Cell. Mol. Biol. (ISSN: 1165-158X)

Journal Homepage: www.cellmolbiol.org

Cellular and Molecular Biology

Original Article

Study of carbohydrate, bioactive compounds, antioxidants, vitamin C, and mineral content at the ripening stage of grapes, rambutan, and pineapple

Abu Bakar Mohammad Sharif Hossain*

Department of Biology, College of Science, Imam Mohammad Ibn Saud Islamic University, Riyadh, Kingdom of Saudi Arabia

Article Info

Article history:

Received: June 27, 2024
Accepted: April 23, 2025
Published: May 31, 2025

Use your device to scan and read the article online

Abstract

The experiment was carried out to investigate the carbohydrate content as represented by glucose, fructose and sucrose, total soluble solids, carotenoid, flavonoid, antioxidant, phenolic content, pH, and minerals as micro-macro nutrient content in grapes, rambutan, and pineapple. A total of 50 fruits were collected for rambutan, five fruits from pineapple, and five bunches were collected for grapes in Experiment 1: Glucose content was higher in rambutan and pineapple than in grapes. The higher fructose content was found in rambutan than in grapes and pineapple. The highest sucrose was observed in rambutan. The highest total soluble solid (TSS) content was found in rambutan. Vitamin C and fiber content exhibited the highest value in pineapple. However, carotenoid was higher in grapes and pineapple than in rambutan. The maximum flavonoid was found in rambutan. In addition, total antioxidant and phenolic content were higher in pineapple and rambutan than in grapes. Potassium content was higher in grapes and pineapple compared to the rambutan, whereas phosphorus content was the highest in pineapple, and calcium content was the highest in rambutan. Mn, Fe, and Zn were found in higher amounts in rambutan than in pineapple and grapes. In Experiment 2: glucose, sucrose, and vitamin C decreased while fructose, TSS, pH, and biomass increased. In addition, moisture decreased with the increase of total antioxidant capacity (TAC) in grapes, rambutan and pineapple. Carotenoid content was highest in grapes, flavonoid was highest in rambutan and total phenol was highest in pineapple. Therefore, it can be concluded that grapes showed better mineral content, rambutan exhibited the highest sugar and flavonoid content, and pineapple showed the highest bioactive compounds.

Keywords: Fruit, Glucose, Fructose, TSS, Nutrient content, Flavonoid.

1. Introduction

Grapes, rambutan, and pineapple fruits are the staple fruit crops in Asia, Europe, America, and worldwide. Fruits are mostly used as fruit, juice, and a source of different food products. These are traditional and common fruits with health benefits and nutritional value. Fruits are an important crop as food material and get the necessary nutritional values for a healthy life. Fruits keep a superlative role in daily food habits [1-3]. Fruits are a vital edible and favorite food on the food menu. It is extensively grown all over the world. Fruit is rich in nutrition and is used for food consumption as the healthiest alternative food content from fruit sources. Fruits contain sugar that delivers high mobility and heat energy levels to the body and can be easily broken down. Moreover, this sugar is not glucose, which rapidly raises the level of blood sugar, but also fruit sugar like fructose [2, 4, 5]. Fruits comprise a great source of many vitamins and minerals, fiber, fat, and proteins. They also contain micro and macronutrient content like sodium, potassium, calcium, magnesium, iron, sulfur, phosphorus, and chlorine, as well as vitamins A, beta-carotene, B1, B2, B3, and B6. The oxytocin substance present in the date is used in modern medicine to facilitate birth. Oxytocin means rapid birth. It is also known to increase levels of mother's milk after birth [6, 7].

It was suggested that nutritional quality was different in different water apple fruit varieties. They also recommended that there might be variations in different varieties of fruit [5]. It was stated that nutrient content was affected by environmental factors in Kiwi fruit and rich in fiber, fat, and proteins [8, 9]. It was reported [10] that fructose, glucose, phytochemical total phenol, antioxidant activity, ascorbic acid, anthocyanin, and flavonoid showed different values in different varieties of apricot. They also stated that this variation happened due to the dependence on variety type and geographical region [9].

It was reported that the potassium content and total sugar were different in different varieties of dates and olive fruit. Nutrient and carbohydrate content was recommended to be significantly different in different fruit species [11, 12]. It has been reported that date fruits, depending on the variety as well as weather, contained significant nutrient composition but quite variable amounts of macro-elements (calcium, phosphorous & potassium) and micro-elements, (iron, zinc & copper) respectively [13, 14, 15]. However, few literatures related to the present research are found.

* Corresponding author.
E-mail address: ashorrain@imamu.edu.sa; hossainsharif41@gmail.com (A. B. M. S. Hossain).
Doi: http://dx.doi.org/10.14715/cmb/2025.71.5.4

The following objectives were undertaken.

1. To investigate the sugars as represented by fructose, glucose, and biochemical content (TSS, pH) and bioactive (organic) compounds (carotenoid, flavonoid, antioxidant, phenolic) in grapes, rambutan, and pineapple fruit.
2. To determine the mineral or macronutrient (P, K, Ca, Mg) and micronutrient (Fe, Zn. Mn, B, Mo, Cu, and Na) content in grapes, rambutan, and pineapple fruit.

2. Materials and Methods

2.1. Study site, soil, and climatic information

The present investigation was carried out at the University of Malaya farm in Selangor, Malaysia. The area of this study had hot and humid tropical weather. The soil in this field was clay-loam soil with a mean pH of 6.6. The same location, climate, and soil were used for the different fruit samples.

2.2. Experiment 1 (May -November 2019)

Materials: Grapes (6 years old plants), rambutan (8 years old plants), and pineapple (5 years old plants) were harvested at the ripening stage from the same weather and collected at the same time (summer season) from the experimental field and fruit garden at the University of Malaya in Serdang, Selangor, Malaysia. These fruits were grown in the tropical clay-loam soil in the same area at the experimental farm garden at the same location (May-November, 2019). Intercultural operations were maintained properly.

2.3. Design for sample collection

A total of 50 fruits were collected at the initial stage of ripening for rambutan (10 fruit/plant was considered as one replication) from 5 plants and pineapple (5 fruits from 5 plants, considered as 5 replication) and 5 bunches, (one bunch bears 10 fruits, one bunch was considered as one replication) from 5 plants for grapes in the same season in 2019 (May- November). Samples were collected randomly following the completely randomized design (CRD).

2.4. Sample preparation

Beginning of the ripening stage, fruits were harvested. Fruits were thoroughly washed with distilled water, cut using a sterile knife, and blended by using a sterilized automatic juice blender and distilled water in a 2:1, fruit: water ratio. Then the juice samples were filtered and kept in the freezer to analyze. The 10ml of juice was used from each sample.

2.5. Fiber and moisture determination

Fiber and moisture determination from grape, rambutan, and pineapple according to the methods by the United Nations Economic Commission for Europe [16].

2.6. Vitamin C determination

Vitamin C concentration was determined by applying a redox titration having potassium iodate in the presence of potassium iodide. 1 ml of titrant was utilized for each flask and calculated.

2.7. Carbohydrate content as fructose, sucrose, and glucose determination by GC-FID

500 mg fruit juice samples were taken in the test tubes, and 20 ml of 80% ethanol was added to each sample. The test tubes were boiled at 80°C in a water bath for 2 h. Then, the samples were filtrated and extracts were evaporated to dryness using a rotary evaporator. An aliquot of 20 µl sample was taken into the vial and dried. Then, 40 µl pyridine including 1, 3, 5, tri-phenyl benzene, 1 mg ml^{-1} as an internal standard, 40 µL hexamethyldisilazane, and 40 µl chloromethyl silane were added to the dried samples. 1µl of the trimethylated samples was injected into a gas chromatograph. Peaks were shown for each sugar. The GC conditions were as follows: column temperature was set from 150-265°C at the increment rate of 10°C min^{-1}. The GC was equipped with a glass column (2.6 mm x 2 m) packed with 1.5% SE-30 coated on Chromosorb WAW DMCS (80-100 mesh) and N_2 was used as carrier gas at the flow rate of 30 ml min^{-1} [17].

2.8. Biochemical content as TSS and pH determination

The total soluble solid (%brix) was determined by a Refractometer, and pH was determined by a pH meter.

2.9. Bioactive compounds as flavonoid and carotenoid determination

Total Flavonoid (FC) was determined using the methods described by aluminum chloride colorimetric assay, using catechin as a standard, and carotenoid was determined according to the methods [18].

2.10. Total antioxidant capacity (TAC assay) determination

1mM Trolox Standard Solution was used. Fruit samples were directly added to the wells. For small molecule TAC, samples were diluted at a 1:1 ratio with Protein Mask. 20 µL of fruit sample was used in wells. Distilled water was put in making the volume of 100 µL. 100 µL of Cu^{2+}. Working Solution was added to all standard and sample wells and mixed properly using a horizontal shaker and the reaction was incubated for 90 minutes at room temperature. The plate was protected from light at the time of incubation and finally measured the absorbance at 570 nm (A570) [19].

2.11. Phenol content determination

The total phenolic content of fruits was determined by using the Folin-Ciocalteu assay (18). Folin-Ciocalteau (FC) colorimetry was based on a chemical reduction of the reagent, a mixture of tungsten and molybdenum oxides. The absorbance against reagent blank was determined with a UV-Vis Spectrophotometer Lambda 5 (at 765 nm) and expressed as mg gallic acid equivalent (GAE)/ 100g fresh weight [20].

2.12. Nutritional content (Minerals) analysis

Micronutrient content, potassium (K) was determined by Horiba Scientific Nutrient meter (Made in the USA). P, Ca, Mg, and micronutrients (Fe, Zn. Mn, B, Mo, Cu, and Na) were determined by an atomic Emission (AE) spectroscopic multi-element analyzer (MOA). After that, 1 ml of the sample was injected into the MOA, and readings were calculated [21].

2.12.1.MOA condition

An Atomic Emission (AE) spectroscopic Multi-element Oil Analyzer MOA (MOA 11 plus, USA) was designed specifically for chemical metal contents analysis by using an atomic emission (AE) spectroscopic. An atomic emission spectrometer employing the rotating disk electrode (RDE) technique used following the temperature of MOA was 30°C (60% R.H.), the dimension was 89 x 81 x 65 cm (LHD) and the power was 1.5 kW.

2.13. Experiment 2 (May - November 2020)

2.13.1. Materials in the second year

In this experiment, the same procedure was used as mentioned in Experiment 1. The same data were collected in the second year from the same experimental farm and location. Samples were collected randomly in 2020, following the completely randomized design (CRD).

2.14. Statistical analysis

Data were analyzed statistically. The standard error (SE) and the Duncan's Multiple Range Test (DMRT) were employed.

3. Results

3.1. Experiment 1

The highest (7.2%) fruit glucose content was exhibited in rambutan (Table 1). Glucose content was found higher in rambutan and pineapple than in grapes (Table 1). The higher fructose content was found in rambutan than in grapes and pineapple. The highest sucrose was observed in rambutan. Total soluble solid (TSS) content was found at 13.4 % in rambutan, followed by 11.1 and 9.4% in grapes and pineapple, respectively. However, pH content was found higher in rambutan and grapes than in pineapple (Table 1).

There was a significant difference in vitamin C among rambutan, grapes, and pineapple (Table 1). The highest biomass content was exhibited in pineapple. Fiber and moisture content were exhibited higher in grapes than in pineapple and rambutan (Table 2). However, carotenoid was found higher in grapes and pineapple than in rambutan (Table 2). The maximum flavonoid was recorded in rambutan. Besides, total antioxidant and phenolic content were observed higher in pineapple and rambutan than in grapes. Potassium content was higher in grapes and pineapple compared to the rambutan (Table 3). Moreover, phosphorus content was the highest in pineapple and calcium content was the highest in rambutan. In addition, magnesium (Mg) content was higher in rambutan and pineapple than in grapes (Table 3). Mn, Fe, and Zn were found in higher amounts in rambutan than in pineapple and grapes (Table 4). Whereas, Bo, Mo, Cu, and Na were higher in grapes and pineapple than in rambutan. Fig. 1

Fig. 1. The photograph shows the fruit's image of the initial ripening stage in 2019.

Table 1. Glucose, TSS, and pH content in the first year (2019).

Fruits	Glucose (%)	Fructose (%)	Sucrose (%)	pH	TSS (%)	Vitamin C (mg/100g)	Biomass (%)
Grapes	5.5±0.01b	8.0±0.0b	6.8±0.3b	6.5±0.1b	11.1±0.1b	4.5±0.2c	5.0±0.1c
Rambutan	7.2±0.02a	11.0±0.2a	7.5±0.2a	6.8±0.0a	13.4±0.2a	43.0±0.4b	8.5±0.3b
Pineapple	6.5±0.03a	7.5±0.2b	6.5±0.4b	5.8±0.2a	9.4±0.1ab	48.4±0.5a	13.0±0.2a

The same letters (a, a) showed no difference at a 5% level of significance by Duncan's Multiple Range Test (DMRT). Mean ± SE (n=5).

Table 2. Determination of Fiber, moisture, and pigments content in 2019.

Fruits	Fiber (%)	Moisture in peel (%)	Carotenoid (mg/100g)	Flavonoid (mg/100g)	Total antioxidant (mg/100g)	Total Phenol (mg GAE/g)
Grapes	1.0 ±0.01c	85±0.01a	62.5±0.1b	20.0±0.5b	39±0.2c	28±0.2c
Rambutan	4.2±0.02b	60±0.01c	3.0±0.2c	33.0±0.4a	44±0.3b	40±0.3b
Pineapple	8.6±0.03a	70±0.01b	70±0.3a	15.0±0.3c	65±0.1a	55±0.3a

The same letters (a, a) showed no difference at a 5% level of significance by Duncan's Multiple Range Test (DMRT). Mean ± SE (n=5).

Table 3. Macro nutrient content in pineapple, rambutan, and grapes in 2019.

Fruits	P (mg/100g)	Ca (mg/100g)	Mg (mg/100g)	K (mg/100g)
Grapes	9.4±0.5	12.5±0.2	4.0±0.8	175±0.7
Rambutan	15±0.3	23.5±0.1	19.69±0.01	91.5±0.4
Pineapple	25±0.2	11.9±0.1	21.5±0.1	185±0.6

Mean±SE (n=5).

Table 4. Micronutrient content in pineapple, rambutan, and grapes in 2019.

Fruits	Mn (mg/100g)	Fe (mg/100g)	Zn (mg/100g)	B (mg/100g)	Mo (mg/100g)	Cu (mg/100g)	Na (mg/100g)
Grapes	1.8±0.1	0.4±0.1	0.2±0.01	1.2±0.01	0.55±0.1	0.04±0.001	2.5±0.3
Rambutan	0.5±0.3	1.5±0.02	0.97±0.02	0.23±0.002	0.1±0.003	0.2±0.002	1.5±0.1
Pineapple	0.55±0.01	0.5±0.03	0.4±0.002	0.3±0.001	0.2±0.001	0.25±0.001	2.4±0.2

Mean±SE (n=5).

shows the fruit's maturity image.

3.2. Experiment 2 (May-November 2020)

In the second year, the same investigation was performed except for minerals. It was exhibited that glucose, sucrose, and vitamin C decreased while fructose, TSS, pH, and biomass increased (Table 5). In addition, moisture decreased with increasing the antioxidant (TAC), carotenoid, flavonoid, and total phenol (Table 6). There are no significant differences among the parameters in 2019 and 2020.

4. Discussion

For the above results, it can be observed that the highest fructose, glucose, TSS, pH, and nutrient content was found in rambutan compared to the other fruits shown in Experiment 1. This may be due to the different species' being controlled by many environmental factors [14]. It was stated that nutrient and carbohydrate content were significantly difference in different fruit species [11, 12]. It was found that biochemical contents and bioactive compounds are different in different fruit cultivars. However, there are no significant differences among the parameters in 2019 and 2020. It might be due to the same environmental factors in 2019 and 2020 in grapes, rambutan, and pineapple. Only fructose content, fibers, and biomass were found a bit higher, but no significant difference between the years of 2019 and 2020. It might be because moisture content was found to reduce in all fruits. In addition, carotenoid, flavonoid, antioxidant, and total phenol showed a bit increasing trend in 2020.

From our results, it can be seen that pineapples, rambutan, and grapes have nutritive and bioactive value. It has been observed that date fruits, depending on the variety and location as well as weather, contained significant but quite variable amounts of macro-elements (calcium, phosphorous, potassium, etc.) and micro-elements (iron, zinc and copper) respectively [15, 22]. Potassium content and total sugar were different in different varieties of dates, olives, figs, and other fruits [22, 23, 24]. It was suggested that nutrient content was affected by environmental factors in Kiwi, peach, and grapes fruits. Nutritional quality was found to be different in different varieties of water apple fruit [25]. They also recommended that it might be due to the variation in different varieties of fruit.

It was suggested that the carotenoids of fruit protect cell membranes from oxidative damage as they have antioxidant properties [26]. They are responsible for the unique orange and yellow peel and pulp color of most Prunus species. The carotenoid contents of apricots have been reported in the range of 9.02 to 91.89 mg/100 g [27]. There was a variation of bioactive compounds variation among all the cultivars that was mainly dependent on cultivars and region of cultivation. Many fruits have the important antioxidant scavenging ability that can quench the free radicals due to the presence of antioxidant activity, and antioxidative compounds (total phenolic contents, total flavonoid, and ascorbic acid [4, 28, 29].

Fruits are considered the prime source of glucose and fructose and protein compared to other fruits. Many factors are involved, including cultivar, genome, climatic conditions, irrigation, sunlight, and post-harvest treatments that may affect the radical scavenging activity and sugar and protein compositions of fruits [30-32]. It was observed that antioxidant compounds like phenolics, flavonoids, soluble tannins, ascorbic acid, and carotenoids could act as single oxygen and lipid peroxidation quenchers, consequently possessing the capacity to counterbalance the free radicals implicated in the oxidative progressions through conjoining with oxidizing species or hydrogenation, and help in depreciating the disease risk [33, 34].

It can be concluded that rambutan contains higher carbohydrate (represented as fructose, glucose, sucrose) and biochemical (TSS and pH) content than grapes and pineapple shown in Experiment 1. Fiber and moisture content were found to be higher in pineapple and grapes than in rambutan. However, flavonoids and carotene were higher in pineapple and grapes than in rambutan. Flavonoid was the highest in rambutan. Besides, antioxidant and phenolic content were higher in pineapple and rambutan than in grapes. There were significant differences found in grapes., rambutan, and pineapples in the case of macro and micronutrients in 2019. The fructose content, fibers, and biomass were found to be a bit higher, but there was no significant difference between the years of 2019 and 2020. So, pineapple was the best for vitamin C, carotenoids, antioxidants, and total phenol content. Rambutan was found best for sugar and flavonoid content. Grapes and pineapple were found better for K, Na & Mn. Therefore, in conclusion, these fruits contain biochemical contents, flavonoids, carotene, antioxidant, and phenolic content that can be used as bioactive natural (organic) products, nutritive, and medicinal value for human health benefits. It can be

Table 5. Glucose, TSS, and pH content in the 2nd year (2020).

Fruits	Glucose (%)	Fructose (%)	Sucrose (%)	pH	TSS (%)	Vitamin C (mg/100g)	Biomass (%)
Grapes	5.3±0.2b	8.5±0.3b	6.6±0.2b	6.6±0.2a	11.3±0.2b	4.3±0.2c	5.5±0.15c
Rambutan	7.1±0.2a	11.4±0.2a	7.4±0.3a	6.9±0.3a	13.6±0.3a	42.9±0.4b	8.9±0.2b
Pineapple	6.3±0.1a	7.9±0.1b	6.3±0.3b	5.9±0.2b	9.7±0.1ab	47.9±0.5a	13.7±0.2a

The same letters (a, a) showed no difference at a 5% level of significance by Duncan's Multiple Range Test (DMRT). Mean ± SE (n=5).

Table 6. Determination of Fiber, moisture, and pigments content in 2020.

Fruits	Fiber (%)	Moisture in peel (%)	Carotenoid (mg/100g)	Flavonoid (mg/100g)	Antioxidant (mg/100g)	Total Phenol (mg GAE/g)
Grapes	1.2 ±0.01c	84.2±0.01a	62.6±0.1b	20.1±0.5b	39.2±0.2c	28.3±0.2c
Rambutan	4.3±0.02b	59.3±0.01c	3.5±0.2c	33.3±0.4a	44.5±0.3b	40.2±0.3b
Pineapple	8.7±0.03a	68.4±0.01b	70.3±0.3a	15.5±0.3c	65.6±0.1a	55.4±0.3a

The same letters (a, a) showed no difference at a 5% level of significance by Duncan's Multiple Range Test (DMRT). Mean ± SE (n=5).

recommended that these fruits can be a better dietary and nutritive food for human health benefits.

Acknowledgments
Authors are thankful to the research students in the Plant Physiology and Biotechnology Laboratory, University of Malaya for their assistance in preparing the Manuscript.

References

1. Hossain ABMS (2023) Influence of Naphthalene Acetic Acid on the Fruit Growth, Chlorophyll, pH and Total Soluble Solid Content in Rose Apple. Int J Li Sci Agri Res 2(1): 1-8.
2. Arji I, Karimpour Kalehjoobi S, Nejatian MA, Upadhyay TK (2022) Yield and Yield Components of Grapevines as Influenced by Mixed Nano Chelated Fertilizer, Humic Acid and Chemical Fertilizers. Agrotech Ind Crops 2(3): 156-165. doi: 10.22126/atic.2023.8478.1076
3. SMQ (2011) Scientific Miracles of the Quran. http://www.miraclesofthequran.com/articles_index.html
4. Haider MS, Khan IA, Jaskani MJ, Naqvi SA, Sajid M, Shahzad U, Abbas H (2018) Pomological and biochemical profiling of date fruits during different fruit maturation phases. Pak J Bot 50:1069-1076.
5. Alsaif AM, Hossain ABMS, Rosna MT (2011) Photosynthetic yield, fruit ripening and quality characteristics of different cultivars of water apple. Afr J Agril Res 6: 3623-3630.
6. Naser SK (2011) Improving nutritional status and yield and fruit quality of date palm. Arab Palm Conference. http://www.arabpalm.org/2011/eng/contact.asp
7. Qing L, Guo-Yi T, Cai-Ning Z, Xiao-Ling F, Xiao-Yu X, Shi-Yu C, Xiao M, Sha L, Ren-You G, Hua-Bin L. (2018) Comparison of Antioxidant Activities of Different Grape Varieties. Moles 23(10): 2432. doi: 10.3390/molecules23102432.
8. Miller A, Smith GS, Boldingh HL and Johansson A (2010) Changes in vascular and transpiration flows affect the seasonal and daily growth of kiwifruit berries. Ann Bot 105 (6): 913-923. doi: 10.1093/aob/mcq070.
9. Hossain A B M S, Ahmed AA, Ibrahim NA (2017a). Residual Effect of Light Intensity on Physio-Biochemical Development, Mineral and Genomic Characterization of Date Fruits. Adv Biores 8 (3):54-61.
10. Waseem M, Summar AN, Haider MS, Shahid M, Muhammad JJ, Khan IA, Haider A (2021) Antioxidant activity, sugar quantification, phytochemical and physical profiling of apricot varieties of Chitral and Gilgit. Pak J Bot 53(4): 2021-2024. doi: http://dx.doi.org/10.30848/PJB
11. Hossain ABMS, Ahmed AA, Ibrahim NA (2017) Antioxidant, flavonoid and nutritional content and Genomic DNA Characterization of Date Fruits. Adv Biores 8 (5):175-182.
12. Hossain A B M S., Abdelmuhsin A and Ibrahim N A. 2017b. Olive fruit development, nutrient content and DNA characterization. Adv Biores 8 (6): 182-187.
13. Hossain ABMS, Alshammari A (2017a). Carbohydrate, Mineral and genomic DNA characterization of olive as influenced by water intensity. Adv Biores 8 (5): 245-250.
14. Hossain ABMS, Abdelmuhsin A (2018) Carbohydrate, biochemical and nutrient content in different dates varieties. J Biol Rec. 2 (1): 181-189.
15. WLB (1997) The World Leading Biotech. Bioportfolio, Health care and Medicinal value. Nutritional quality of date fruit varieties http://www.bioportfolio.com/resources/pmarticle/171091/16.
16. UNECF, (2003) United Nations Economic Commission for Europe. Determination of the moisture content for dried fruit. https://www.unece.org/agri.
17. Mizutani F, Masahlko Y, Takashl T (1982) Differential water prunus tolerance species under and flooded ethanol accumulation conditions. J. Japan. Soc. Hort. Sci. 51(1): 29-34.
18. Lucia et al. (2012) Total carotenoid content, α-carotene and β-carotene, of landrace pumpkins: A preliminary study. Food Res Int 47 (2): 337-340. doi.org/10.1016/j.foodres.2011.07.040.
19. Singleton V, Rossi J (1965) Colorimetry of total phenolic compounds with phosphomolybdic phosphotungstic acid reagents. Am J Enol and Viti 16:144- 58.
20. Singleton, VL, Orthofer R, Lamuela-Raventos RM (1999) Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin–Ciocalteu reagent. Meth Enzy. 299:152–178.
21. Doo-Gyung M, Young-Son C, Mizutani F, Kipkorionry LR, Bhusal RC (2003) Wax deposition on the fruit surface of satsuma mandarin as affected by water stress. Asi J Pl Sci 2: 1138-1141. DOI: 10.3923/ajps.2003.1138.1141.
22. Mine Y, Roy MK (2011) Antioxidant activities on egg components. Comprehensive Biotechnology. Second Edition. 4 (2): Pp553-565.
23. Morton J, Julia F, Miami FL (1987) In: Fruits of warm climates. Purdue University. Center for New Crops and Plants Products. Dates. p. 5–11.
24. FAOSTAT (2009). Food and Agriculture Statistical report. P 30.
25. DP (2009) Date People. About sugar in Dates. Niland CA 92257, 760-359-3211. California. http://www.datepeople.net.
26. Lin S, Guo H, Gong JD B, Lu M, Lu MY, Wang L, Zhang Q, Qin W, Wu DT (2018) Phenolic profiles, β-glucan contents, and antioxidant capacities of colored Qingke cultivars. J Cer Sci 81: 69–75.
27. Ali S, Masud T, Abbasi KS, Mahmood T, Ali A (2014) Some physic-chemical and functional attributes of sixindigenous apricot genotypes from Gilgit-Baltistan, Pakistan. Int J Biosci 4: 221-231.
28. Imdadul H, Hossain ABMS, Rosna MT (2011) Total phelolic compound and antioxidant activities in S. Alba tree. J Med Pl Res 4: 23-27.
29. Awad MA, Al-Qurashi AD, Mohamed SA (2011) Antioxidant capacity, antioxidant compounds and antioxidant enzyme activities in five date cultivars during development and ripening. Scien Hortic 129: 688-693.
30. Amira EA, Behija SE, Beligh M, Lamia L, Manel I, Mohamed H, Lotfi A (2012) Effects of the ripening stage on phenolic profile, phytochemical composition and antioxidant activity of date palm fruit. J Agri Food Chem 60: 10896-10902. Doi:10.1021/jf302602v.
31. Baliga MS, Baliga BRV, Kandathil SM, Bhat HP, Vayalil PK (2011) A review of the chemistry and pharmacology of the date fruits. Food Res Int 44: 1812-1822.
32. Alhamdan A, Hassan B, Alkahtani H, Younis M, Abdelkarim D (2016) Quality changes in fresh date fruits (barhi) during individual quick freezing and conventional slow freezing. Pak J Agri Sci 53: 917-924.
33. Hossain ABMS, Uddin MM (2019) Callus cell weight, antioxidant, carbohydrate, pigment and nutritional properties from broccoli explants in vitro: A nutritional vegetable. Int J Biosci Biochem 1: 4-8.
34. Haider MS, Khan IA, Naqvi SA, Jaskani MJ, Khan RW, Nafees M, Pasha M (2013) Fruit developmental stages effects on biochemical attributes in date palm. Pak J Agri Sci 50: 577-583.