Food and Applied Bioscience Journal, 2020, 8(2): 40−52

Physicochemical and sensory properties of juice from different types of date

Kittanan Burapalit, Kamolnate Kitsawad and Tatsawan Tipvarakarnkoon*

Abstract

The date palm juice was made from different level of ripening and grading of date palm fruits (fresh date, premature fruit drop, and dried date). This study focused on the physiochemical and sensory properties of developed pasteurized date juice, total soluble solid (TSS), pH, color, opacity, overall yield from date pulp, and yield by filtration of pasteurized date juices. Fifty consumers were asked to rate the intensity and their liking products using rate−all−that−apply (RATA). The pasteurized date juices with different date fruits were produced by adjusted at the same TSS at 10.5°Brix of final juices. The results revealed that the initial total TSS of date juice and overall yield increased conversely the pH, color (L*) and opacity of date juice by stage of ripening of date fruit. Premature fruit drop juice was bright in color but cloudy. Lesser overall yield than dried date juice, but comparable to fresh date juice has been found. Among all, the flavor intensity of premature fruit drop was higher than others. Even though the physicochemical and sensorial characteristics of juices were different, the consumer preference was comparable with different date fruits.

Keywords: Date fruit, *Phoenix dactylifera L.*, premature fruit drop, date juice, rate−all−that−apply (RATA)

Department of Food Biotechnology, Faculty of Food Biotechnology, Assumption University, Bangkok 10240, Thailand

**Corresponding author E−mail: kittanan.b@hotmail.com*

Received: 27 February 2020, Accepted: 10 June 2020

Food and Applied Bioscience Journal, 2020, 8(2): 40-52

1. Introduction

The date palm (*Phoenix dactylifera L.*) is the fruit crop that can grow in hot arid regions of South West Asia, North Africa and Middle East countries. The temperatures in the date growing areas of the world are low humidity, no rainfall, arid or semi-arid, hot and long in summer (Zaid and De Wet, 1999). The date fruit is composed of epicarp (skin), mesocarp (pulp), endocarp and seed (pit) (Ghnimi *et al.,* 2017). Date fruit is a rich source of carbohydrates mostly simple sugar form. Sugar contents range from about 40% (fresh dates) to 80% (dried dates) (Aleid and Kader, 2013). The major sugar content of a date fruit is fructose and glucose called invert sugar. The invert sugar in dates was proven in research showing low glycemic impact especially when eat alone or mix meal with yogurt. Also, extracts of dates stimulate mother milk with providing immune for mother and child (Gad *et al.,* 2010). As well as the fresh date fruits contain high amount of antioxidants such as anthocyanidins and carotenoids, while dried date contain polyphenols. Moreover, the date pulp has a good source of minerals such as potassium, iron, magnesium, and calcium (Prior and Cao, 2000).

The development of ripening of date fruit can classified into five stages which are hababuak, kimri, khalal, rutab, and tamar stages (Abbas and Ibrahim, 1996; Ait-Oubahou and Yahia E.M., 1999). Hababuak and kimri are green color, decrease the rate of sugar, high acidity, high moisture content, and astringent taste. The green to yellow color at khalal and rutab are decreasing in weight, moisture content and converse the sugar from sucrose to glucose and fructose called reducing sugar. For the tamar stage, it considered as a dried date that give dark brown color, highest sugar, lowest moisture content, and lost all astringent taste (Aleid and Kader, 2013; Yahia, 2011). Barhee fresh date cultivar is broadly ovate round, hard and crisp with opaque yellow color while Barhee dried date cultivar is brown color, firm and hard texture. Recently, the growing of Barhee date palm tree is also widely interest by Thai farmer. However, the Thai cultivated fruit crops are lower sweet, and astringent compared to those imports. Pre-harvesting and post-harvesting or during processing is found cause the date fruit the black spot or bruise spot, showed lower quality especially appearance. Premature fruits fall from the tree uncontrollably with defects to the fruit. Those low qualities of date fruits do affect the market price of Thai dates. To make more value added of the product such as date juice and syrup is needed. Nowadays, most of pasteurized and sterilized date juice products produced commercially from dried dates. It was prepared industrialized by date washed or air dried before grinding (Youssif *et al.,* 1990 and Youssif *et al.,* 1987). The water was added to date paste. The date paste and water was mixed and pasteurized at temperatures between 60 and 95°C (Salah *et al.,* 2011). To prevent the surviving spore-producing microorganisms, the product should be stored in temperatures below 20°C

Food and Applied Bioscience Journal, 2020, 8(2): 40-52

(James and Kuipers, 2003). Researches on the juice production from Thai fresh dates or detected fruits are still rarely. The comparative quality among those different types is still unknown. RATA question use to describe the sample from consumer and rate intensity scale. it was use to increase the number of attributes terms select for describing sample and increase small percentage of terms for leading significant different among samples were identified was higher. RATA was used in the sensory analysis due to need to describe the terms of sample and rate the intensity each description by using 10-box scale. This study, therefore, aimed to standardize juice processing and compare the quality of pasteurized fruit juice utilized from three different types of date fruit (fresh date, premature fruit drop, and dried date). Their physiochemical and sensory properties were investigated among them.

2. Materials and Methods

2.1 Materials

2.1.1 Fresh date: Barhee date cultivated in Thailand at the Khalal stage of ripening were used in this experiment based on its availability in the market. Fresh date fruit is uniform size, smooth surface, and light yellow color. The sample was vacuum-packed and kept in freezer at -20°C.

2.1.2 Premature fruit drop: Barhee date, cultivated in Thailand, falls from the tree before ripening, would contain defect as black spot, bruise spot, showed lower quality especially appearance. The sample was vacuum-packed and kept in freezer at -20°C.

2.1.3 Dried date: Barhee date imported from Saudi Arabia at the Tamar stage of ripening dried was used in this experiment. The sample was kept in refrigerator at 4°C.

2.2 Production of pasteurized date palm juice

The sample was cleaned, defrosted, and pitted to spate the flesh. The boiling water (97 ± 2°C) was added into the sample at 1:2 v/w and soaked for 15 min. The soaking date pieces were blended for 10 seconds. The dates paste was filtrated using double sheet cloth for 3 times to obtain clear filtrated date juice. The filtered date juice was adjusted its total soluble solid (TSS) at 10.5°Brix that from the previous preliminary test by adding boiling water and pasteurized in hot water bath at 72 ± 2°C for 15 seconds. The pasteurized date juice was kept in Duran® bottle, cooled and refrigerated at 4°C.

2.3 Color measurement and opacity

The color parameters CIE L*, a*, and b* were analyzed with HunterLab colorimeter (MiniScan® EZ 4500L Spectrophotometer, USA). The color analysis is expressed as L* = brightness (100) to darkness (0), a* = red (+) to green (-), and b* = yellow (+) to blue (-). The small viewing area port was used for date fruit where large viewing area port was used for

Food and Applied Bioscience Journal, 2020, 8(2): 40–52

date juice. All fruit samples were measured at least 4 replicates. The date juices were filled in a standard transparent glass cup with 88 mm depth of sample and covered with black cover lid and white cover with at least 3 replicates. The percentage of opacity was also calculated as shown by Riquelme *et al.* (2015).

$$\text{Opacity (\%)} = \frac{\text{L* black blackground}}{\text{L* white blackgroung}} \times 100$$

2.4 pH

The date fruit and juice were measured using a pH meter (Haida HD–024 Bench Top pH Meter, China). The 15 mL of the samples were determined at 25 ± 2°C. Buffer solutions of pH 4 and 7 were used to calibrate the equipment before measurement (AOAC, 1982).

2.5 Total soluble solid (°Brix)

The date fruit and juice were determined using an Abbe Refractometer (Iymen Optic system) at 25 ± 2°C. The fresh date fruit and premature fruit drop were squeezed and directly measured while the dried date fruit was diluted with water (1:1). The date juice was measured directly on different dates (AOAC, 2000)

2.6 Moisture content (%)

Percentage of moisture content was determined by oven drying 1 gram of date fruit samples at 105°C in oven dryer to constant weight (5.30 h) with 3 replicates. The percentage of moisture content was calculated by dividing the dry weight (in grams) by wet weight (in grams), multiplied by 100% (AOAC, 2000).

$$\text{Moisture content (\%)} = \frac{\text{Wet weight} - \text{Dry weight}}{\text{Wet weight}} \times 100$$

2.7 Yield (%)

The percentage of overall yield from date pulp or the quantity of juice how much that can squeeze from each dates was calculated by dividing amount of juice (grams) by the initial date pulp (grams) and multiplies by 100. The percentage yield of filtrate or pulp of each date that lose was calculated by dividing the amount of filtered juice (grams) by the sum of initial date pulp and added water (grams), multiplies by 100. The percentage of yield lost by filtration was calculated by 100 percent excluded the percentage yield of the filtrate.

Calculation 1;

$$\text{Overall yeild from date pulp (\%)} = \frac{\text{Amount of juice (g)}}{\text{Initial date pulp (g)}} \times 100$$

Food and Applied Bioscience Journal, 2020, 8(2): 40−52

Calculation 2;

$$\text{Yield lost by filtration (\%)} = 100 - \left[\frac{\text{Amount of filtered juice (g)}}{\text{Initial date pulp (g)} + \text{ Added water (g)}} \times 100\right]$$

2.8 Texture

The different types of date fruit were analyzed with 9 replicates using texture analyzer (TA−XTplus, Stable Micro System, London, UK). Toughness (peak force, kg) and work of shear (area under curve, kg.mm) were analyzed using extended craft knife at 5.00 mm/sec by cutting the whole fruits. Warner−Bratzler blades was used to analyzed firmness (average peak force) at 5 mm/sec and post−test speed at 5 mm/sec by shearing the pitted half−piece date fruits. The data of texture was affected when blend and squeeze the sample that benefit to upscale process in further.

2.9 Sugar profile

Glucose, fructose, lactose, maltose, and sucrose were measured using HPLC method (AOAC, 2016) Reducing sugars were measured by the dinitrosalicylic acid method using D−glucose as a standard according to Miller (1959).

2.10 Sensory test of prepared date juice

The sensory test was conducted using 9−point hedonic score with 50 untrained panelists from Assumption University Hua Mak Campus. Date juice samples were refrigerated and served in clear plastic glass (15 mL) with drinking water as palate cleanser. Three−digit random numbers were used to code the samples and the serving order was counterbalanced. Preference test was conducted to the degree of liking or dislike of the product using 9− hedonic scale for color, aroma, flavor, taste, texture, amount of pulp, and overall liking.

2.11 Rate−All−That−Apply (RATA)

The RATA test was conducted with 50 participants. Participants were carried out from the consumer database of Assumption University Hua Mak Campus who drink fruit juice which were selected based on their interest, availability, no food allergies to test product, describe characteristics. The RATA questions consist of definitions of sensory terms (24 terms) were from 12 training panelists who generate the terms by brain storm as group discussion, and rate the intensity of detected sensory terms. A 10−box scale was used instead of low to high of the sensory for each definition. RATA data were collected on paper equipped with individual sensory booths. Date juice samples were refrigerated and served in clear plastic glass (15 mL) with drinking water as palate cleanser. Each sample was test at different time to reduce the bias from panelist.

Food and Applied Bioscience Journal, 2020, 8(2): 40-52

2.12 Data analysis

Randomized Complete Block Design was used in this experiment to compare the treatment differences. Duncan's test for multiple mean comparisons was performed to determine differences ($P \leq 0.05$) between means. The effect of ingredients and results from sensory analysis were analyzed using ANOVA. pH of fruit was analyzed using t-test. All data analyses were carried out using R-Program (R core Team, 2013).

3. Results and Discussion

3.1 Physicochemical properties of three types of date fruit

The different raw materials which were fresh date, premature fruit drop, and dried date of Barhee cultivar was used in this experiment. There were significantly different in pH, moisture content, color, and texture between different fruit samples (Table 1). pH had significant differences between fresh date and premature fruit drop which were 7.02 and 5.99 ($P \leq 0.05$), respectively. Moisture content of different fruits decreased as in ripening stage ($P \leq 0.05$) while the total soluble solid increased from fresh to dried date fruits. Fresh date color was yellow and develop to be more reddish on skin color as shown in premature fruit drop. When repined, dried date fruits were dark reddish brown with highest in a* value and lowest in L* and b* values. The darker color of date fruit was developed by losing moisture content and accumulating sugar.

Table 1 Physicochemical properties of different types of date fruit

Fruit	TSS (°Brix)	pH*	MC (%)	Color		
				L*	a*	b*
Fresh date	29-34	7.02 ± 0.01	71.91 ± 0.17^{a}	37.77 ± 3.12^{a}	6.89 ± 0.95^{c}	43.17 ± 4.35^{a}
Premature fruit drop	38-42	5.99 ± 0.04	63.06 ± 1.28^{b}	33.28 ± 3.58^{b}	8.20 ± 1.06^{b}	38.16 ± 4.14^{b}
Dried date	69-72	N/A	15.12 ± 0.11^{c}	25.31 ± 4.01^{c}	17.00 ± 3.36^{a}	32.67 ± 7.07^{c}

Note: Different letters in the same column represent significant difference ($P \leq 0.05$)

Among all, dried date was toughest and highest firmness (Table 2), while fresh date and premature fruit drop were not difference in their texture. More than triple times of work of shear values estimated in dried date compared to other fruits. This would be implied that it will be hard to shear during mincing in the fruit juice extract process.

Food and Applied Bioscience Journal, 2020, 8(2): 40–52

Table 2 Texture analysis of different types of date fruit

Fruit	Texture		
	Toughness (kg)	Work of shear (kg.mm)	Firmness (kg)
Fresh date	3.26 ± 1.46[b]	14.05 ± 5.18[b]	2.98 ± 0.47[b]
Premature fruit drop	2.89 ± 1.24[b]	14.94 ± 94[b]	2.41 ± 0.45[b]
Dried date	14.03 ± 5.20[a]	51.31 ± 17.55[a]	5.24 ± 0.23[a]

Note: Different letters in the same column represent significant difference ($P \leq 0.05$)

The sugar profile of three types of date fruits used in this study was determined using HPLC method. Total sugar was increased during ripening (Table 3). Dried dates contained highest amount of total sugar which was double increased because of it is in dried stage. Fructose and glucose are the main sugar types in dates with the ratio of 1:1 between them. These make date to be a good source of energy and would gave low glycemic index as stated in researches (Gad *et al.,* 2010; Alkaabi *et al.,* 2011). None of lactose and maltose were detected in the fruits, where sucrose was detected with small amount in fruit drop. None of sucrose was further detected in dried date. The stage of ripening dates converse from sucrose to reducing sugars which are fructose and glucose (Al–Farsi *et al.*, 2008). Reducing sugar of fresh date and premature fruit drop were then lower than dried date (Table 3).

Table 3 Sugar profile of different types of date fruit (g/ 100 g dry weight)

Fruit	Total sugar	Fructose	Glucose	Lactose	Maltose	Sucrose	Reducing sugar (mg/mL)
Fresh date	22.16	10.54	11.62	-	-	-	2.78
Premature fruit drop	29.28	13.25	14.39	-	-	1.64	2.88
Dried date	69.42	33.92	35.50	-	-	-	5.07

Note: (–) = Not Detected, reducing sugar mg/mL = g/L

3.2 Effect of date fruit type on pasteurized date juice

Premature fruit drop were used to produce pasteurized date juice and compare to those of fresh date and dried date. From Table 4, pHs of fruit drop juice was lower than fresh date. It decreased from 7.35 to 6.47 when used the ripen dried date. This was related to the sugar content in raw materials before juice extract. Initial total soluble solid of extracted juices were higher when increased the ripening stage. Due to the increasing of sugar in the date

Food and Applied Bioscience Journal, 2020, 8(2): 40–52

fruits which further increasing the rate accumulating sugar in dried date. This also affect to the overall yield of juice products. Higher initial total soluble solid, in another word, sugar content in raw materials was produced higher overall yield of juice products calculated from the same basis of raw material pulp. Even dried date fruit produced highest overall yield percentage, however, showed highest yield lost by filtration. Dried date pulp meat was tough and cannot be squeezed easily without high pressure as specified in the previous section. Yield of juice extract was significantly lost by filtration but this would be diminished by developed industrial process.

The color of juices (Table 4) made from dried date was darker, higher in reddish, and yellower color than others. On the other hand, fresh date and premature fruit drop were not significant different which showed lighter and yellow color ($P>0.05$). For the opacity, fresh date and premature fruit drop were higher than dried date.

Table 4 Physicochemical properties of date juice made from different date fruits with final total soluble solid (TSS) of 10.5°Brix

Sample	pH	Initial TSS (°Brix)	Overall yield from date pulp (%)	Yield by filtration (%)	Color			Opacity (%)
					L*	a*	b*	
Fresh date	7.35 ± 0.02^{a}	11	282.15	13.15	39.18 ± 0.47^{a}	0.14 ± 0.27^{b}	37.18 ± 0.79^{b}	34.30
Premature fruit drop	6.73 ± 0.04^{b}	12.5	267.67	15.41	38.41 ± 0.02^{a}	0.02 ± 0.01^{b}	34.49 ± 0.02^{c}	36.41
Dried date	6.47 ± 0.02^{c}	30	637.75	23.55	36.64 ± 0.52^{b}	9.20 ± 0.48^{a}	54.39 ± 0.86^{a}	4.06

Note: Different letters in the same column represent significant difference ($P\leq0.05$)

The preference test results showed that there was no significant difference in all attributes ($P>0.05$) (Table 5). Even color and opacity of the juices were different, the liking score on those color attributes was comparable. This indicates that different types of date fruit did not have significant impact on the preference of date juice. Although different type of date fruits were different in color, sugar profile and initial total solid, the total soluble solid of juices were adjusted to reach at 10.5°Brix. So, the sweetness for sensory was no significant differences by consumer while other attributes also has no significant differences. As the result showed that the overall liking was 7.04–7.32. As results, this indicates that different types of date fruit, used in this studied, did not have significant impact on the preference of date juice. The quality of pasteurized date juice made from premature fruit drop, which was considered to have the lowest raw materials quality from all three types of date fruit used in this study because of appearances outside and it was not develop ripening on the tree that was fall

Food and Applied Bioscience Journal, 2020, 8(2): 40–52

before maturity and showed bruise spot, was comparable to those made from fresh date that date can sell at the high price by itself and dried date which cannot dried on the tree because of climate change. Therefore, the premature fruit juice sensorial quality was comparable to other even the physicochemical of fruit was different, consumer gave like moderately in overall liking. So, to make value added, the premature fruit can increase the price to Thai farm when compare to others.

Table 5 Liking score of date juice products prepared by different date fruits (n=50)

Sample	Color^{ns}	Turbidity^{ns}	Aroma^{ns}	Flavor^{ns}	Sweetness^{ns}	Thickness^{ns}	Amount of pulp^{ns}	Overall liking^{ns}
Fresh date	6.52±1.69	6.74±1.60	6.54±1.39	6.84±1.52	6.96±1.21	6.8±1.77	6.42±1.82	7.28±1.14
Premature fruit drop	6.31±1.86	6.47±1.94	6.69±1.62	6.59±1.54	6.78±1.88	6.61±1.98	6.00±1.88	7.04±1.35
Dried date	6.88±1.64	6.52±1.91	6.46±1.85	6.84±1.73	7.04±1.46	6.58±1.90	5.96±1.77	7.32±1.17

Note: Different letters in the same column represent significant difference ($P \leq 0.05$)

The sensory characteristics of date juice made from fresh date, premature fruit drop, and dried date was evaluated by RATA. The results were shown in Fig 1. All juices had a rather higher intensity of sweet aroma, fruity aroma, body, sweet taste, sweet flavor, and fruity flavor. In terms of color, date juice from dried date was more brownish than the other two date juices. Premature fruit drop also contributed to turbidity, coconut water, raw fruit aroma, and slightly more fruity flavor. Higher intensity of these flavors found in premature fruit drop juice would significant in its uniqueness in extent.

The three types of date that sugar was accumulated, the color change from yellowish to dark brown color by lost moisture content and gave harder texture as ripening. The texture were affected to quality of date juice by overall yield and yield lost by filtration that hard texture has to take more pressure to squeeze. Juice from developed fruit showed higher initial total soluble solid and overall yield from date pulp was higher by adding water to reach 10.5°Brix. For the sensory, even the raw material was different in texture, color, sugar, and moisture content, yield and overall liking was no significant difference as like moderately (7.04–7.32).

The different types of date fruits gave different total soluble solid (TSS), total sugar, and texture (toughness, work of shear, and firmness). The fresh date and premature fruit drop were lower total soluble solid (TSS) and total sugar because they are at khalal and rutab stage while dried date was highest in total sugar because it is at tamar stage. The yield lost by filtration of dried date was higher than fresh date and premature fruit drop because the moisture content of date decreased, and total sugar increased as ripen. The concentration of

Food and Applied Bioscience Journal, 2020, 8(2): 40–52

sugar increased from Khalal stage to Tamar stage was related to decrease the water content of date fruit during the ripening stags. When the moisture loosed from the date fruit, the sugar was accumulated by converse from sucrose to invert sugar (glucose and fructose) (Yahia, 2011). Low moisture content and high sugar rate of dates fruit was shrunk and gave harder texture and the skin was dried and sifted of flesh. The overall yield of the dried date juice was higher because it was contained higher concentrations of sugar in dried date fruit.

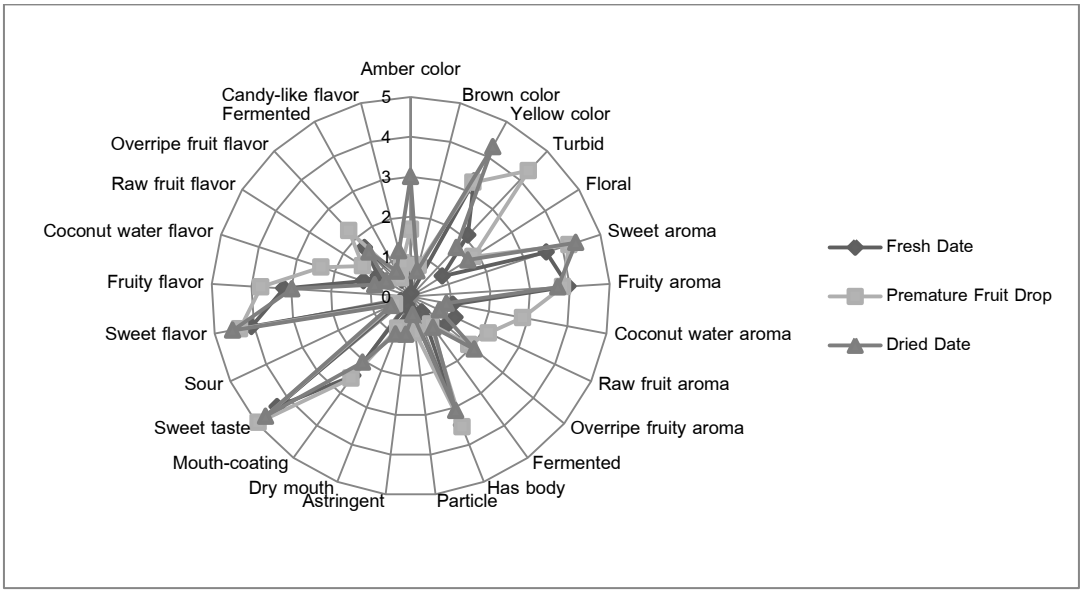

Fig 1 The intensity of sensory characteristics of date juice using RATA

Moreover, the color changed by both enzymatic and non–enzymatic browning occurred in the date fruit that contained higher moisture content, sugar content and high temperature. Then the enzymatic browning was occurred. Also, dried date fruit contained higher reducing sugar was shown dark color that made the dried date juice darker color than others. Juices from fresh date and premature fruit drop were not only brighter in color, but also high in cloudiness. It probably resulted from the amount of pectin was high in their products compared to dried date juice. Pectin is the agent causing the most turbidity that contain 0.5–3.9% in date depend on verities (Fayadh and Al–Showiman, 1990; Al–Shahib and Marshall, 2003). The date extract contains various amount of pectin, protein, minerals, and hemicelluloses substance. In the fruit, fiber is chemically bound to insoluble protein of date fresh, and is mainly compose of cellulose, hemicelluloses, lignin, and lignocelluloses. During the ripening process, these substances are gradually broken down by enzymes to more soluble compounds, rendering the fruit renderer and softer. Dried date juice however contains less of those substances in juice for its cloudiness.

Food and Applied Bioscience Journal, 2020, 8(2): 40−52

5. Conclusion

The different level and quality of date fruits, Barhee fresh date, premature fruit drop, and dried date are important factor for commercialized date products that influence to the waste, cost, and value added. The premature fruit drop considered as low quality although no significant difference of preference by consumer. Resulted from this study, juices made from different three date fruit types were not significantly different in liking score, even though it showed different appearance and other physical properties. This can consider that the juice products from low quality date fruit can compare with high quality date fruit. Further, the low quality of premature date fruit that do not pass the high quality to consume directly can produce juice product that can compare to fresh date which are high quality and expensive raw material and to dried date that do not dry on the tree as well as cannot grow in Thailand by climate changing. These benefits to reduce the waste and increase the value of premature fruit drop products.

Acknowledgements

The author would like to acknowledge Rattanasin Agriculture Limited for funding support and kindly provided raw materials for this project.

References

Abbas, M. A. F. and Ibrahim M. A. 1996. The role of ethylene in the regulation of fruit ripening in the Hillawi date palm (Phoenix dactylifera). Journal Science of Food and Agriculture. 72(3): 306−308.

Ait−Oubahou, A. and Yahia, E. M. 1999. Postharvest handling of dates, Postharvest News and Information. 10(6): 67−74.

Al−Farsi, M. A., and Lee, C. Y. 2008. Nutritional and functional properties of dates: a review. Critical Reviews in Food Science and Nutrition. 48(10): 877−887.

Aleid, S. M., and Kader, A. A. 2013. Dates: postharvest science, processing technology and health benefits. John Wiley & Sons.

Alkaabi, J. M., Al−Dabbagh, B., Ahmad, S., Saadi, H. F., Gariballa, S., and Al Ghazali, M. 2011. Glycemic indices of five varieties of dates in healthy and diabetic subjects. Nutrition Journal. 10(1): 59.

Al−Shahib, W., and Marshall, R. J. 2003. The fruit of the date palm: its possible use as the best food for the future?. International Journal of Food Sciences and Nutrition. 54(4): 247−259.

AOAC. 1982. AOAC Official Method 981.12: pH of acidified foods.

AOAC. 2000. Official Method of Analysis of AOAC international. 17th ed. The Association of Official Analytical Chemists.

AOAC. 2016. AOAC Official Method 982.14: Glucose, Fructose, Sucrose, and Maltose in Presweetened Cereals.

Fayadh, J. M. and Al–Showiman, 1990. Chemical composition of datepalm (*Phoenix dactylifera* L.). Journal of The Chemical Society of Pakistan. 12(1): 84–103.

Gad, A. S., Kholif, A. M., and Sayed, A. F. 2010. Evaluation of the nutritional value of functional yogurt resulting from combination of date palm syrup and skim milk. American Journal of Food Technology. 5(4): 250–259.

Ghnimi, S., Umer, S., Karim, A., and Kamal–Eldin, A. 2017. Date fruit (*Phoenix dactylifera* L.): An underutilized food seeking industrial valorization. Journal of the Society of Nutrition and Food Science. 6: 1–10.

James, I. F. and Kuipers, B. 2003. Preservation of Fruits and Vegetables. Aromisa Foundation, Wageningen.

Miller, G. L. 1959. Use of dinitrosalicylic acid reagent for determination of reducing sugar. Analytical Chemistry. 31(3): 426–428.

Prior, R. L., and Cao, G. 2000. Antioxidant phytochemicals in fruits and vegetables: diet and health implications. Hort Science. 35(4): 588–592.

R Core Team. 2013. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3–900051–07–0, URL http://www.R–project.org/.

Riquelme, N., Díaz–Calderón, P., Enrione, J., and Matiacevich, S. 2015. Effect of physical state of gelatin–plasticizer based films on to the occurrence of Maillard reactions. Food Chemistry. 175: 478–484.

Salah, R. B., Jaouadi, B., Bouaziz, A., Chaari, K., Blecker, C., Derrouane, C., and Besbes, S. 2011. Fermentation of date palm juice by curdlan gum production from Rhizobium radiobacter ATCC 6466™: Purification, rheological and physico–chemical characterization. LWT–Food Science and Technology. 44(4): 1026–1034.

Yahia, E. M. (Ed.). 2011. Postharvest biology and technology of tropical and subtropical fruits: fundamental issues. Elsevier.

Youssif, A. K., Abou Ali, M., and Abou Idreese, A. 1990. Processing, evaluation and storability of date jelly. Journal of Food Science and Technology. 27: 264–266.

Youssif, A. K., Al-Shaawan, A. F., Mininah, M. Z., and El-Taisan, S. M. 1987. Processing of date preserve, date jelly and date-kutter. Date Palm Journal. 5: 73-86.

Zaid, A., De Wet, P. F. 1999. Chapter V Date Palm Propagation. FAO Plant Production and Protection Papers: 74-106.