officarum*) Selama Penyimpanan Dengan Penambahan Akar Kawao (*Milletia* sp.) dan Kulit Batang Manggis (*Garcinia Mangostana* L.) Sebagai Bahan Pengawet. *Jurnal Teknologi Industri Pertanian,* 20(1), 57-64. [In Bahasa Indonesia].

Haagen, A. and Lantican, C.B. (2015). Arenga Pinnata (Wurmb) Merr Promising Source of Bioethanol and Low Glycemic Index Sugar. Philippines: Kaong R&D Project.

Lantemona, H. (2013). Optimasi Fermentasi Nira Aren Dari Sulawesi Utara Dalam Pembuatan Etanol Sebagai Energi Terbarukan. Malang, Indonesia: Universitas Brawijaya, PhD. Dissertation. [In Bahasa Indonesia].

Muhammad, I., Rusgiyono, A. and Mukid, M.A. (2014). Penilaian Cara Mengajar Menggunakan Rancangan Acak Lengkap (Studi Kasus: Cara Mengajar Dosen Jurusan Statistika Undip. *Jurnal Gaussian*, 3(2), 183 -192. [In Bahasa Indonesia].

Pontoh, J., Mirah, G., Karundeng, P. and Kamuh, V. (2016). Metode Analisa Dextran Dalam Nira Dan Gula Aren. *Buletin Palma*, 13(2), 109-114. [In Bahasa Indonesia].

Sar, Y. (2013). Uji Aktivitas Inhibisi Fraksi-Fraksi Hasil Kolom Kromatografi dari Ekstrak Kulit Buah Manggis (*Garcinia mangostana* L.) terhadap Enzim RNA Helikase Virus Hepatitis C. Jakarta, Indoensia: UIN Syarif Hidayatullah Jakarta, BSc. Thesis. [In Bahasa Indonesia].

https://doi.org/10.26656/fr.2017.7(3).942