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Preservation and Packaging Methods to Extend the Shelf Life of Fresh Lontar (*Borassus flabellifer* L.) Pulp

Dewi Pratiwi Sasmito[1,✉], Emmy Darmawati[1], Rokhani[1]

[1] Department of Mechanical and Biosystem Engineering, Faculty of Agricultural Engineering and Technology, IPB University, Bogor, INDONESIA.

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Corresponding Author:
✉ dewipratiwisasmito@gmail.com
(Dewi Pratiwi Sasmito)

ABSTRACT

Lontar is a palm with fruits having a various important biomolecules containing proteins, carbohydrates, vitamins, and minerals, which are beneficial to human health. The shelf life of lontar fruit pulp is generally limited to approximately 1–2 days. The objective of this study was to analyze the effect of water amount and citric acid concentration combining with packaging types and temperature ranges on the quality of fresh lontar fruit pulp and the shelf life of the pulp. The research used Response Surface Methodology with a Central Composite Design as the design model to find the best combination of water and citric acid concentration. The selected combination was applied in preservation treatment with polypropylene and nylon packaging under storage temperatures of 15°C and 25–28 °C. The quality parameters observed included brightness, hardness, pH, and total dissolved solids, as well as organoleptic tests. The optimization results indicated that the optimal ratio of water to citric acid concentration was 40 ml to 0.2%. Cold storage significantly extended the shelf life of lontar fruit pulp to 6 days, compared to just 3 days at room temperature. The organoleptic test results showed that PP packaging received a higher level of favorability compared to nylon packaging.

1. INTRODUCTION

Lontar (*Borassus flabellifer* L.) is a palm species of the palmae family commonly found in Indonesia. This species is distributed in various parts of Indonesia, especially in Bali, West Nusa Tenggara (NTB), East Nusa Tenggara (NTT), Java, and Madura. In addition, according to Leida *et al*. (2020), this species is also found in South Sulawesi. Jeneponto Regency is one of the regencies in South Sulawesi that has a lot of potential in the development of lontar plants (Islamiyah *et al*., 2024).

Lontar fruit pulp is one of the main products produced from lontar fruit (Golly *et al*., 2017). The pulp of young fruit is sweet, gelatinous and juicy, but gradually hardens with age (Dewi *et al*., 2024). The fresh palm fruit pulp contains various biomolecules, including carbohydrates, proteins, vitamins (A, B and C,) and minerals that provide added value in terms of health (Thevamirtha *et al*., 2023).

Fresh palm fruit pulp is susceptible to damage such as mucilage, discoloration and rapid fermentation due to exposure to air and oxidation after removal from the shell. The impact of this damage is a decrease in selling value because the appearance of the fruit pulp becomes not fresh. In general, fresh palm fruit pulp has a limited shelf life of about 1-2 days (Rao, 2020).

Damage that occurs to palm fruit pulp can be overcome by several methods, namely soaking in water, adding natural preservatives and using packaging to protect palm fruit pulp from damage during the storage process. Research by Dameswari *et al*. (2017) found that a water ratio of 1:3 has been proven to be the best ratio in maintaining the hardness and brightness of kolang-kaling during the storage period at room temperature. Furthermore, the use of a 1:4 water ratio in aloe vera can extend the shelf life up to 6 days when stored at refrigerated temperatures. The water used for soaking (especially cold water) can reduce the temperature of the food. Lower temperatures will slow down the activity of enzymes and microorganisms that normally cause spoilage, thus slowing down the deterioration process.

Utilization of preservatives such as citric acid is another method to maintain the quality of fresh palm fruit pulp. The results of research by Behera *et al*. (2021) stated that citric acid is a type of organic acid that is often used in the food and beverage industry. Its antioxidant properties allow its use to preserve food. Antioxidants can maintain food preservation by inhibiting or slowing down the oxidation reaction, which is one of the main causes of food damage. In addition to the addition of citric acid, the use of packaging plays an important role in protecting the product from contamination during storage. One contamination that often occurs is exposure to air so it is necessary to do good packaging. Packaging is very important to maintain the properties of food and beverage products (Ritonga, 2022). The results of research by Ambrose (2018) stated that the quality of fresh palm fruit meat can last for two days with poor packaging.

Thus, the difference between the current research and the previous one lies in the addition of preservatives and the selection of appropriate packaging materials and appropriate storage temperatures to maintain the quality of fresh palm fruit pulp. This study aims to assess the effect of the ratio of soaking water amount and citric acid on the quality of fresh lontar fruit pulp, and combine it with the type of packaging and the use of the best temperature to extend the shelf life of lontar fruit pulp.

2. MATERIALS AND RESEARCH METHODS

The materials used in this study were palm fruit flesh obtained from 2 districts (Tuban and Jeneponto) with a harvest age of 1 month, PP plastic packaging, Nylon plastic packaging, distilled water, and citric acid. While the equipment used in this study are pH meter (Want, PH-3C, China), digital Refractometer (Atago PAL-1 BLT/I), Minolta Chromameter (Konica Minolta, CR-400, Japan), and Rheometer (35-12-208, Sun Scientific Co., Ltd., Japan).

2.1. Research Procedure

The research was executed in two phases. The first phase was to obtain the optimum preservation technique in the form of a combination of soaking water quantitiy and citric acid concentration. The second phase was the application of preservation techniques combined with packaging types and storage temperature ranges to maintain the quality of fresh lontar fruit pulp during storage. The procedure of this study was depicted in Figure 1.

2.2. Experimental Design

2.2.1. Preservation Optimization with RSM

The experimental design used in the preservation stage uses the Response Surface Methodology (RSM) method. The experimental design used is Central Composite Design (CCD) with two factors, namely water (X1) and citric acid (X2). The response variables analyzed were acidity (pH) (Y1), total dissolved solids (TPT) (Y2), brightness (Y3), and hardness (Y4). The number of experiments resulting from the CCD design model was 10 treatments with 14 observations.

Table 1. Treatments and treatment codes

Factor	Code	Treatment Codes				
		- α	-1	0	1	+ α
Water	X1	36	40	50	60	64
Citric acid	X2	0.08	0.2	0.5	0.8	0.92

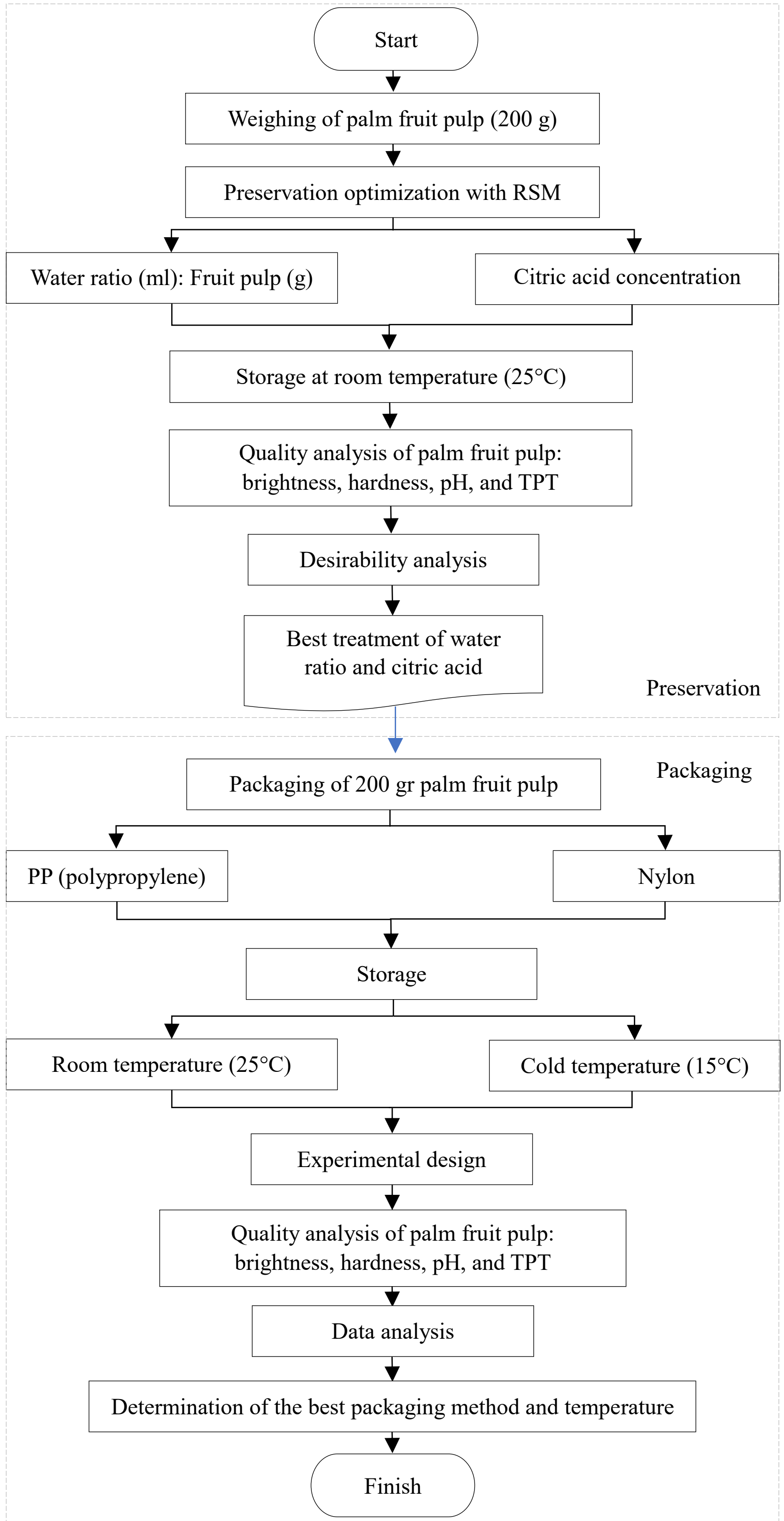

Figure 1. Research flow chart

If the relationship between the response and the independent variables follows a linear function, then the function approach is called a first-order model, and is shown according to Equation 1:

$$\hat{y} = \beta o + \sum_{i=1}^{k} \beta_i x_i \quad (1)$$

where β is regression coefficient. If the form of the relationship is quadratic, then the function is second-order model, and is shown in Equation (2):

$$\hat{y} = \beta_o + \sum_{i=1}^{k} \beta_o x_i + \sum_{i=1}^{k} \beta_{ii} x_i^2 + \sum_{i=1,j=2}^{k-1,k} \beta_{ij} x_i x_j + \varepsilon \quad (2)$$

where ŷ is observation response, β_o is cut-off point, β_i is linear coefficient, β_{ii} is quadratic coefficient, β_{ij} is treatment interaction coefficient, x_i is treatment code for the i^{th} factor, x_j is treatment code for the j^{th} factor, and *k* is number of factors tried.

2.2.2. Effect of Packaging Types and Storage Temperatures

The experimental design used in the packaging stage is a Randomized Complete Factorial Design (RALF) consisting of 2 factors. Factor I is the type of packaging, namely PP packaging (K1) and nylon packaging (K2). Factor II is storage temperature, namely cold temperature (15 °C) (S1) and room temperature (25 °C) (S2). Thus, there are 4 treatment combinations and the experimental unit consists of 8 experiments (replication 2 times). The mathematical model of this experimental design is as follows:

$$y_{ijk} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \varepsilon_{ijk} \quad (3)$$

where y_{ijk} is observation value due to the effect of the use of i-th packaging and j^{th} storage temperature on the kth replicate fresh palm fruit pulp sample, μ is general mean, α_i is the effect of using the i^{th} packaging, β_j is effect of the j^{th} storage temperature, $(\alpha\beta)_{ij}$ is interaction effect between the use of i^{th} packaging and j^{th} storage temperature, ε_{ijk} is experimental error for the use of the i^{th} packaging and the j^{th} storage temperature and the k^{th} replication.

2.3. Quality Analysis

2.3.1. Brightness

Brightness measurement is one of the methods used in assessing the visual quality of palm fruit flesh. Measurements are made using a chromameter and based on a value expressed by the *L** value (brightness).

2.3.2. Hardness

Hardness measurement is one of the methods to determine the physical quality value of palm fruit flesh. Hardness measurement is carried out using a rheometer.

2.3.3. Degree of Acidity (pH)

The pH measurement of palm fruit flesh was carried out to determine its acidity and assess its freshness. The pH measurement was carried out using a pH meter based on AOAC (2005).

2.3.4. Total Dissolved Solids (TDS)

Total soluble solids were measured to determine the sweetness and ripeness of the palm fruit pulp. TDS measurement was carried out using a refractometer based on AOAC (2005).

2.4. Data Analysis

2.4.1. Determining Desirability Value

The data obtained in this study was analyzed using the Analysis of Variance (ANOVA) test with a confidence level of 95% and carried out using software. The ANOVA result with the largest R^2 value was selected. The Lack of Fit (F-Value) > 0.05 indicates an insignificant Lack of Fit, which is required for a good model because it implies the suitability of the response data with the model. The most optimal formula is the formula with the maximum desirability value.

2.4.2. Model Validation

Model validation is conducted to ensure that the developed model is able to accurately represent the data. In this case, the Mean Absolute Percentage Error (MAPE) is calculated. The MAPE value is used to assess the model: <10% excellent, 10-20% good, 20-50% poor, and >50% poor (Nabillah *et al*., 2020).

3. RESULTS AND DISCUSSION

3.1. Optimization of Palm Fruit Pulp Preservation

Response Surface Methodology (RSM) analysis with a Central Composite Design (CCD) design resulted in four responses which can be seen in Table 2. The RSM measurement results are the results obtained on the second day of the preservation process. This is because on the first day of storage, there was no significant change in the palm fruit pulp that had been soaked in a solution of water and citric acid concentration. Whereas on the third day of storage, the palm fruit pulp had already experienced significant damage.

Table 2. Measurement results of Response Surface Method (RSM)

No	Water	Citric Acid	Response Variable			
	ml	(%)	Brightness	Hardness (kgf)	pH	TDS (°Brix)
1	50	0.5	42.79	0.07	4.6	5.37
2	40	0.2	38.71	0.1	5.1	5.97
3	40	0.8	33.42	0.07	4.4	4.86
4	60	0.2	39.58	0.08	4.8	5.49
5	50	0.5	43.80	0.08	4.4	5.50
6	50	0.5	39.88	0.07	4.3	4.81
7	60	0.8	32.92	0.05	3.6	4.85
8	50	0.5	38.37	0.07	4.3	4.69
9	36	0.5	34.25	0.08	4.4	5.30
10	50	0.5	37.79	0.07	5.1	4.89
11	50	0.5	38.60	0.07	4.2	4.84
12	64	0.5	34.80	0.05	4.1	4.62
13	50	0.08	37.94	0.07	5.2	5.48
14	50	0.92	31.02	0.05	3.6	4.16

Description: Data obtained from measurements on the second day of storage.

3.1.1. Brightness

From the observations obtained, that in general the initial brightness of good palm fruit pulp is in the range of 34-43 or clear white color. So that after making observations for several days of storage, there are changes in different brightness responses. Where the brightness response <34 changes color to transparent white, while the brightness response >43 changes color to milky white. These changes can be seen in the physical and visual properties of palm fruit pulp after several days of storage. Rodiah *et al*. (2019) stated that bioactive components (phenolic compounds and Polyphenol Oxidase (PPO) enzyme) in fresh palm fruit pulp can cause discoloration.

Figure 2a shows that the appropriate polynomial model for optimizing the brightness response is quadratic. The lack of fit *p*-value is 0.6010 (>0.05) which means there is no lack of fit or insignificant. The results of ANOVA show that the influential factor is citric acid concentration, with the best concentration being 0.5%, while water has no effect. The optimum brightness value is at 50 ml water concentration and 0.5% citric acid, with the brightness level of 34–43 (clear white). With A = water, and B = citric acid, the model used to predict the brightness response is as follows:

$$\text{Brightness} = -27.09867 + 2.52760\,A + 24.14681\,B - 0.114167\,A*B - 0.024561\,A^2 - 27.54538\,B^2 \quad (3)$$

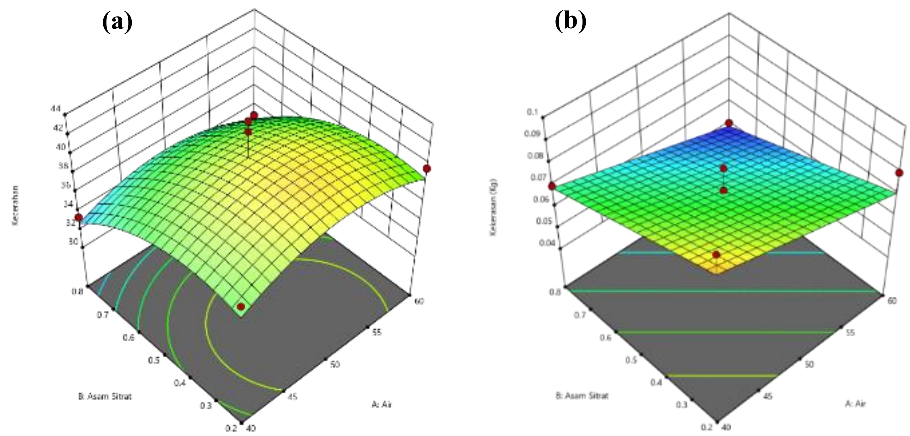

Figure 2. Three-dimensional response on the effect of water factor (A) and citric acid factor (B) on: (a) Brightness, (b) hardness

3.1.2. Hardness

Based on the observations that have been made, data on the hardness of palm fruit pulp is obtained with a range of values between 0.05 kgf to 0.1 kgf. The hardness of palm fruit pulp can be predicted through the brightness response value. When the brightness value of the fruit is <34, the palm fruit pulp tends to be soft (0.00-0.05), while in the range of 34-43 the palm fruit pulp is soft (0.06-0.09), then if the brightness value is >43 the fruit pulp will experience hardening during storage (≥1). Research by Idayati *et al*. (2014) stated that palm fruit pulp which originally had a clear white color turned into transparent white or milky white and experienced a significant loss of water content at an advanced stage of ripening, which could cause the fruit pulp to soften or harden.

Figure 2b shows that the appropriate polynomial model for optimizing the process conditions is the linear model. The lack of fit *p*-value is greater than 0.05, which is 0.9155, indicating that there is no lack of fit or insignificance. The results of ANOVA analysis show that the influential factors are the concentration of water and citric acid. Based on response surface analysis, the optimum hardness value was obtained at the best concentration with 40 ml water treatment and 0.2% citric acid, with the highest hardness value of 0.1 kgf.

With A = water, and B = citric acid, the model used to predict the hardness response is as follows:

$$\text{Hardness} = +6.72679 - 0.018207\,A - 1.51431\,B \quad (4)$$

3.1.3. Degree of Acidity (pH)

Observations showed that the initial pH of palm fruit pulp ranged from 6-7 (neutral). During storage, a good pH for palm fruit pulp is 5-7. If the pH is <5, the pulp becomes sour and smells bad, indicating deterioration. Lutfiyah *et al*. (2022) found that the decrease in pH in dragon fruit during storage was caused by the activity of microorganisms, which caused decay.

Figure 3a shows that the appropriate polynomial model for optimizing the acidity response is linear. The lack of fit *p*-value is greater than 0.05, which is 0.1978, indicating that there is no lack of fit or insignificance. The results of ANOVA analysis showed that the influential factors were the concentration of water and citric acid. Increasing the concentration of citric acid significantly lowers the pH. This is in accordance with the nature of citric acid which lowers the pH of the solution. Based on response surface analysis, the optimum pH value was obtained at the best concentration with 40 ml water treatment and 0.2% citric acid. With A = water, and B = citric acid, the model used to predict the pH response is as follows:

$$\text{pH} = +0.140286 - 0.001035\,A - 0.037037\,B \quad (5)$$

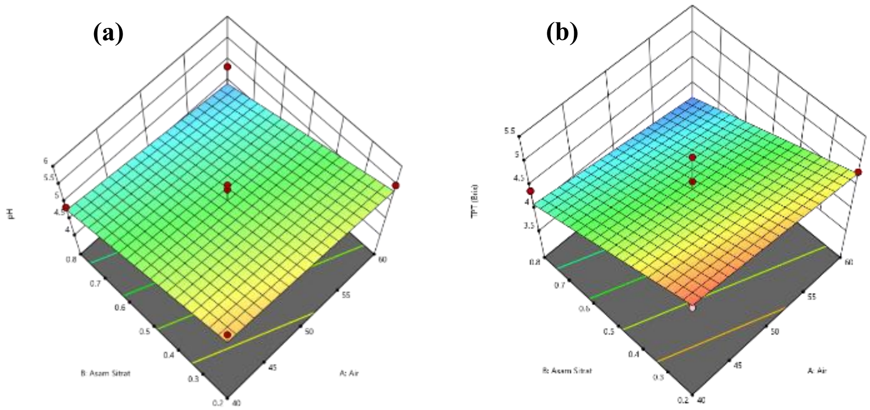

Figure 3. Three-dimensional response on the effect of water factor (A) and citric acid factor (B) on: (a) pH, and (b) TDS

3.1.4. Total Dissolved Solids (TDS)

Research shows the Total Dissolved Solids (TDS) in palm fruit pulp ranges from 4.16 °Brix to 5.97 °Brix, reflecting the concentration of sugar and other solid components. According to Ho *et al*. (2020), TDS is dominated by sugar, thus reflecting the level of sweetness and ripeness of the fruit.

Figure 3b shows that the appropriate polynomial model for optimizing the process conditions is the linear model. The lack of fit *p*-value is greater than 0.05, which is 0.9107, which means there is no lack of fit or insignificant. The results of ANOVA analysis showed that the optimum TPT value was at 40 ml water concentration and 0.2% citric acid. The results of ANOVA analysis showed that the influential factor was citric acid concentration, with the best concentration being 0.2% while water had no effect. The model used to predict the TDS response is given in Equation (6) with A = water, and B = citric acid.

$$TDS = +6.26652 - 0.019192\ A - 1.74242\ B \qquad (6)$$

3.2. Optimization of Water and Citric Acid as Preservative

The optimization stage aims to obtain water and citric acid concentration parameters with optimal response values according to the specified criteria. To consider all responses to the treatments tested for optimization, the D (desirability) value was calculated. This D value is used to determine the optimum combination of water and citric acid. The optimization results in Table 3 show that the optimum amount of water and citric acid is 40 ml of water and 0.2% citric acid. This was chosen based on the maximum desirability value of 0.896. The value of the desirability function is between 0 and 1. A value of 0 is given when the factor is given an undesirable response, while a value of 1 indicates optimal performance for the factor under study (Amdoun *et al*., 2018). The study provided the best results in terms of quality and shelf life of palm fruit flesh.

The optimum results obtained were validated in the laboratory with the treatment of 40 ml water and 0.2% citric acid. The prediction and measurement results with these treatments are presented in Table 4. Verification results showed that brightness, hardness, and TDS were higher than predicted, while pH was slightly lower. The brightness, pH, and TDS models were considered excellent as the difference between the predictions and the measurements was below 10%. However, hardness showed a difference of more than 30%, indicating that the model needs to be improved.

Table 3. Combination of optimum formulas of selected optimization results

Formula	Water (g)	Citric Acid (%)	Desirability	
1	**40**	**0.2**	**0.896**	**Selected**
2	40.288	0.2	0.892	
3	41.161	0.2	0.877	

Table 4. Prediction results using model and experimental measurements

Response	Prediction	Measurement result	MAPE
Brightness	37.52	42.12	10%
Hardness	0.1	0.15	33%
pH	5.69	5.66	0.4%
TDS	5.2	5.7	8%

3.3. Effect of Packaging Type and Storage Temperature

The results of the preservation treatment research showed that the optimum concentration for soaking 200 grams of palm fruit meat was 40 ml of water and 0.2% citric acid. This soaking treatment was applied to PP packaging and Nylon packaging. The results of observations and measurements of quality parameters, which include brightness, hardness, pH, and TPT were carried out during storage at cold temperature (15°C) and room temperature (25°C).

Table 5. Analysis of variance of the effect of packaging material and storage temperature on day 2

Treatment		Observation response			
Packaging	Temperature	Packaging	Temperature	Packaging	Temperature
PP	15°C	46.37±1.4	0.17±0.015	6.85±0.08	6.8±0.05
	25°C	42.12±0.5	0.16±0.005	5.59±0.08	5.7±0
Nylon	15°C	45.12±0.2	0.21±0.050	6.49±0.17	6.2±0.05
	25°C	41.13±1.9	0.17±0.005	5.67±0.29	5.6±0.05

Table 6. Analysis of variance of the effect of packaging material and storage temperature on day 4

Treatment		Observation response			
Packaging	Temperature	Brightness	Hardness	pH	TDS
PP	15°C	40.57±0.5	0.15±0.010	6.08±0.03	5.4±0
	25°C	33.97±0.7	0.09±0.005	3.52±0.03	3.9±0.05
Nylon	15°C	43.32±0.6	0.15±0.015	6.07±0.08	5.3±0.25
	25°C	35.71±1.5	0.09±0.005	3.34±0.04	3.2±0.05

The results of the analysis of variance of the effect of packaging material and storage temperature in Table 5 and Table 6 show that the effect of packaging type is not significantly different, except for the TDS ($\alpha<0.05$). As for storage temperature, there were significant differences in brightness, hardness, pH and TDS. The interaction between packaging and storage temperature also showed that there were no significant differences. Therefore, further analysis was carried out using a trend line approach to see the interaction between packaging type and storage temperature on the quality and shelf life of fresh palm fruit pulp.

The results of the trend line obtained the best treatment using PP packaging at cold temperature and room temperature, because this packaging is able to survive in both temperature conditions. At cold temperatures, palm fruit meat can last up to 6 days, while at room temperature, palm fruit pulp can only last 3 days. This is due to the slower rate of respiration and microbial activity at cold temperatures, which is slower at cold temperatures, thus slowing down the deterioration process and maintaining the quality of the fruit longer. In addition, the difference in permeability of the two types of packaging to oxygen affects the decline in fruit pulp quality. According to Sari *et al.* (2017) polypropylene packaging has good inhibition of oxygen and light, so it can block the entry of oxygen, because the presence of oxygen can affect product changes.

4. CONCLUSION

The optimal amount of soaking water and concentration of citric acid as a preservative for 200 grams of palm fruit pulp is 40 ml of water and 0.2% citric acid, with a desirability value of 0.896. RSM prediction results on the model and experimental measurement results obtained percentage differences for brightness, pH, and TDS responses below 10%, thus indicating that the treatment is effective in maintaining the quality of palm fruit pulp.

The addition of water and citric acid concentration in the packaging of palm fruit pulp is able to maintain the response of brightness, hardness, pH and TDS. Based on the results of analysis of variance (ANOVA), packaging material affects TDS and has no effect on brightness, hardness and pH. Storage temperature affects brightness, hardness, pH, and TDS. The interaction of packaging material and storage temperature has no effect on the quality of palm fruit pulp. PP packaging and cold temperature (15°C) were able to extend the shelf life of palm fruit pulp up to 6 days. At room temperature (25°C), lontar fruit pulp supplemented with water and citric acid could last 3 days while the control (no treatment) only lasted less than 24 hours. In addition, trend line analysis showed that polypropylene (PP) packaging is more effective in maintaining the quality of palm fruit pulp compared to nylon packaging

REFERENCES

Ambrose, D.C.P. (2018). Effect of packaging on the shelf life of tender palmyra (*Borassus flabellifer*) fruit endosperm. *Journal of Applied and Natural Science*, ***10***(2), 705–709. https://doi.org/10.31018/jans.v10i2.1770

Amdoun, R., Khelifi, L., Khelifi-Slaoui, M., Amroune, S., Asch, M., Assaf-ducrocq, C., & Gontier, E. (2018). The desirability optimization methodology; a tool to predict two antagonist responses in biotechnological systems: Case of biomass growth and hyoscyamine content in elicited datura starmonium hairy roots. *Iranian Journal of Biotechnology*, ***16***(1), 11–19. https://doi.org/10.21859/ijb.1339

AOAC. (2005). *Official Methods of Analysis, 18th edition*. Association of Official Analitycal Chemist.

Behera, B.C., Mishra, R., & Mohapatra, S. (2021). Microbial citric acid: Production, properties, application, and future perspectives. *Food Frontiers*, ***2***(1), 62–76. https://doi.org/10.1002/fft2.66

Dameswari, H.A., Darmawati, E., & Nugroho, L.P.E. (2017). Kombinasi teknologi kemasan dan bahan tambahan untuk mempertahankan mutu kolang kaling. *Jurnal Keteknikan Pertanian*, ***05***(3), 1–11. https://doi.org/10.19028/jtep.05.3.201-208

Dewi, B., & Tri, Y. (2024). Pemanfaatan buah lontar (*Borassus flabellifer*) pada olahan puding sebagai pangan fungsional untuk kesehatan tubuh. *Jurnal Pengabdian*, ***3***(1), 1–6. https://doi.org/10.58222/jp.v3i1.367

Golly, M.K., Amponsah, A.S., Mintah-Prempeh, V., Agbamakah, E., Akari, M.A., Adu-Poku, L., Pokuaa, G.F., Gandaa, V., & Agodey, B. (2017). Development of food products from Palmyra palm (*Borassus flabellifer* L.) fruit pulp for possible commercialization. *STU International Journal of Technology (STUIJT)*, ***1***(4), 89–102.

Ho, H.L., Yasmira, I.S.R.R., & Norlia, M. (2020). Proximate composition, physicochemical characteristics, and sensory evaluation of reduced-calorie belimbi fruit (*Averrhoa belimbi*) jam with maltitol. *Food Research*, ***4***(5), 1545–1553. https://doi.org/10.26656/fr.2017.4(5).090

Idayati E., Suparmo S., & Darmadji, P. (2014). Potensi senyawa bioaktif mesocarp buah lontar (*Borassus fl abeliffer* L.) sebagai sumber antioksidan alami. *Jurnal Agritech*, ***34***(03), 277. https://doi.org/10.22146/agritech.9455

Islamiyah, S.A., & Fadillah, U.F. (2024). Struktur hierarki strategi prioritas pengembangan industri gula merah lontar. *JASATHP: Jurnal Sains dan Teknologi Hasil Pertanian*, ***4***(2). https://doi.org/10.55678/jasathp.v4i2.1720

Leida, M., Thaha, R.M.., Yusnitasari, A.S., & Afsahyana. (2020). Effect of sap palm (*Borassus flabellifer*) on blood glucose level in pre-diabetic patients. *International Journal of Current Research and Review*, ***12***(24), 96-100. http://dx.doi.org/10.31782/IJCRR.2020.122419

Lutfiyah, I., Sudarti, S., & Bektiarso, S. (2022). Analisis Perubahan ph dan tekstur daging buah naga merah (*Hylocereus polyrhizus*) oleh pengaruh paparan medan magnet extremely low frequency (Elf). *ORBITA: Jurnal Pendidikan dan Ilmu Fisika*, ***8***(1), 143. https://doi.org/10.31764/orbita.v8i1.8609

Nabillah, I., & Ranggadara, I. (2020). Mean absolute percentage error untuk evaluasi hasil prediksi komoditas laut. *JOINS: Journal of Information System*, ***5***(2), 250–255. https://doi.org/10.33633/joins.v5i2.3900

Rao, M.C.S. (2020). Influence of packing material and storage conditions on quality and sensory attributes of Palmyrah (*Borassus flabellifer* L.) tender fruit endosperm. *International Journal For Innovative Engineering and Management Research*, ***9***(12), 581–590. https://doi.org/10.48047/ijiemr/v09/i12/101

Ritonga, A.M. (2022). Pengaruh kombinasi proses termal dan jenis kemasan terhadap mutu cimplung singkong siap saji. *Journal of Agricultural and Biosystem Engineering Research*, ***3***(2), 45. https://doi.org/10.20884/1.jaber.2022.3.2.7177

Rodiah, M.H., Jamilah, B., Kharidah, S.M.S., & Russly A.R. (2019). Physico-chemical and antioxidant properties of mesocarp and exocarp from Borassus flabellifer. *International Food Research Journal*, *26*(5), 1469–1476. http://www.ifrj.upm.edu.my/26 (05) 2019/07.pdf

Sari, S.D., Dali, F.A., & Harmain, R.M. (2017). Karakteristik organoleptik stik alga laut *Kappaphycus alvarezii* fortifikasi tepung udang rebon (*Mysis sp*) selama penyimpanan dalam kemasan polipropilen. *Jambura Journal of Educational Chemistry*, ***12***(1), 33–38. https://www.neliti.com/publications/277441/

Thevamirtha, C., Balasubramaniyam, A., Srithayalan, S., & Selvakumar, P.M. (2023). An Insight into the antioxidant activity of the facial cream, solid soap and liquid soap made using the carotenoid extract of palmyrah (*Borassus flabellifer*) fruit pulp. *Industrial Crops and Products*, ***195***, 116413. https://doi.org/10.1016/j.indcrop.2023.116413