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Degreening and Low Temperature Storage to Improve the Quality of Mandarin Orange

Henny Nurpa Anggriani[1]✉, Sutrisno[1], Slamet Susanto[2]

[1]Departement of Mechanical and Biosystem Engineering, IPB University, Bogor, INDONESIA
[2]Departement of Agronomy and Hortikulture, IPB University, Bogor, INDONESIA

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✉Corresponding Author:
nurpahenny@gmail.com

ABSTRACT

Several citrus species when physiologically ripe are still yellow-green in color, one of which is the Tangerine RGL (Rimau Gerga Lebong) grown in the city of Pagar Alam, South Sumatra. To improve the physical quality of tangerines, RGL can be applied with degreening technology and low-temperature storage. This study aims to examine the effect of degreening and low-temperature storage on physicochemical changes and to determine the optimum method of degreening and low-temperature storage on citrus quality. This study used a completely randomized 2-factor design. The first factor is degreening with 4 levels (0 ppm, 250 ppm, 500 ppm, 750 ppm), and the second factor is storage temperature with 3 temperature levels (10ºC, 20ºC, and room temperature). The results showed degreening increased the CCI value by 3.48-3.82, changing the skin color to uniformly yellow and did not affect the internal quality of the fruit. Treatment with a temperature of 10^{o}C extended the shelf life of the fruit up to 29 days. The combination of 250 ppm ethepon and 10^{o}C effectively suppressed weight loss to maintain the quality of RGL tangerines.

1. INTRODUCTION

Oranges are a type of fruit preferred by the people of Indonesia, where the annual consumption rate reached 3.28 kg/capita in 2015, and increased to 3.60 kg/capita in 2016 (Kementerian Pertanian, 2018). Oranges that develop in Indonesia are classified according to their types, namely Siamese oranges, tangerines and large oranges (pamelo). One of the varieties of tangerines that is growing in Sumatra is the RGL (Rimau Gerga Lebong) mandarin oranges. RGL oranges, commonly known as Gerga oranges, were first cultivated in the city of Pagar Alam, South Sumatra in 2013. This citrus plantation is located in Agung Lawangan Village, North Dempo District, Pagar Alam City, South Sumatra with a land area of 1.5 hectares and has reached ± 500 hectares (Datika *et al*., 2018; Arif & Muslim, 2019).

Visually, the quality of Indonesian oranges is low because the skin of the fruit is generally yellowish-green and not uniform. Oranges that grow in the tropics, generally the color of the fruit skin will change from green to yellow or greenish-yellow when the fruit is ripe, while citrus fruits in subtropical areas the color of the fruit skin changes from green to orange (Gautama *et al*., 2019).

Gerga Pagar Alam oranges are picked when the fruit is large and the fruit skin looks yellowish, the fruit is not too hard and the bottom is soft when held with the fingers, the age of picking the fruit after 7-8 months (Datika *et al*., 2018). Gerga Pagar Alam oranges when harvested, the color of the orange peel is still greenish yellow. Efforts to improve the quality of Gerga Pagar Alam oranges by improving the physical appearance of the fruit, especially the skin color so that it is evenly yellow or orange, can be done with degreening technology. In addition to maintaining freshness and extending the shelf life of Gerga Pagar Alam oranges can be stored at low temperatures. This study aims to examine the effect of degreening and storage temperature on the quality of Gerga Pagar Alam oranges, physicochemical changes, and determine the optimum degreening method and storage temperature to maintain the quality of Gerga Pagar Alam oranges.

2. MATERIALS AND METHODS

This research was conducted in December 2021 - January 2022 at the Food and Agricultural Products Processing Engineering Laboratory, Faculty of Agricultural Technology, IPB University, Bogor.

2.1. Materials and Tools

The sample used was Gerga Pagar Alam oranges weighing 190-250 grams, yellow-green in color, with a harvesting age of 7-8 months, obtained directly from citrus orchards planted in the middle plains with an altitude of ±700 m above sea level, Agung Lawangan Village, Dempo District North, City of Pagar Alam. The materials used in this study were ethepon and distilled water. Tools used: plastic basket, refrigerator, chromameter, analytical balance, refractometer, ATAGO Brix Acidity Meter PAL BX ACID, rheometer, thermometer, filter, measuring cup, spectrophotometer, stationery and documentation.

2.2. Methods

This study used a factorial Completely Randomized Design (CRD), with two factors (Mattjik & Sumertajaya, 2013). The first factor was degreening with 4 ethepon concentration levels of 0 ppm (E0), 250 ppm (E250), 500 ppm (E500), 750 ppm (E750). The second factor is storage temperature with 3 levels, namely temperature 10ºC (T10), 20ºC (T20) and room temperature (TR). There were 12 treatment combinations which were repeated 3 times, so there were 36 experimental units. Data analysis used analysis of variance with the Duncan Multiple Range Test (DMRT) to determine the difference in the effect of each treatment at the level of $\alpha = 0.05$.

2.2.1. Preparation of Citrus Fruits

Gerga oranges are harvested directly from the farmer's garden, sorted and the fruit weighing 190-250 grams is taken, then cleaned, wiped using a wet cloth or wet tissue, then packaged and transported. Each citrus fruit is wrapped in newspaper to minimize friction and impact during the trip, then arranged and put in a plastic basket. After that it was transported to the city of Bogor.

2.2.2. Preparation of Ethepon Solution and Degreening Application

The concentrations of the ethepon solution used in this study were 0 ppm, 250 ppm, 500 ppm and 750 ppm. To prepare an ethepon solution (according to treatment) from an existing ethepon solution with a concentration of 480 g/L or 480000 ppm, stock dilution (480 mg/ml) was carried out with Equation 1:

$$M1 \times V1 = M2 \times V2 \quad (1)$$

where M1 is initial substance concentration or molarity of ethepon starting substance, M2 is Ethepon concentration or molarity after dilution, V1 is initial volume, and V2 is volume after dilution (V1 + water).

The degreening process is carried out after the fruit arrives at the Food and Agricultural Product Processing Engineering Laboratory at the Faculty of Agricultural Technology, IPB University, Bogor. The degreening method is carried out by immersing in a container for 60 s, after soaking the oranges were air-dried and incubated for 48 h at 20 °C, then stored at 10 °C, 20 °C, and room temperature.

2.2.3. Low Temperature Storage

Low temperature (10 °C, 20 °C) and room temperature storage of Gerga oranges were carried out after the degreening process. At low temperatures citrus fruits are stored in the refrigerator with a temperature of 10 °C and 20 °C, while at room temperature (29±1 °C). Observations were made on day 0 to day 29 of storage.

2.2.4. Destructive and Non-destructive Measurements

Destructive and non-destructive measurements started on day 0, then after the degreening process and the incubation period, observations were made every 3 days. Non-destructive measurements include: skin color, fruit weight loss, percentage of rotten fruit, while destructive measurements include: hardness, total dissolved solids, total acid and vitamin C content. Hunter color notation is characterized by three color parameters, namely *L** denotes brightness with a value of 0 (black) to 100 (white), *a** denotes a red-green mixed chromatic color with a value of +*a* from 0 to 60 for red and –*a* from 0 to -60 for green. The *b** value represents the chromatic color of a yellow-blue mixture with a value of +*b* from 0 to 60 for yellow and a –*b* value from 0 to -60 for blue. Orange peel color seen from the value of Citrus Color Index (CCI) with Equation 2 Jimenez-Cuesta *et al*. (1981) :

$$CCI = \frac{1000a*}{L*b*} \quad (2)$$

where *L** is lightness, *a** chrome green-red, and *b** is chrome blue-yellow.

Measurement of weight loss using an analytical balance, starting on day 0 of storage and each time of observation. The value of weight loss is obtained from the reduction of the initial weight (w) with the storage weight of the a day (wa) divided by the initial weight (w) and is expressed in percent (%). Loss of weight is calculated using Equation 3:

$$Weight\ loss = \frac{w_i - w_n}{w_i} \quad (3)$$

where w_i is initial weight and w_n is weight on day n.

Observation of rotten fruit was carried out by counting the number of rotten fruit against the total number of fruit in each observation. Calculation of the percentage of rotten fruit is done using Equation 4:

$$Percentage\ of\ rotten\ fruit = \frac{Number\ of\ rotten\ fruit}{Total\ fruit} \times 100\% \quad (4)$$

Destructive measurements included: hardness, total dissolved solids, total acid and vitamin C content, using three oranges every three days of observation. The hardness of Gerga Pagar Alam oranges was measured using a rheometer. The principle of hardness testing is by measuring the fruit's resistance to a needle on a rheometer. Total dissolved solids were measured using a refractometer by squeezing oranges to get the juice then measuring the sugar content by placing the liquid into the refractometer prism, the number printed on the refractometer indicates the total dissolved solids level (°Brix) which represents sweetness. The acid content was measured using the ATAGO Brix Acidity Meter PAL BX ACID by weighing the mixture of 1 gram of orange juice, then adding distilled water until it weighed 50 grams and stirring until smooth, then putting it into the prism of the ATAGO Brix Acidity Meter PAL BX ACID one drop, the number The label shown shows the acid content (%) in Gerga Pagar Alam oranges. Testing for vitamin C in Gerga Pagar Alam oranges was carried out three times during storage, namely on day 0, day 14 and day 29, measured using a spectrophotometer.

2.2.5. Organoleptic Test

The purpose of the organoleptic test is to determine the consumer's response or impression of the product obtained by the five human senses (Setyaningsih, 2010). The organoleptic test is carried out by means of a hedonic rating test, panelists are asked to give an assessment based on their preferences. The test parameters include color, aroma, texture and taste. The hedonic rating test uses a scale of 1-5, where the assessment criteria are (1) do not like, (2) do not like, (3) quite like, (4) like, (5) really like, against predetermined test parameters (Ayustaningwarno, 2014). This organoleptic test was carried out by a panel of 25 untrained people who were randomly selected. The panelists observed and directly tested the sample and then recorded the results in the questionnaire provided.

3. RESULTS AND DISCUSSION

The recapitulation of the results of the analysis of variance for the quality parameters of Gerga oranges is presented in Table 1. The results showed that the degreening treatment had a significant effect on the CCI value. Temperature treatment has a significant effect on the value of CCI, weight loss, hardness, TDS and total acid. The interaction of degreening and storage temperature has an effect on weight loss and hardness. The effect of degreening and storage temperature on the CCI value was significant from the 5th to the 29th day of observation, but there was no interaction between the two treatments. There was no significant effect on the weight loss of the degreening treatment, but the temperature showed a significant effect on the 2nd to 29th day of observation. The interaction of degreening and storage temperature on weight loss occurred on the 11th day of observation and the 14th day of observation. On hardness values, degreening did not show a significant effect, but temperature treatment showed an effect on observations on days 8, 20, 23, 26 and 29. Interaction occurred on observations on days 17, 20 and 29. In total acid, degreening did not show

a significant effect, but storage temperature showed significant effect on the observations on days 11, 14, 23, 26 and 29, and there was no interaction between the two treatments on total acid.

Table 1. Recapitulation of variance of the effect of degreening treatment and storage temperature during storage

Quality Parameters	Treatment	ANOVA for day-										
		0	2	5	8	11	14	17	20	23	26	29
CCI (Citrus Color Index)	Degreening	tn	tn	*	*	*	*	*	*	*	*	*
	Temperature	tn	tn	*	*	*	*	*	*	*	*	*
	Interaction	tn	tn	tn	tn	tn	tn	tn	tn	tn	tn	tn
	CV (%)	5.7	12,8	7	21,7	15,5	15,1	13	15,1	14,2	10,9	10,2
Weight loss	Degreening	--	tn	tn	tn	tn	tn	tn	tn	tn	tn	tn
	Temperature	--	*	*	*	*	*	*	*	*	*	*
	Interaction	--	tn	tn	tn	*	*	tn	tn	tn	tn	tn
	CV (%)	--	20,4	12,1	13,3	8,8	8,4	10,1	8,9	10,9	11,4	11
Hardness	Degreening	tn	tn	tn	tn	tn	tn	tn	tn	tn	tn	tn
	Temperature	tn	tn	tn	*	*	*	*	*	*	*	*
	Interaction	tn	tn	tn	tn	tn	tn	*	*	tn	tn	*
	CV (%)	12.5	13,9	14,3	14,4	12,4	15,4	14,1	13	12,5	11,1	11,9
TDS (Total Dissolved Solid)	Degreening	tn	tn	tn	tn	tn	tn	tn	tn	tn	tn	tn
	Temperature	tn	tn	tn	*	tn	tn	tn	*	*	*	*
	Interaction	tn	tn	tn	tn	tn	tn	tn	tn	tn	*	tn
	CV (%)	1.2	6,8	6,1	4,6	7,4	5,8	7,3	5,3	7,9	5,5	8,6
TA (Total Acid)	Degreening	tn	tn	tn	tn	tn	tn	tn	tn	tn	tn	tn
	Temperature	tn	tn	tn	tn	*	*	tn	tn	*	*	*
	Interaction	tn	tn	tn	tn	tn	tn	tn	tn	tn	tn	tn
	CV (%)	1.6	10,9	10,1	9,5	7,4	10,8	12	8,8	7,8	9,2	7,6

Note: tn = not significantly different, * = significantly different at a = 5%, CV = coefficient of variance

3.1. Effect of Degreening and Storage Temperature on CCI Values

The results showed that there was a change in the color of the Gerga Pagar Alam orange peel from green on day 0 (CCI -1.64) to a uniform and even yellow (CCI 3.09 - 3.95) on day 29. This was indicated by the increasing the CCI value increases with the length of storage with a smaller standard deviation (Table 2).

Table 2. Effect of degreening and storage temperature on CCI values during storage

Day	Degreening				Temperature			Sig.
	0 ppm	250 ppm	500 ppm	750 ppm	Room	10 °C	10 °C	
0	-1,64	-1,64	-1,64	-1,64	-1,64	-1,64	-1,64	ns
2	-0,99	-0,45	-0,25	-0,12	-0,14	-0,73	-0,49	ns
5	0,00 a	1,26±1,10b	1,43±0,92b	1,51±0,78b	1,71±0,90b	0,02±0,76a	1,42±0,63b	ns
8	0,63±0,65a	1,87±0,91b	2,19±0,82b	2,16±0,73b	2,16±0,99b	0,79±0,67a	2,19±0,57b	ns
11	1,13±0,53a	2,41±0,75b	2,71±0,67b	2,56±0,54b	2,54±0,96b	1,50±0,63a	2,56 ±0,57b	ns
14	1,48±0,47a	2,64±0,67b	2,89±0,71b	2,68±0,48b	2,76±1,00b	1,83±0,48a	2,69±0,47b	ns
17	1,89±0,41a	2,85±0,58b	3,08±0,47b	2,82±0,43b	2,96±0,81b	2,22±0,41a	2,81±0,43b	ns
20	2,09±0,60a	3,06±0,53b	3,24±0,38b	2,94±0,37b	3,07±0,93b	2,53±0,35a	2,89±0,39b	ns
23	2,39±0,58a	3,25±0,48b	3,42±0,46b	3,11±0,39b	3,39±0,84b	2,77±0,34a	2,97±0,38a	ns
26	2,71±0,43a	3,37±0,48b	3,67±0,41b	3,37±0,44b	3,66±0,69b	3,15±0,35a	3,03±0,35a	ns
29	2,89±0,47a	3,52±0,55b	3,82±0,52b	3,48±0,50b	3,95±0,65b	3,24±0,34a	3,09±0,35a	ns

Note: numbers followed by the same letters in the same column are not significantly different at the 5% DMRT test level, ns = not significantly different, * = significantly different at the α = 5%

The degreening treatment of Gerga Pagar Alam oranges on day 5 to day 29 showed a significant effect ($p < 0.05$) on the CCI value, as well as storage temperature which showed a significant effect ($p < 0.05$), but there was no interaction between the two treatments. Degreening of Gerga Pagar Alam oranges at ethepon concentrations of 250ppm, 500ppm and 750ppm was not significantly different from the CCI value, while degreening at a concentration of 0 ppm was significantly different. The highest CCI value was observed on the 29th day of the degreening treatment with 500 ppm ethepon concentration reaching 3.82, then at 250 ppm ethepon concentration reaching 3.52, then 750 ppm ethepon treatment reaching 3.47. Whereas in the degreening treatment with 0 ppm ethepon concentration the CCI value was 2.89 (Figure 1A). This shows that degreening with ethepon concentrations of 250 ppm to 750 ppm can increase the CCI value of Gerga Pagar Alam oranges, producing an even yellow color. In the research by Arzam *et al.* (2015) Siamese oranges given ethylene concentrations of 100, 200 and 300 ppm had higher CCI values than oranges without ethylene. Oranges without ethylene treatment showed a slower change in CCI values compared to oranges treated with ethylene (Ramadhani *et al.*, 2015, Hasimi *et al.*, 2016). Likewise the results of Gautama *et al.* (2019) the CCI value of Garut tangerines has increased after degreening. Based on research by Dewayani *et al.* (2016) Tankan, Ponkan, Sunkist and Siem oranges which were degraded using ethepon had an even yellow skin color and had no effect on the chemical characteristics or nutritional content of the fruit.

The storage temperature treatment showed a significant effect on the CCI value of Gerga Pagar Alam oranges. This is in accordance with the research of Musdalifah *et al.* (2014) on storage temperature treatment can increase the CCI value of Siamese oranges. The CCI values at room temperature and 20 °C were not significantly different from the 5th to 23rd day of observation, but significantly different from the 26th and 29th observation (Table 2). Citrus fruits treated at room temperature experienced an increase in CCI values faster than oranges at 10oC and 20oC, this indicates that at room temperature the green color of oranges is easily degraded. The optimum CCI values of Gerga orange peels on the 29th day of observation each reached 3.95 at room temperature, 3.24 at 10 °C, and 3.09 at 20 °C, indicating an even yellow skin color (Figure 1B).

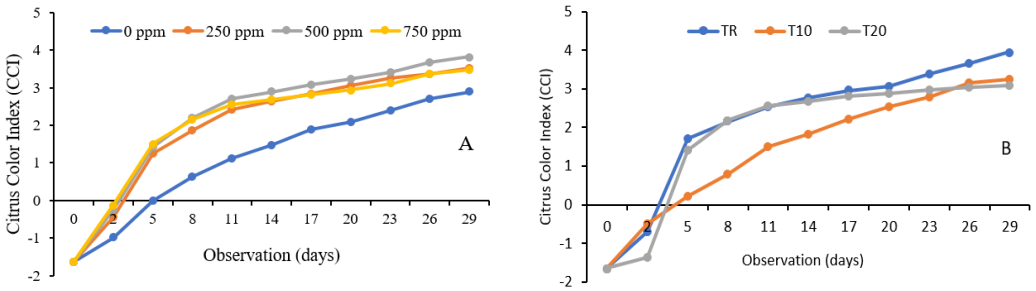

Figure 1. CCI value of RGL tangerine degreening treatment (0ppm, 250ppm, 500ppm, 750ppm) (A) and storage at room temperature (TR), temperature 10 ^{o}C (T10), temperature 20 ^{o}C (T20) (B)

Gerga oranges resulting from degreening experience degradation of green to yellow faster than oranges without degreening (0 ppm). At the end of storage, the orange peel color was uniformly yellow for all treatments except degreening with 0 ppm ethepon concentration stored at room temperature, the yellow color of oranges still

appeared uneven (pale yellow). Visually, the physical appearance of degreening Gerga oranges stored at room temperature during storage becomes unattractive because they are wilted, wrinkled and brown. Changes in the color of the Gerga Pagar Alam orange peel can be seen in Figure 2, Figure 3 and Figure 4.

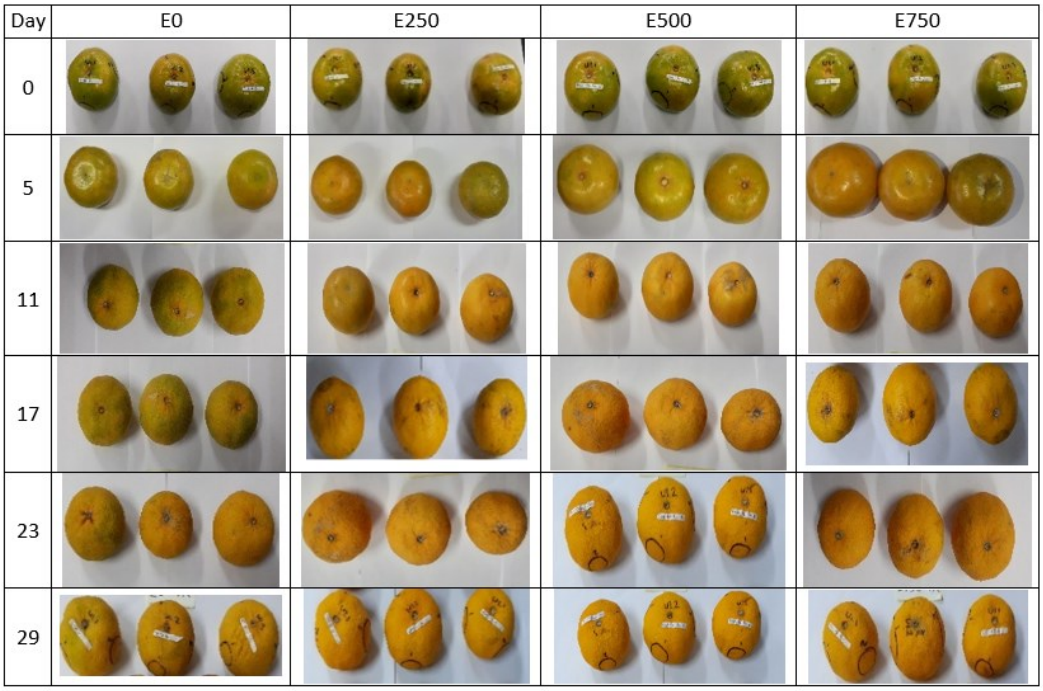

Figure 2. Color change of RGL tangerine peel as a result of degreening at room temperature

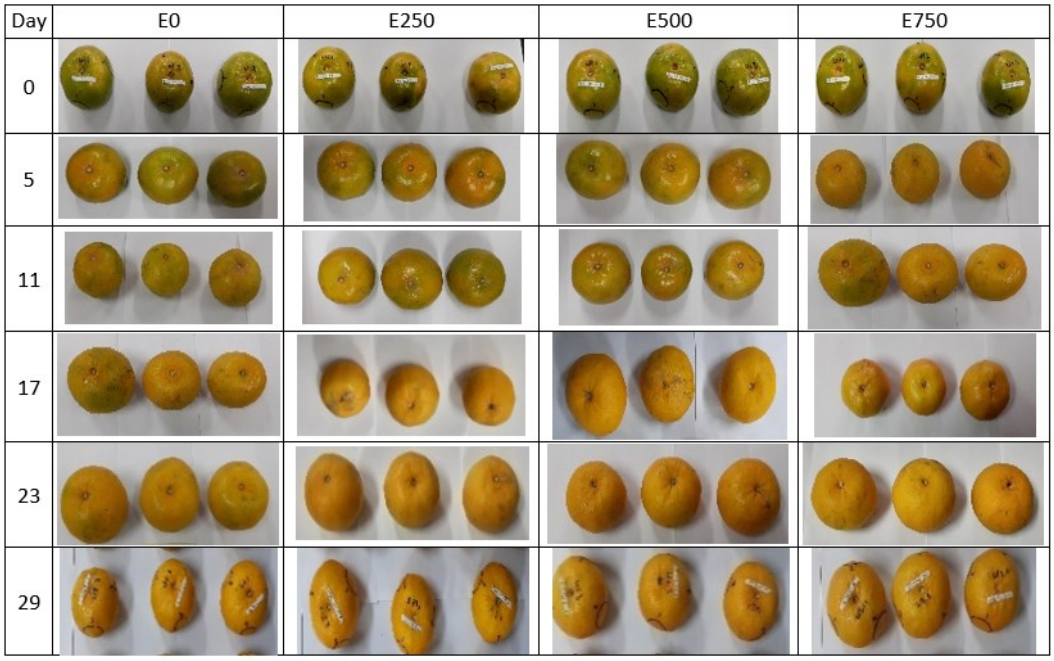

Figure 3. Color change of RGL tangerine peel results of degreening at 10 ^{o}C storage temperature

Figure 4. Color change of RGL tangerine peel results of degreening at 20 °C storage temperature

3.2. Changes in the Physicochemical Properties of Gerga Pagar Alam Citrus

3.2.1. Weight loss

During storage, the weight loss of Gerga Pagar Alam oranges increased. The results of the analysis (Table 3) show that degreening has no effect on weight loss during storage, but storage temperature shows a significant effect. This is in accordance with Nacing (2017) that the administration of ethepon had no effect on the shrinkage of Tangerines. The storage temperature treatment showed an effect from day 2 to day 29. The highest weight loss on observation day 29 reached 30.87% at room temperature treatment. This shows that the loss of water at room temperature is very high so that it affects the weight loss. These results are in accordance with the research of Arzam *et a*l. (2018) Selayar oranges stored at room temperature showed a very high shrinkage rate compared to 18 °C and 20 °C. According to Tiara (2019) on Garut tangerines, Sidik *et al.* (2022) on RGL oranges that unwaxed oranges at room temperature have the highest weight loss. In the research by Arzam *et al*. (2015) degreening at room temperature Tejakula tangerines, Kintamani tangerines and Kintamani tangerines experienced the highest weight loss. In Siamese oranges, the weight loss increases with the longer storage time, which occurs faster at room temperature (28±2 °C) (Dewi *et al*., 2020). Low temperatures can suppress or reduce factors that cause fruit spoilage such as the activity of microorganisms, respiration processes, enzyme activity and evaporation, so as to reduce the percentage of weight loss in fruit and extend fruit shelf life (Muchtadi *et al*., 2013; Ahmad, 2013). In the study (Sulistyo *et al*., 2020) at the end of the observation (day 40) the weight and diameter of citrus fruits decreased at room temperature on average by 41% and 6.9% of the initial dimensions.

The effect of the interaction of degreening and storage temperature on the weight loss of Gerga Pagar Alam oranges on the 14th day of observation is presented in Table 4. The degreening treatment with ethepon concentration of 250 ppm combined at room temperature 20°C resulted in the lowest weight loss of 6.55%, and was not significantly different from the combination of 250ppm ethepon at 10°C is 6.98%. This

shows that the combination of degreening the ethepon concentration of 250 ppm at 10°C and/or 20°C effectively suppresses the weight loss of Gerga Pagar Alam oranges and can maintain fruit quality.

Table 3. Effect of degreening and storage temperature on weight loss of Gerga Pagar Alam oranges during storage

Day	Degreening				Temperature			Sig.
	0 ppm	250 ppm	500 ppm	750 ppm	Room	10 °C	10 °C	
0	0	0	0	0	0	0	0	tn
2	2,06±0,25	2,18±0,45	2,12±0,26	2,29±0,92	2,22±0,37b	2,45±0, 70b	1,82±0,21a	tn
5	4,68 ±1,54	4,9±2,41	4,84±1,77	5,09±2,03	7,35±0,78b	3,83±0,68a	3,45±0,35a	tn
8	6,76±2,72	7,11±4,9	7±3,17	7,15±3,39	11,29±1,04b	5,09 ±1,16a	4,64±0,46a	tn
11	8,79±3,93	9,09±5,32	8,93±4,27	8,99±4,16	14,77±1,23b	6,28±0,66a	5,81±0,58a	tn
14	10,7±5,0	11,07±6,52	10,8±5,32	10.84±5,03	18,09±1,45b	7,48 ±0,70a	7,01±0,65a	tn
17	12,59±6,14	12,94±7,63	12,38±6,67	12,93±6,0	21,39±1,55b	8,69±0,71a	8,04±1,44a	tn
20	14,28±6,77	14,88±8,7	14,34±7,69	14,86±7,06	24,55±1,67b	9,98 ±0,73a	9,23±1,51a	tn
23	16,05±7,6	16,12±8,16	15,94±8,66	16,4±8,16	26,79±1,93b	11,24±0,79a	10,35± 1,80a	tn
26	17,78±8,20	17,74±8,85	17,21±8,95	17,54±8,24	28,72±2,33b	12,56±0,85a	11.42±1,85a	tn
29	19,08±8,80	19,22±9,34	18,67±9,50	18,99±8,76	30,87±2,41b	13,54±0,83a	12,56±1,94a	tn

Note: numbers followed by the same letters in the same column are not significantly different at the 5% DMRT test level, tn = not significantly different, * = significantly different at the α = 5%

Table 4. Interaction of degreening and storage temperature on weight loss of Gerga Pagar Alam oranges on the 14th day

Degreening Treatment	Storage Temperature (°)		
	Room	10	20
0 ppm	17,36 ± 1,40b	7,47 ±0,47a	7,29 ±0,85a
250 ppm	19,69 ± 1,73c	6,98 ± 0,27a	6,55 ± 0,38a
500 ppm	17,83 ± 1,01b	7,40 ± 0,39a	7,17 ± 0,94a
750 ppm	17,47 ± 0,57b	8,06 ± 1,19a	7,01 ± 0,35a

Note: numbers followed by the same letter in the same column are not significantly different at the 5% DMRT test level

3.2.2. Hardness

The effect of degreening and storage temperature on the hardness of Gerga Pagar Alam oranges during storage is presented in Figure 5. The data shows that during storage the hardness values of Gerga Pagar Alam oranges range from 1.79 to 3.01 kgf, this indicates that the skin texture is hard. The results of the analysis showed that degreening had no effect on the hardness value of Gerga Pagar Alam oranges, but storage temperature showed an effect on hardness from the 8th to 29th day of observation. The hardness value of Gerga oranges at 20 °C was lower than at 10 °C and room temperature. On the 29th day of observation, the orange hardness values at 20 °C, 10°C and room temperature were 1.90 kgf, 2.49 kgf and 3.01 kgf, respectively. Hardness changes that occur at different temperatures produce different hardness values. According to Sugianti *et al*. (2014) textural changes that occur in fruit as a result of wilting processes due to respiration and transpiration. Withering and wrinkling on the surface of the fruit occurs due to evaporation or transpiration processes which result in water loss resulting in a decrease in quality (Muhctadi *et al*. 2013, Nasution *et al*., 2012).

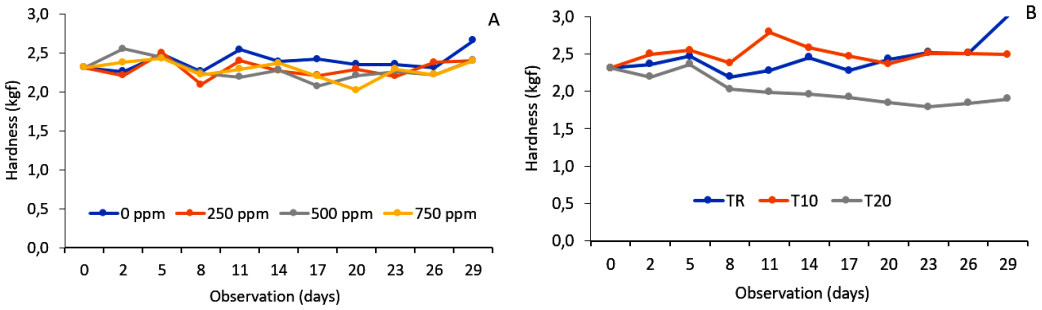

Figure 5. The hardness value of RGL tangerines degreening treatment (0ppm, 250ppm, 500ppm, 750ppm) (A) and storage temperature at room temperature (TR), 10 °C (T10), 20 °C (T20) (B)

The interaction of degreening and storage temperature of Gerga Pagar Alam oranges on the hardness value occurred on the 17th, 20th and 29th day of observation. The effect of the degreening interaction and storage temperature of Gerga oranges on the hardness value on the 29th day of observation (Table 5) showed a combination of degreening with an ethepon concentration of 250 ppm and a temperature of 20 °C resulted in the lowest hardness value of 1.64 kgf, this indicated that the combination was effective in maintaining the quality of Gerga Pagar Alam orange peels so that the skin texture did not become harder.

Table 5. Interaction of degreening and storage temperature on hardness of Gerga Pagar Alam oranges on the 29th day

Degreening Treatment	Storage Temperature (°)		
	Room	10	20
0 ppm	2.93±0.32efg	2.81±0.41efg	2.24±0.20bcd
250 ppm	3.11±0.15fg	2.46±0.34efg	1.64±0.14a
500 ppm	3.34±0.12g	2.15±0.16abcd	1.74±0.12ab
750 ppm	2.67±0.53def	2.54±0.40cde	2.00±0.22abc

Note: numbers followed by the same letter in the same column are not significantly different at the 5% DMRT test level

3.2.3. Total Dissolved Solids

During storage, the total dissolved solids value of the Gerga Pagar Alam oranges increased (Figure 6), this indicates that the level of sweetness of the oranges increased. TDS will increase rapidly when the fruit is ripening and will continue to decrease with the length of storage (Anggraini *et al.*, 2015). The TDS value of Gerga Pagar Alam oranges during storage ranged from 9.21 – 11.74 °Brix. This is in line with research by Hasimi *et al.* (2016) the TDS content of Siamese oranges increased during storage in the range of 8.56 – 11.27 °Brix at 12 HSD, Rosalina *et al.* (2015) in RGL oranges during 16 days of storage the TDS content in the control treatment increased faster by 11.16 °Brix and Sidik *et al.* (2022) for RGL oranges in the control treatment on day 20 it reached 12.33 °Brix. From the results of the analysis, degreening has no significant effect on TDS values, this is in accordance with the research of Arzam *et al.* 2022 in Selayar oranges which were given ethepon had no effect on the total dissolved solids. While the storage temperature affects the TDS value of Gerga oranges. Storage temperature significantly affected the observations on days 8, 20, 23, 26 and 29. The highest TDS content was observed on day 29, namely at room temperature, which was significantly different from the TDS content at 20 °C and 10 °C respectively, namely

11.74 °Brix , 10.55 °Brix, and 10.26 °Brix. From the TDS value produced on the 29th day of observation, the Gerga Pagar Alam oranges were classified as sweet. According to Qomariah *et al*. (2013) one of the requirements for the quality of citrus fruit exports in terms of TDS (total dissolved solids) content of at least 10oBrix. The highest TDS value at room temperature indicates that fruit ripens more quickly, where complex compounds such as starch are broken down into simple sugars which give fruit a sweet taste (Marlina *et al*. 2014).

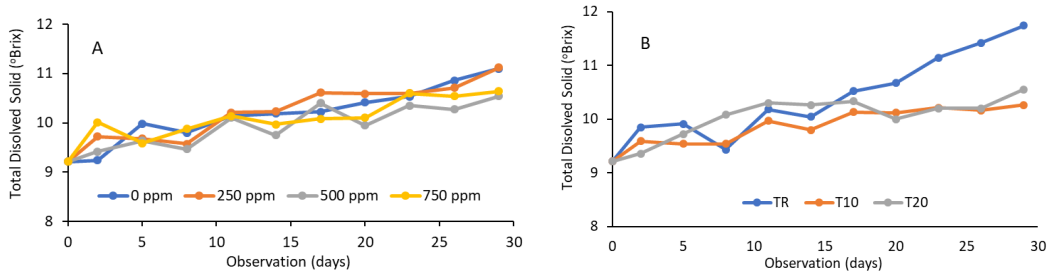

Figure 6. Total dissolved solids of tangerine RGL at degreening treatment (0ppm, 250ppm, 500ppm, 750ppm) (A) and storage temperature at room temperature (TR), 10 °C (T10), 20 °C (T20) (B)

3.2.4. Total Acids

From the results of the analysis the degreening treatment did not show a significant effect on the total acid value of Gerga Pagar Alam citrus (Figure 7A), while the temperature treatment showed a significant effect only on the observations on days 11, 14, 23, 26 and 29 (Figure 7B). There was no interaction between the two treatments. In general, the total acid content in oranges tends to decrease during storage. From the research results, the total acid content of Gerga Pagar Alam citrus ranged from 0.52-0.68%, decreased at the end of storage. This is in line with research by Prabowo *et al*. (2020) the total acid value of Siamese oranges tends to decrease during storage time. In the study by Sidik *et al*. (2022) the acid content of RGL oranges decreased, ranging from 0.53 -0.64%, as well as research by Rosalina *et al*. (2015) on the 16th day of observation, the highest RGL citrus acid content was 0.81% without coating and the lowest was 0.58% with edible coating. In the study of Gautama *et al*. (2019) acid content in Tangerines According to Sugianti *et al*. (2014) the acid content in the fruit will reach a maximum during growth and development and will decrease during storage. The fluctuating total acid value indicates a decrease in fruit quality (Muthmainnah, 2014).

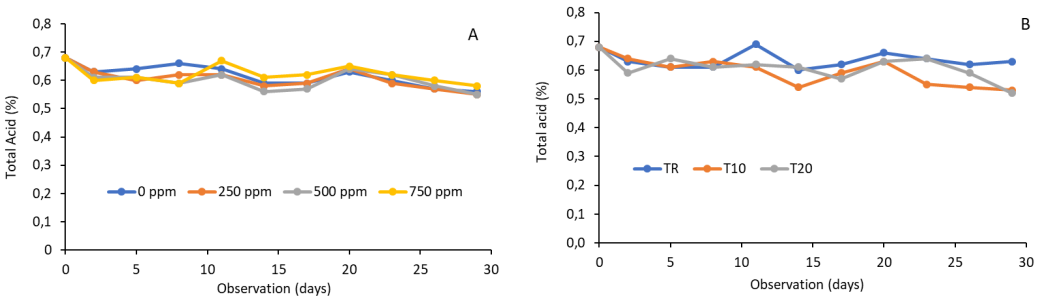

Figure 7. The value of RGL orange acid content at degreening treatment (0ppm, 250ppm, 500ppm, 750ppm) (A) and storage temperature at room temperature (TR), 10 °C (T10), 20 °C (T20) (B)

3.2.5 Vitamin C

The results of the analysis showed that the degreening treatment and storage temperature had no significant effect on the vitamin C of Gerga Pagar Alam oranges on day 0, but it was significant on the observations on days 14 and 29, where there was an interaction between the two treatments (Table 6). In general, the content of vitamin C in oranges during storage decreased. According to Hasmini (2017) the decrease in vitamin C content (ascorbic acid) occurs due to the degradation of vitamin C during storage. From the research results, the vitamin C content of Gerga Pagar Alam oranges decreased during storage (Table 6). On day 0 the vitamin C content reached 57.85 mg/100g then decreased by 33.64 – 40 mg/100g (Table 6). This is in accordance with research by Hasimi *et al*. (2016), the content of vitamin C in Siamese oranges ranges from 34.32 – 48.50 mg/100g. In the study by Mikasari *et al*. (2015) the vitamin C content of RGL oranges was 46 mg/100g. Table 10 shows the interaction effect of degreening and storage temperature on the vitamin C on the 29th day.

Table 6. Effect of degreening and storage temperature on vitamin C $(\mathrm{mg}/100\mathrm{g})$ in Gerga Pagar Alam oranges during storage

Treatment	0	14	29
Degreening			
0 ppm	57,85 ± 3,26	52,68 ± 7,12c	36,73 ± 3,98b
250 ppm	57,85 ± 3,26	44,51 ± 3,80a	36,45 ± 4,25b
500 ppm	57,85 ± 3,26	46,18 ± 3,95b	36,09 ± 1,13b
750 ppm	57,85 ± 3,26	57,22 ±15,23d	35,07 ± 4,0a
Temperature			
Room	57,85 ± 3,26	49,67 ± 9,22a	34,44 ± 1,42b
10^{o}C	57,85 ± 3,26	51,63 ± 12,30c	33,64 ± 2,12a
20^{o}C	57,85 ± 3,26	49,15 ± 8,51a	40,18 ± 2,08c
Interaction	tn	*	*

Note: numbers followed by the same letters in the same column are not significantly different at the 5% DMRT test level, tn = not significantly different, * = significantly different at the 5% level

Table 7. Interaction of degreening and storage temperature of vitamin C in Gerga Pagar Alam oranges on the 29th day of observation

Degreening Treatment	Storage temperature		
	TR	T10	T20
0 ppm	35,11 ± 1,18c	33,22 ± 0,45b	41,86 ± 0,33f
250 ppm	32,50 ± 0,23b	34,92 ± 0,45c	41,93 ± 0,53f
500 ppm	35,26 ± 1,42c	35,82 ± 0,39c	37,18 ± 0,17d
750 ppm	34,88 ± 0,17c	30,58 ± 0,58a	39,75 ± 0,90e

Note: numbers followed by the same letters in the same column are not significantly different at the 5% DMRT test level

From the DMRT test results on the interaction of degreening and storage temperature on the 29th day of observation, it showed that the highest vitamin C content was in the combination of degreening 250 ppm at 20 °C and not significantly different from degreening 0 ppm at a temperature of 20 °C, this shows the combination of degreening 250 ppm and temperature 20 °C can maintain the Vitamin C content of Gerga Pagar Alam oranges.

3.2.6 Percentage of rotten fruit

During the storage of the Gerga Pagar Alam orange samples used in color measurements, some of them rotted and experienced brownish wrinkles. One of the causes of product damage is evaporation of the water content in the product resulting in shrinkage of the Siamese orange peel, the fruit becomes rotten because it can also cause a decrease in the quality of its appearance, causing the quality of food products to decrease physically or in texture (Wahyuningsih *et al*., 2016).

From the analysis results, degreening did not have a significant effect on the percentage of rotten fruit, but temperature had a significant effect on the percentage of rotten fruit on the 23rd to the 29th day of observation, where there was no interaction between the two treatments. The highest percentage of rotten and wrinkled brown fruit was at room temperature reaching 22.22% (observation day 29), at this temperature the damage to the fruit began on observation day 8 (Figure 8). The percentage of rotten fruit at 20oC was smaller than at room temperature (19.44%) on the 29th day of observation, where fruit damage at this temperature began to occur on the 17th day of storage, and had a shelf life of 8 days longer than room temperature. At a temperature of 10 °C Gerga Pagar Alam oranges do not rot, so at this temperature it is more effective in suppressing the activity of microorganisms so as to prevent rotting of the fruit and extend the shelf life of the fruit up to 29 days. Based on research by Muthmainnah *et al*. (2014) on three varieties of tangerines during storage 18 HSP to 30 HSP experienced fruit rot due to fungi, where at room temperature as many as 9 fruits were rotten and as many as 4 fruits were rotten at 18oC. Musdalifah *et al*. (2016) reported that Pontianak siam oranges stored at 10 °C can last up to 42 days. In addition, cold temperatures of 10-16 °C can reduce sporulation, respiration, and the capacity of enzyme degradation by fungi (Sharma, 2015). Based on research by Wahyuningsih *et al*. (2016) the shelf life of Siamese oranges at 10 °C is 15 days, at 15 °C the shelf life is 14 days, and at 28 °C the shelf life is 13 days. In the research by Khairunnisa *et al*. (2022) Arumanis mangoes were treated with EAB and stored at cold temperatures (13 ± 2 °C) with a shelf life and shelf life of 14-20 days.

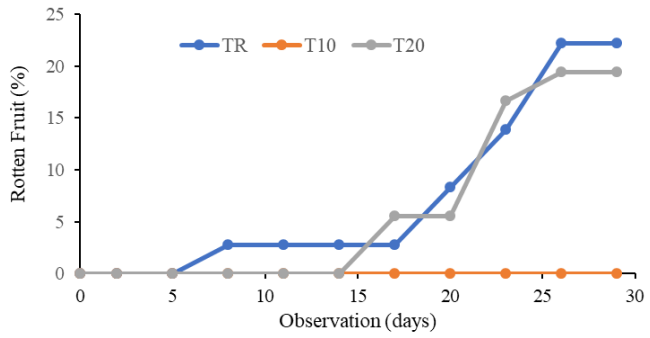

Figure 8. Percentage of RGL orange rot at room temperature (TR), 10 °C (T10), and 20 °C (T20) during storage

3.2 Organolapetic Test

The hedonic test or preference test was carried out to find out the degreening results and the most preferred storage temperature by the panelists. The attributes used in the hedonic test are color, aroma, taste, and texture attributes. The effect of degreening and storage temperature on the organoleptic test results of Gerga Pagar Alam oranges is presented in Table 7.

Table 7. Effect of degreening treatment and storage temperature on color, aroma, texture and taste

Treatment	Color	Aroma	Texture	Taste
Degreening				
0 ppm	3.57 ± 1.01a	3.42±0.91	3.7±1.02	3.84±1.04
250 ppm	4.09 ± 1.08b	3.64±0.92	3.7±1.17	3.7±1.08
500 ppm	3.81 ± 1.08ab	3.58±0.95	3.53±1.09	3.78±1.06
750 ppm	3.97 ±0.95b	3.48±1.0	3.85±0.95	3.6±1.01
Temperature				
Room	3.13 ±1.16a	3.32 ±1.0a	3.23 ±1.11a	3.49 ±1.12a
10 °C	4.37 ±0.73c	3.55 ± 0.89ab	3.9± 0.94b	3.76 ±1.03ab
20 °C	4.09 ±0.75b	3.73 ± 0.91b	3.97 ±0.96b	3.95 ±0.94b
Interaction	tn	tn	tn	tn

Note: numbers followed by the same letters in the same column are not significantly different at the 5% DMRT test level, tn= not significantly different, * =significantly different at the 5% level

From the analysis results, degreening treatment and storage temperature can increase the panelist's preference for color, while the temperature treatment increases the panelist's aroma, texture and taste. This is in accordance with research by Anggraini (2014) degreening increased the panelist's preference value for skin color, and did not affect the panelist's preference value for sweetness, texture or the aroma of Terigas honey tangerines.

3.3.1. Color

Degreening treatment and storage temperature showed a significant effect ($p < 0.05$) on color values. From the test results in Table 13, it shows that the average panelists' preference for color ranges from 3.13 to 4.37 which is between the parameters quite like (3) and really like (5). The degreening treatment at 250 ppm ethepon concentration was the panelist's highest preference score for color, namely 4.09, not significantly different at 500 ppm and 750 ppm degreening, but significantly different at 0 ppm degreening. This shows that the color of the orange resulting from degreening is preferred by the panelists compared to the orange without degreening (0 ppm). Whereas in the temperature treatment the highest score of panelists' preference for color was at 10oC it reached 4.37, then at 20 °C it was 4.09. This shows that orange color at 10 °C and 20 °C is preferred by the panelists.

3.3.2. Aroma

The results of the hedonic test on aromas showed that the average preference of panelists for aromas ranged from 3.32 to 3.73 which was between the parameters quite like (3) and like (4). The results of the analysis showed that degreening had no effect on the aroma value, but the storage temperature had an effect on the aroma. The highest average aroma attribute values were found at 20 ^{o}C and were not significantly different at 10 ^{o}C. This shows that the orange aroma at 10 ^{o}C and 20 ^{o}C is preferred by the panelists compared to room temperature.

3.3.3. Texture

The results of the panelists' assessment of texture ranged from 3.23 to 3.97 between the parameters quite like (3) and like (4). The results of the analysis of variance showed that degreening had no effect on the texture value, but the storage temperature had an effect on the texture. The highest level of panelists' preference for texture was at 20

^{o}C, namely 3.97, not significantly different at 10 ^{o}C, but significantly different at room temperature. This shows that textures at 10 ^{o}C and 20 ^{o}C are preferred by panelists compared to textures at room temperature.

3.3.4. Taste

The results of the panelists' assessment of taste ranged from 3.6 to 3.95 between the parameters quite like (3) and like (4). The results of the analysis of variance showed that degreening had no effect on texture values, but storage temperature had an effect on taste. The highest scores of panelists' preference for taste were at 20 °C and 10 °C respectively 3.95 and 3.76. This shows that the flavors produced at 10 °C and 20 °C are preferred by the panelists.

4. CONCLUSIONS

Degreening shows a significant effect on changes in the color of the Gerga Pagar Alam orange peel, but does not reduce the internal quality of the fruit. Degreening treatment (ethepon concentration 250ppm, 500ppm, 750ppm) resulted in a CCI value of 3.48-3.82, forming an even yellow skin color at the end of storage (on the 29th day of observation). Treatment with a temperature of 10oC was more effective in suppressing weight loss and preventing spoilage of the fruit during storage, thereby extending the shelf life up to the 29th day. The combination of degreening treatment and 250 ppm ethepon concentration at 10 °C and 20 °C could maintain the quality of Gerga oranges resulting in the lowest weight loss on the 14th day of storage, can reduce the hardness of the skin and can maintain the vitamin C content on the 29th day of observation. Further research is needed on Gerga Pagar Alam oranges through precooling treatment before degreening, with a storage temperature of 15 °C (after degreening) to produce an orange color on Orange peel to make it more attractive.

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