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Quality Evaluation of Color and Texture of the Dabai Fruit (*Canarium odontophyllum* Miq.) at Different Temperatures and Times of Blanching

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ABSTRACT

The Dabai fruit (*Canarium odontophyllum* Miq.) is seasonal in Sarawak. The flesh is often blanched in hot or lukewarm water to make it creamier and softer before being served as a snack or side dish. The fruit was blanched at temperatures ranging from 60°C to 100°C, with 10°C increments, for up to 10 minutes, whereby the quality changes in color and texture were investigated. Notably, the L parameter has remained unchanged during the blanching process, indicating that the dabai fruit's dark color is retained. The parameters a*, b*, chroma (C), and total color difference (TCD), on the other hand, have increased significantly as the temperature and time of blanching are increased. However, the change in firmness was not substantial due to the slight variations in firmness as the temperature and time increased. From these findings, it can be inferred that the temperature and duration of blanching have significantly changed the dabai fruit's color except for the firmness of the fruit. These findings would be useful in designing thermal processes and related calculations for the dabai fruit.

Keywords: Blanching, color, dabai, firmness, quality evaluation

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INTRODUCTION

The dabai fruit (*Canarium odontophyllum* Miq.) is in the family of Burseraceae of Sapindales order, where it belongs to the Eudicotyledonae class. It is categorized in the drupe fruit family, where in botany, it is often known as 'stone fruit,' which includes olive oil and palm oil. It is an indigenous seasonal fruit that can only be found in Borneo Island, mainly in the Sibu and Kapit regions of Sarawak (Rukayah, 2009; Chua & Nicholas, 2009; Chua et al., 2015). The most fruitful annual seasons for dabai are from May to June and December to January. The dabai fruits were collected using a sickle and a net to gather the falling fruits and branches owing to the cutting of terminal branches of the fruit panicles when the immature white fruit became purplish-black (Ding, 2011). Significantly, dabai fruits are known for their high nutritional value, antioxidant, and mineral content, including potassium, phosphorus, calcium, and magnesium, all of which are present in the skin (Shakirin et al., 2010; Ariffin et al., 2020). The dabai fruit is always eaten by dipping it in soy sauce or is used as an ingredient in a dish such as 'nasi goreng dabai.' Furthermore, a few studies have reported that the skin of dabai fruits has high phytochemical contents such as anthocyanin and flavanoids (Pin et al., 2014; Khoo et al., 2016; Ariffin et al., 2020). According to Ding (2011), one of the most common methods to prepare the dabai fruit is by blanching it for 15 minutes using lukewarm water.

Blanching is rapidly heating vegetables and fruits to a certain temperature and holding them for 1 to 10 minutes. The process is a thermal treatment used to enhance the taste or texture of fruits and vegetables. The convectional water method is the common technique for blanching dabai fruit. It is easier to be operated as the dabai fruit is immersed in hot or lukewarm water for several minutes. Then, the water will be drained, and the blanched products will be cooled before the next process is continued. As aforementioned in the previous study, the dabai fruits are served after soaking in lukewarm water at 50°C for about 15 to 20 minutes to soften the fruit's flesh (Ding, 2011). As a result, the blanched dabai will have a smooth, creamy texture and enhance the flavor. Usually, the locals will eat the blanched dabai directly after the treatment. Thus, there is no processing operation after the blanching process. However, the blanching process by the locals varies as they do not have a predetermined temperature and duration. In the traditional method, most of them blanched the dabai fruits judging merely by their appearances.

Quality products were defined as the products that meet the consumer's perception, whereby the quality of the products was judged based on the product attributions that the consumer needed. The attributes or characteristics of the products can be measurable or based on the consumer's liking, the characteristics of the environment of the products, the reliability, and more. Generally, quality components consist of appearance, such as freshness, ripeness, color, flavor, and firmness of the measured fruits. For example, Abu-Ghannam and Jaiswal (2015) observed the effects of blanching on the Irish York cabbage and found that the texture and color of the cabbage were reduced. Color is one of the important parameters for the consumers' judgment as it contributes to the appearance attributes; thereby, if the product's color is undesirable, it will influence the consumers' acceptance, thus, affecting the market value of the product.

The color of the products can be related to other quality properties (Xiao et al., 2017). Color can be used as the indicator of quality change of the products when they undergo the blanching process and to determine the quality degradation caused by the thermal blanching process. Moreover, color is also important in determining the shelf life of the dabai fruits and indicates the fruits' maturity in the duration of storage. When fully matured, the skin of the dabai fruit is blue-black. The pigment color of the skin is mainly attributed to anthocyanin (cyanine-3-glucoside) (Deylami et al., 2016; Shakirin et al., 2010). During the blanching process, a Maillard reaction might affect the dabai fruit's color changes (Razak et al., 2021). The texture is also one of the important attributes to ensure that the products are of good quality and value for the consumers. Therefore, the texture is often used as an indicator in the blanching process. It will determine the physical-chemical properties of the cell wall and indicate what has happened to the texture of the products during processing (Xiao et al., 2017). According to Jaiswal et al. (2012), during the blanching process, a loss of texture occurs that continues up to 14 minutes.

The process of chemicals changes the texture of processed fruit and vegetables. Furthermore, during the blanching or soaking process, it can escalate moisture diffusivity, which leads to the significance in hydration frequency, thus, catalyzing the water absorption and changing the textural (Shafaei et al., 2016; Ehiem et al., 2019; Razak et al., 2021). Subsequently, the process will affect the dabai fruit's nutritional content, such as its crude fat that provides the texture and flavor (Razak et al., 2021). The color and texture were regarded as the qualitative features of food items to guarantee product acceptance. After the blanching process, it is important to observe the quality of the dabai fruit in terms of color and firmness to avoid under-blanching and over-blanching. It is because under-blanching can speed-up enzyme activity, while over-blanching can cause degradation of texture and color (Ruiz-Ojeda & Peñas, 2013; Shamsudin et al., 2021). There has been little study on the effect of blanching conditions, including temperature and the duration of blanching that can retain the quality of the dabai fruits, which have yet to be determined.

In this paper, the researchers attempt to understand and determine the effects of blanching conditions on the quality of the dabai fruit that is blanched under a range of time-temperature conditions. This data will benefit in designing the future thermal processes and related calculations for dabai fruit.

METHODOLOGY

Plant Materials

The dabai fruits were supplied by a supplier from Sibu, Sarawak, in Malaysia. The fruit was packed in an icebox and delivered within 24 hours to Universiti Putra Malaysia, Serdang, Selangor, in Malaysia. Upon arrival, they were stored in the freezer (SJC218, Sharp, Selangor, Malaysia) at a temperature of −4°C. Dabai fruits that were free of damage and pests were used as the raw material for the blanching assessment (in triplicate). The Dabai fruit was defrosted at room temperature for a few minutes before being treated, prior to blanching.

Water Blanching

The dabai fruit was immersed in a beaker filled with distilled water for each trial. It was then heated using a water bath (JSSB, Laft Technologies, Melbourne, Australia) at a temperature between 60°C and 100°C, with an increment of 10°C. Samples were blanched for up to 10 minutes at each temperature, at 2 minutes intervals. After that, the samples were analyzed for color and texture properties.

Color Analysis

A colorimeter (Miniscan EZ Spectrophotometer, HunterLab, Virginia, USA) was used to examine the visual color of the blanched dabai samples. The color parameters measured were L* for whiteness or brightness, a* for redness or greenness, and b* for yellowness or blueness. The quantitative attribute of colorfulness, also known as chroma, C*, and total color difference, TCD, are calculated using Equations 1 and 2, respectively (Cruz et al., 2007):

$$C = \sqrt{a*^2 + b*^2} \tag{1}$$

$$TCD = \sqrt{(L* - Lo*) + (a* - ao*)^2 + (b* - bo*)^2} \tag{2}$$

Texture Analysis

The texture of the blanched dabai fruit was determined using a Texture Analyzer (TA-XT plus, Stable Micro Systems, Surrey, UK), where the parameter measured was firmness (N). For energy and firmness measurements, a 500 g load cell with a 5 mm diameter probe was employed (Gonçalves et al., 2007). A single puncture measurement of 10 mm penetration depth on each sample was performed at a velocity of 1.0 mm s^{-1}. In addition, the area under the curves and the slope newton (N/mm) were measured to determine the hardness of the force formation curves.

RESULTS AND DISCUSSION

Effect of Blanching on the Color of Dabai Fruit

Color is one of the most important quality parameters attributed to food materials. Table 1 shows the color characteristics of the dabai fruit before blanching. The dabai fruit has dark purplish color, as indicated in Table 1. Before blanching, the dabai fruit has a value of 0.000 for the L parameter, which is translated to the blackish region. Furthermore, it has a negative value of a* parameter, which is -0.275, which indicates a shift towards greenness. On the other hand, the positive value of the b* parameter, which is 5.923, suggests a shift towards yellow. Therefore, the combination of a* parameter (-0.275) and b* parameter (5.923) is identified as neutral color or gray.

Table 1

Color characteristics of dabai fruit 'Ngemah' variety before blanching

Parameter	Initial value
L	0.000
a*	-0.275
b*	5.923
C	5.213
TCD	0.000

The changes of color in the dabai fruit after blanching were studied at 60°C, 70°C, 80°C, 90°C, and 100°C at different durations which were 2, 4, 6, 8, and 10 minutes as shown in Figure 1(a-d). From the observations, the L parameter remained unchanged even after blanching at a high temperature and for a prolonged blanching time. The robust stability of the anthocyanins pigment responsible for the dark purple color of dabai may have been why the L parameter does not change (Khoo et al., 2017). Since the L value indicates the sample's darkness, the sample will not turn darker due to its initial color, which is already a dark purplish color (Ganjloo et al., 2009).

In Figure 1(a), the a* value increases as the duration time increases from 2 to 10 minutes for all the temperatures except the blanching temperatures, which is at 60°C. The a* value at 60°C does not show any significant changes ($p>0.05$) at any blanching time, suggesting that the heat supplied has not been sufficient to change the a* value. On the other hand, for blanching at a higher temperature, 100°C, the value of a* at 2 min was 5.876, which showed a high shift towards the redness color. A similar trend can be seen at temperatures of 70°C, 80°C, and 90°C. The trend for the temperature at 70°C shows a value that has increased gradually from 2 minutes until 10 minutes as time increased. However, the trend for the temperatures 80°C, 90°C, and 100°C shows that the value of a* has increased significantly from 4 to 10 minutes. The significant increase ($p<0.05$) value of a* as the processing time and the temperature increased indicated that the dabai fruit gained a red color. This finding agrees with the study by Krokida et al. (2001), where the a* parameter has increased significantly due to the drying process on the potato strips indicated in the product's browning.

The b* parameter for the blanched dabai fruit also showed some changes in values, as shown in Figure 1(b). At 60°C at 2 minutes b* value was 6.063 and increased to 7.480 for 10 minutes of blanching. For 100°C, the value of b* after blanching at 2 minutes was 8.574 and rose to 11.563 at 10 minutes. A similar trend can also be seen in 70°C, 80°C, and 90°C. The result showed that the b* value increased significantly ($p<0.05$) as the temperature and time duration increased. At all temperatures, the b* values gradually increased except for the temperature of 100°C, where the b* value had increased significantly from 9.431 (6 min) to 11.447 (8 min). However, the temperature of 60°C and 70°C increased moderately throughout the 10 minutes. Overall, because of blanching on the b* parameter, it can be concluded that as the temperature and time of blanching increase, the b* parameter will increase too, resulting in the yellowness of the dabai fruit after blanching. This result is also in agreement with the drying and dehydration effect on the b* parameter color, where a significant increase of yellowness can be seen on the carrots after both of the heat treatments (Zielinska & Markowski, 2012).

Based on Figure 1(c), the value of chroma after blanching at 60°C for 2 minutes is 6.066 and has increased to 7.577 at 10 minutes. For 100°C, the value of chroma at 2 minutes is 10.394 and has increased to 22.662 at 10 minutes. The temperature at 70°C, 80°C, and 90°C has also shown the same trend. The result showed that the degree of chroma during blanching increased significantly ($p<0.05$) as the time increased for all temperatures. Figure 1(c) describes that the temperatures 80°C, 90°C, and 100°C for 60°C and 70°C have gradually increased, where the chroma value rises at 6 minutes of blanching. However, the temperature of 60°C and 70°C increased moderately throughout the 10 minutes. Thus, the temperature and time of blanching affect the chroma value of the dabai fruit. This finding was in agreement with Brewer et al. (1995), where blanching treatments such as conventional boiling water, steam blanching, and microwave blanching of the frozen broccoli increased the broccoli's chroma color florets and stems. The increment value of chroma (C) suggested that the blanched dabai fruit gained vividness or saturation of color. The chroma parameter is related to the proportion of the grey component responsible for characterizing the color (Olivera et al., 2008). As C increases, the intensity of the color has also increased.

The TCD for all temperatures in Figure 1(d) displayed increasing values of TCD as the blanching time increased. The temperature of 80°C, 90°C, and 100°C showed that the value of TCD soared after 4 minutes. However, the temperature of 60°C and 70°C increased moderately throughout the 10 minutes. For example, at 60°C at 4 minutes, the value of TCD is 0.653 and has increased to 1.045 at 6 minutes which is a 37.47% difference. As for 100°C, the TCD value at 4 minutes is 7.795, which soars to 16.671 at 6 minutes which is 46.76%. The result shows that the TCD has increased significantly ($p<0.05$) as the blanching duration increases. The increasing value of the total color difference of the dabai fruit caused by the blanching suggested that the color had changed due to the thermal blanching process. According to Jaiswal et al. (2012), the TCD increases during blanching due to the different reactions that may have resulted in the color changes, such as thermal degradation of the pigments and the oxidation of ascorbic acid enzymatic browning and non-enzymatic browning.

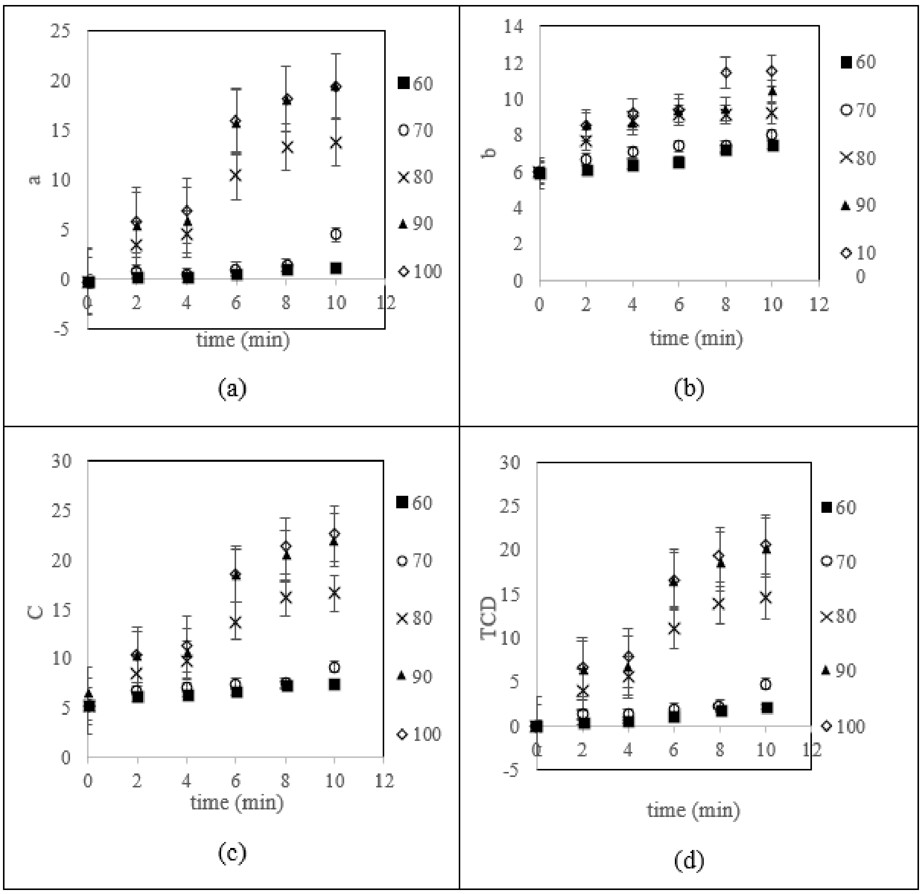

Figure 1. The effect of blanching (60℃,70℃, 80℃, 90℃, and 100℃) on the color parameters of dabai fruit: (a) a*; (b) b*; (c) C; and (d) TCD

Effect of Blanching on the Texture of Dabai Fruit

The effect of blanching on the dabai fruit in terms of texture was measured using the firmness parameter. For 60℃, at 2 minutes of blanching, the firmness value was 3.616 N and increased to 4.065 at 10 minutes, as shown in Figure 2. For 100℃, the firmness of the dabai fruit after blanching at 2 minutes decreased to 2.034N from 5.304N (0 min) and increased again at 10 minutes to 2.075N. A similar trend can be seen at temperatures 70℃, 80°C, and 90°C. According to the Figure 2, the firmness of the dabai fruit decreased as the blanching time increased. However, at 8 minutes, the degree of firmness started to grow for all the temperatures. It may be due to the pectin methylesterase enzyme in some vegetables and fruits. The enzyme pectin methylesterase (PME) was found to have a firming effect on fruits or vegetables if activated by blanching (Anthon & Barrett, 2006). The decrease in the firmness of the dabai fruit may be caused by the changes in the pectin strengths caused by the thermal softening and enzyme degradation (Kim, 2006). The phenomena that started at 8 minutes can be explained by the PME enzyme activity that increases when the pectic substances inside the dabai fruit are demethoxylated, which causes the formation of calcium and magnesium pectate (Inheiro et al., 2009). However, most researchers have stated that the firming effect of the pectin methylesterase enzyme is often around the temperature range of 50°C to 70°C (Kim, 2006; Ni et al., 2005). In addition, according to the research by Abu-Ghannam and Crowley (2006), pre-treatment using 65°C before the blanching process, which ranges from 95°C to 100°C, causes the firmness of the potato to increase compared with the blanching process without any pre-treatment. However, Table 2 shows that the firmness value has no significant ($p>0.05$) difference after blanching at 60°C to 100°C between 2 to 10 minutes. It is due to the small value increment and decrement of firmness in all temperatures and durations. It shows that the blanching time does not affect the firmness of the dabai fruit.

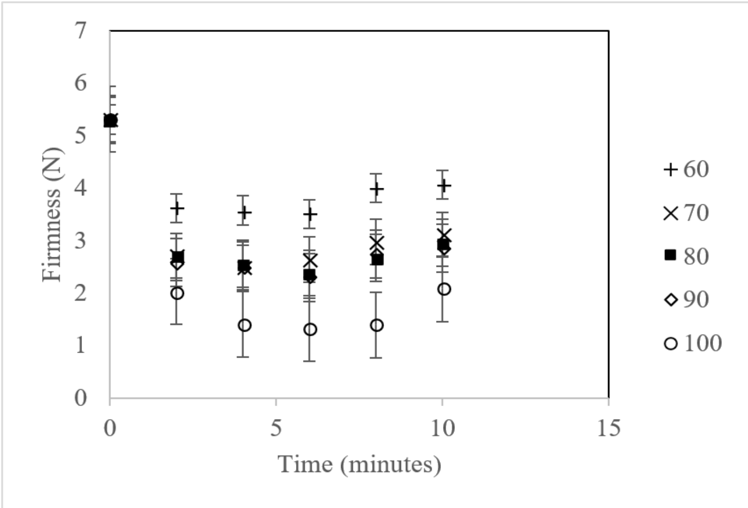

Figure 2. The effect of blanching (60°C,70°C, 80°C, 90°C, and 100°C) on the firmness of dabai fruit

Table 2
Effect of different temperature and duration of blanching on the firmness dabai fruit

Temperature (°C)	Duration of blanching (min)					
	0	2	4	6	8	10
60	5.300 ± 3.250^{Aa}	3.616 ± 1.660^{Aa}	3.570 ± 1.930^{Aa}	3.503 ± 1.5018^{Aa}	3.994 ± 0.533^{Aa}	4.070 ± 2.960^{Aa}
70	5.300 ± 3.250^{Aa}	2.709 ± 0.880^{Aa}	2.485 ± 0.648^{Aa}	2.631 ± 1.033^{Aa}	2.974 ± 0.574^{Aa}	3.110 ± 2.860^{Aa}
80	5.300 ± 3.250^{Aa}	2.684 ± 0.767^{Aa}	2.553 ± 0.696^{Aa}	2.357 ± 0.473^{Aa}	2.664 ± 0.244^{Aa}	2.952 ± 0.107^{Aa}
90	5.300 ± 3.250^{Aa}	2.580 ± 2.480^{Aa}	2.510 ± 2.070^{Aa}	2.300 ± 1.870^{Aa}	2.738 ± 1.179^{Aa}	2.848 ± 1.303^{Aa}
100	5.300 ± 3.250^{Aa}	2.034 ± 1.227^{Aa}	1.4074 ± 0.1143^{Aa}	1.325 ± 0.547^{Aa}	1.382 ± 0.328^{Aa}	2.075 ± 0.604^{Aa}

*Mean with capital letter A represents same temperature of blanching with different minutes of blanching are not significantly differ ($p>0.05$)
**Mean with different small letter a represents same duration of blanching with different temperature of blanching are not significantly differ ($p>0.05$)

CONCLUSION

The findings in the present study confirmed that blanching has a deleterious effect on the color and texture of the dabai fruit. For the color analysis, parameters a*, b*, C, and TCD for the blanched dabai fruit showed significant changes for each temperature and time of blanching, except for the L parameter. However, the firmness of the blanched dabai fruit at different temperatures and blanching times was insignificant as there were only minor changes. This information will add to the knowledge that contributes as an advantage and an impact on consumer food selection and enhances the ability to find the right conditions for blanching the dabai fruit. Furthermore, the information would also be useful in designing thermal processes and related calculations for the dabai fruit.

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REFERENCES

Abu-Ghannam, N., & Jaiswal, A. K. (2015). Blanching as a treatment process: effect on polyphenol and antioxidant capacity of cabbage. In *Processing and impact on active components in food* (pp. 35-43). Academic Press. https://doi.org/10.1016/B978-0-12-404699-3.00005-6

Anthon, G. E., & Barrett, D. M. (2006). Characterization of the temperature activation of pectin methylesterase in green beans and tomatoes. *Journal of Agricultural and Food Chemistry, 54*(1), 204-211. https://doi.org/10.1021/jf051877q

Ariffin, S. H., Shamsudin, R., & Tawakkal, I. S. M. A. (2020). Dabai fruit: Postharvest handling and storage. *Advances in Agricultutal and Food Research Journal, 1*(2), 1-12. https://doi.org/10.36877/aafrj.a0000126

Brewer, M. S., Begum, S., & Bozeman, A. V. A. (1995). Microwave and conventional blanching effects on chemical, sensory, and color characteristics of frozen broccoli. *Journal of Food Quality, 18*(6), 479-493. https://doi.org/10.1111/j.1745-4557.1995.tb00398.x

Chua, H. P., & Nicholas, D. (2009). Dabai - Speciality fruit of Sarawak. *Agromedia, 30*, 28-30.

Chua, H. P., Nicholas, D., & Yahya, M. N. A. (2015). Physical properties and nutritional values of dabai fruit (*Canarium odontophyllum*) of different genotypes. *Journal Tropical Agriculture and Food Science, 43*(1), 1-10.

Cruz, R. M. S., Vieira, M. C., & Silva, C. L. M. (2007). Modelling kinetics of watercress (*Nasturtium officinale*) colour changes due to heat and thermosonication treatments. *Innovative Food Science & Emerging Technologies, 8*(2), 244-252, https://doi.org/10.1016/j.ifset.2007.01.003

Deylami, M. Z., Rahman, R. A., Tan, C. P., Bakar, J., & Olusegun, L. (2016). Effect of blanching on enzyme activity, color changes, anthocyanin stability and extractability of mangosteen pericarp: A kinetic study. *Journal of Food Engineering, 178*, 12-19. https://doi.org/10.1016/j.jfoodeng.2016.01.001

Ding, P. (2011). *Dabai (Canarium odontophyllum Miq.), Postharvest biology and technology of tropical and subtropical fruits: Volume 3: Cocona to mango*. Woodhead Publishing Limited. https://doi.org/10.1016/B978-1-84569-735-8.50003-6

Ehiem, J. C., Ndirika, V. I. O., Onwuka, U. N., Gariepy, Y., & Raghavan, V. (2019). Water absorption characteristics of *Canarium Schweinfurthii* fruits. *Information Processing in Agriculture, 6*(3), 386-395. https://doi.org/10.1016/j.inpa.2018.12.002

Ganjloo, A., Rahman, R. A., Bakar, J., Osman, A., & Bimakr, M. (2009). Modelling the kinetics of peroxidase inactivation and colour changes of seedless guava (*Psidium guajava* L.) during thermal treatments. *Applied Sciences, 7*(1), 105-112.

Gonçalves, E. M., Pinheiro, J., Abreu, M., Brandão, T. R. S., & Silva, C. L. M. (2007). Modelling the kinetics of peroxidase inactivation, colour and texture changes of pumpkin (*Cucurbita maxima* L.) during blanching. *Journal of Food Engineering, 81*, 693-701. https://doi.org/10.1016/j.jfoodeng.2007.01.011

Inheiro, J. O. P., Legria, C. A. A., & Breu, M. A. A. (2009). Degradation kinetics of peroxidase enzyme, phenolic content, and physical and sensorial characteristics in broccoli (*Brassica oleracea* L. ssp. *Italica*) during blanching. *Journal of Agricultural and Food Chemistry, 57*(12), 5370-5375. https://doi.org/10.1021/jf900314x

Jaiswal, A. K., Gupta, S., & Abu-Ghannam, N. (2012). Kinetic evaluation of colour, texture, polyphenols and antioxidant capacity of Irish York cabbage after blanching treatment. *Food Chemistry, 131*(1), 63-72. https://doi.org/10.1016/j.foodchem.2011.08.032

Khoo, H. E., Azlan, A., Kong, K. W., & Ismail, A. (2016). Phytochemicals and medicinal properties of indigenous tropical fruits with potential for comercial development. *Evidence-Based Complementary and Alternative Medicine, 2016*, Article 7591951. https://doi.org/10.1155/2016/7591951

Khoo, H. E., Azlan, A., Tang, S. T., & Lim, S. M. (2017). Anthocyanidins and anthocyanins: Colored pigments as food, pharmaceutical ingredients, and the potential health benefits. *Food and Nutrition Research, 61*(1), 0-21. https://doi.org/10.1080/16546628.2017.1361779

Kim, J. A. E. C. (2006). Firmness of thermal processes onion as affected by blanching. *Journal of Food Processing and Preservation, 30*(6), 659-669. https://doi.org/10.1111/j.1745-4549.2006.00096.x

Krokida, M. K., Oreopoulou, V., Maroulis, Z. B., & Marinos-Kouris, D. (2001). Deep fat frying of potato strips-quality issues. *Drying Technology, 19*(5), 879-935. https://doi.org/10.1081/DRT-100103773

Ni, L., Lin, D., & Barrett, D. M. (2005). Pectin methylesterase catalyzed firming effects on low temperature blanched vegetables. *Journal of Food Engineering, 70*(4), 546-556. https://doi.org/10.1016/j.jfoodeng.2004.10.009

Olivera, D. F., Viña, S. Z., Marani, C. M., Ferreyra, R. M., Mugridge, A., Chaves, A. R., & Mascheroni, R. H. (2008). Effect of blanching on the quality of brussels sprouts (*Brassica oleracea* L. gemmifera DC) after frozen storage. *Journal of Food Engineering, 84*(1), 148-155. https://doi.org/10.1016/j.jfoodeng.2007.05.005

Pin, C. H., Daniel, N., & Mos, S. (2014). Phenolic and flavonoid contents and antioxidant activities of selected dabai (*Canarium odontophyllum*) genotypes. *Journal of Tropical Agriculture and Food Science, 42*(2), 105-114.

Razak, A. F. A., Abidin, M. Z., Hassan, N. A., Edwin, A. J., Abdullah, M. S., Razak, A., Salleh, M. H., & Hamim, N. A. (2021). The impact of (*Canarium Odontophyllum* Miq.) dabai optimum soaking condition towards the development of dabai peanut spread physicochemical properties and sensory evaluation. *Journal of Agrobiotechnology, 12*(2), 56-67.

Ruiz-Ojeda, L. M., & Peñas, F. J. (2013). Comparison study of conventional hot-water and microwave blanching on quality of green beans. *Innovative Food Science and Emerging Technologies, 20*, 191-197. https://doi.org/10.1016/j.ifset.2013.09.009

Rukayah, A. (2009). Buah-buahan eksotik dari Sabah dan Sarawak di Mardi, Serdang [Exotic fruits from Sabah and Sarawak in Mardi, Serdang]. *Agromedia, 22*, 28-34.

Shafaei, S. M., Masoumi, A. A., & Roshan, H. (2016). Analysis of water absorption of bean and chickpea during soaking using Peleg model. *Journal of the Saudi Society of Agricultural Sciences, 15*(2), 135-144. https://doi.org/10.1016/j.jssas.2014.08.003

Shakirin, F. H., Prasad, K. N., Ismail, A., Yuon, L. C., & Azlan, A. (2010). Antioxidant capacity of underutilized Malaysian *Canarium odontophyllum* (dabai) Miq. fruit. *Journal of Food Composition and Analysis, 23*(8), 777-781. https://doi.org/10.1016/j.jfca.2010.04.008

Shamsudin, R., Ariffin, S. H., Zainol@Abdullah, W. N. Z., Azmi, N. S., & Halim, A. A. A. (2021). Modelling the kinetics of color and texture changes of dabai (*Canarium odontophyllum Miq.*) during blanching. *Agronomy, 11*(11), Article 2185. https://doi.org/10.3390/agronomy11112185

Xiao, H. W., Pan, Z., Deng, L. Z., El-Mashad, H. M., Yang, X. H., Mujumdar, A. S., Gao, Z. J., & Zhang, Q. (2017). Recent developments and trends in thermal blanching - A comprehensive review. *Information Processing in Agriculture, 4*(2), 101-127. https://doi.org/10.1016/j.inpa.2017.02.001

Zielinska, M., & Markowski, M. (2012). Color characteristics of carrots: Effect of drying and rehydration. *International Journal of Food Properties, 15*(2), 450-466. https://doi.org/10.1080/10942912.2010.489209