JKAU: Sci., vol. 6, pp. 29-36 (1414 A.H. / 1994 A.D.

Changes in Sugar Quality and Mineral Elements During Fruit Development in Five Date Palm Cultivars in Al-Madinah Al-Munawwarah

ABDUL AZIZ A. GASIM
Dept. of Natural Sciences, Faculty of Education,
King Abdulaziz University, Al-Madinah Al-Munawarrah, Saudi Arabia

ABSTRACT. The reducing and non-reducing sugars and nine nutrient were determined in fruits of Ajwa, Beid, Burni, Rabeia and Safawi Date Palm cultivars, grown at Al-Madinah Al-Munawwarah, during four stages of fruit development. Results showed that most of the studied characters (physical and chemical composition) at four stages of fruit maturity differed from one cultivar to another. Higher values of fruit and seed weight as well as length and diameter were found during the early stages of development and minimum in the Tamre stage. Sugars contents accumulated gradually during fruit development in all cultivars were also found to vary among the five cultivars. Nitrogen and potassium contents were higher as compared to the minerals in the different cultivars. Also in the micro-elements, iron was present in higher concentration than zinc and copper. The change from Kimri to the Tamre stage was accompanied with a reduction in the amounts of all minerals for all the cultivars.

Introduction

Date Palm (*Phoenix dactylifera* L.) is considered as one of the most important fruit trees in the Arab countries, particularly Saudi Arabia. However, earlier study of physical and chemical composition of the fruits of different date palm cultivars has been reported at different countries by several workers (Haas[1], Furr & Cook[2], Hussein *et al.*[3], Hussein & El-Zeid[4], Minessy *et al.*[5], Sawaya *et al.*[6-9], and Saad *et al.*[10]). Al-Madinah Al-Munawwarah is number one producer of dates in Saudi Arabia (Asif *et al.*[11]).

The main aim of this study is to evaluate the fruit growth and changes in sugars and nutrient element content of five date palm cultivars Ajwa, Beid, Burni, Rabeia and Safawi growth at Al-Madinah Al-Munawwarah region at four different development stages (Kimri, Khalal, Rutab and Tamre).

Material and Methods

Five date palm (*Phoenix dactylifera* L.) cultivars grown at an orchard in Quba area in Al-Madinah Al-Munawwarah, were used in this investigation. Five date palm varieties were included; Ajwa, Beid, Burni, Rabeia, and Safawi. The trees were about 17-year-old. Three palm trees of similar vigour were selected from each cultivar. Orchard was fertilized and irrigated according to the requirement of the field. All trees were pollinated by hand on April 15, 1989. Fruit samples were collected on July 2, 12 weeks after pollination, and continued at 15 days interval upto September 1. Fruit samples were collected at four different stages of fruit development. These stages were as follows: (1) Kimri, (2) Khalal, (3) Rutab, and (4) Tamre. Three samples were taken from each cultivar at the fourth stage of fruit development. Each sample, consisting of 120 dates, was collected from each of the three trees of the five cultivars. Physical characteristics of the fruits (fruit length and diameter, fruit and seed weight, pulp weight) were determined. Vernier caliper was used for measuring length and diameter of fruits.

Total sugars, reducing and non-reducing sugars, were estimated according to the A.O.A.C. methods[12]. Mineral content of the flesh were carried out. Oven-dried and ground for chemical analysis, nitrogen was determined by microkjeldahl method (A.O.A.C.)[12] and P, K, Na, Ca, Mg, Fe, Zn and Cu, were determined by AA-775 series, atomic absorption spectrophotometry (A.O.A.C.)[12].

Results and Discussion

Morphological Changes

The data on the morphological changes occurring during the development of fruits of Ajwa, Beid, Burni, Rabeia and Safawi are presented in Table 1. The average length and diameter of the fruit, in the five cultivars increased as the dates reached the Khalal stage and then decreased in the Tamre stage. The fruits of Safawi cultivar were largest in size followed by Burni and Rabeia cultivars while Beid and Ajwa were about the same measurements in both stages (Rutab and Tamre). The weight of fruit and seed in the five cultivars increased at the Rutab stage and then decreased in the Tamre stage. Also data showed that the Pulp percentage was higher during developmental stages. Similar results were obtained by Sawaya *et al.*[6] in Khudari, Selej and Sifri date palm cultivars grown in Riyadh.

Sugar Analysis

Total sugar content of the fruits in the five cultivars reached its maximum in the Tamre stage (Table 2). At the Kimri stage, the content ranged from 42.5-54.3% and then increased rapidly in the Khalal stage. Thereafter, the total sugar content in-

ILE Morphological characteristics of Ajwa, Beid, Burni, Rabeia and Safawi date cultivars.

Cultivar	Stage of development									
	Kimri					Khalal				
	F. length cm	F. diameter cm	Wt/fruit g	Wt/seed g	Pulp %	F. length cm	F. diameter cm	Wt/fruit g	Wt/seed g	Pulp %
Ajwa	1.22 ± 0.06	0.79 ± 0.08	4.67 ± 0.96	1.21 ± 0.21	79	3.34 ± 0.18	2.39 ± 0.09	8.75 ± 1.76	1.32 ± 0.31	87
Beid	1.34 ± 0.02	1.18 ± 0.06	5.12 ± 0.72	1.13 ± 0.11	82	3.52 ± 0.22	2.97 ± 0.13	8.92 ± 1.33	1.25 ± 0.20	88
Burni	1.67 ± 0.15	0.56 ± 0.02	4.96 ± 0.95	1.11 ± 0.05	77	4.49 ± 0.29	2.31 ± 0.35	9.21 ± 1.19	1.25 ± 0.11	82
Rabeia	1.19 ± 0.17	0.51 ± 0.04	3.92 ± 0.21	1.11 ± 0.10	82	3.99 ± 0.35	2.34 ± 0.25	6.25 ± 0.39	1.34 ± 0.24	87
Safawi	1.52 ± 0.18	0.85 ± 0.05	5.21 ± 0.19	1.09 ± 0.08	78	4.49 ± 0.41	2.62 ± 0.29	10.91 ± 0.12	1.35 ± 0.12	82
	Rutab					Tamre				
	F. length cm	F. diameter cm	Wt/fruit g	Wt/seed g	Pulp %	F. length cm	F. diameter cm	Wt/fruit g	Wt/seed g	Pulp %
Ajwa	3.19 ± 0.25	2.25 ± 0.18	11.2 ± 1.21	1.20 ± 0.22	90	3.07 ± 0.06	2.21 ± 0.01	8.24 ± 0.32	0.97 ± 0.03	89
Beid	3.11 ± 0.26	2.45 ± 0.31	13.2 ± 1.15	1.42 ± 0.11	91	2.99 ± 0.06	2.44 ± 0.03	7.14 ± 0.28	0.80 ± 0.03	90
Burni	4.22 ± 0.19	2.25 ± 0.29	15.13 ± 1.93	1.10 ± 0.06	89	3.95 ± 0.05	2.11 ± 0.04	8.15 ± 0.32	0.75 ± 0.02	89
Rabeia	3.77 ± 0.24	2.24 ± 0.18	11.21 ± 0.79	1.49 ± 0.74	91	3.28 ± 0.10	2.13 ± 0.05	7.88 ± 0.33	0.95 ± 0.06	91
Safawi	4.52 ± 0.25	2.44 ± 0.19	13.82 ± 0.78	1.55 ± 0.22	88	4.07 ± 0.07	2.45 ± 0.04	9.46 ± 0.43	1.00 ± 0.05	89

S.D.

creased slightly upto Tamre stage and were 84.2, 75.5, 81.5 and 75.2 for Ajwa, Beid, Burni, Rabeia and Safawi cultivars, respectively. These results are in harmony with those reported by Ragab *et al.*[13], Mawlood[14], Hussein *et al.*[3], and Sawaya *et al.*[6,7] on different date-palm cultivars.

Table 2 also represented the development changes in reducing sugars content in fruits of the cultivars under study. The preparation of glucose to fructose changed with development of fruits, from 1.4-1.7:1 at the early stages of the development to 1:1 in Tamre stages. In general, the reducing sugars in the five date cultivars showed a trend similar to that of total sugars. At Kimri stage, Safawi fruits were highest in reducing sugars (54.3%), while Ajwa fruits recorded the lowest values 42.5. Afterwards, the fruits continued to gain more reducing sugars during all developmental stages to reach a maximum at Tamre stage.

Table 3 presents the accumulation of total sugars in fruits of the cultivars under study at Tamre stage. Statistical analysis indicated that no significant differences among Beid, Rabeia and Safawi with regard to their contents of total sugars, and they had the lowest values, while Burni was in between. On the other hand, Ajwa had the highest total sugar values that significantly excelled the other cultivars. Similar results were obtained by Sawaya *et al.*[7].

With respect to non-reducing sugars, (which consisted of sucrose only), data showed that it increased from low level in the Kimri stage (1.3-2.4%) to relatively higher level in the Rutab stage (11.2-24.5%). However, at Tamre stage, Safawi fruits

TABLE 2. Sugar contents of Ajwa, Beid, Burni, Rabeia and Safawi date cultivars at different stage of development (% of dry weight).

Stage of development	Total sugar	Reducing sugar (R.S.)	Sucrose non-R.S.	Glucose % of R.S.	Fructose % of R.S.	Ratio G/F
			Ajwa			
Kimri	42.5	41.2	1.3	61.2	38.8	1.5
Khalal	65.8	42.5	23.5	56.3	43.7	1.2
Rutab	70.0	45.3	24.7	51.5	48.5	1.1
Tamre	84.2	81.1	3.1	51.2	48.7	1.1
			Beid			
Kimri	45.7	43.7	2.0	63.2	36.8	1.7
Khalal	64.5	52.2	12.3	60.3	39.7	1.5
Rutab	67.8	53.1	14.7	55.4	44.6	1.2
Tamre	75.5	72.2	3.3	52.7	47.3	1.1
			Burni			
Kimri	52.3	50.5	1.8	59.7	40.3	1.4
Khalal	65.5	53.0	12.5	57.5	42.5	1.3
Rutab	70.4	56.6	13.8	56.0	44.0	1.3
Tamre	81.5	78.5	3.0	54.2	45.8	1.2
			Rabeia			
Kimri	43.3	41.8	1.5	63.2	36.8	1.7
Khalal	57.5	44.2	13.3	61.5	38.5	1.6
Rutab	72.6	58.4	14.2	59.2	40.8	1.4
Tamre	77.7	72.9	4.8	51.3	48.2	1.1
			Safawi			
Kimri	54.3	51.9	2.4	58.9	41.1	1.4
Khalal	57.8	54.0	3.8	56.5	43.5	1.3
Rutab	69.9	58.7	11.2	54.2	45.8	1.2
Tamre	75.2	70.2	5.0	51.7	48.3	1.0

TABLE 3. Comparison of sugar contents of fruits between the date cultivars at Tamre stage.

Cultivars	Tot.	Red	Suc.	Glucose	Fructose
Ajwa	84.2 a*	81.1 a	3.1 b	51.2 b	48.7 b
Beid	75.5 b	72.2 b	3.3 b	52.7 b	47.3 b
Burni	81.5 ab	78.5 a	3.0 b	54.2 a	45.8 a
Rabeia	77.7 b	72.9 b	4.8 a	51.3 b	48.2 b
Safawi	75.2 b	70.4 b	4.8 a	51.7 b	48.3 b

*Means, within a column followed by the same letter do not differ significantly of the 5% level of probability according to Duncan's Multiple Range Test.

were highest in sucrose (5.0%), while Ajwa fruits recorded the lowest values (1.3%). These results are in agreement with those reported by Sawaya *et al.*[6] in three Riyadh date palm cultivars. The data indicated that reducing sugars were the dominant for sugars during all developmental stages as compared with in a decrease in non-reduc-

ing sugars. Haas and Bliss[15], working on different date palm cultivars, pointed out that at the early stage of development, the sugars' content was largely in the form of reducing sugars. Cook and Furr[16] found that soft date cultivars contained little amounts of sucrose. Hussein[17] suggested that fruits of soft date cultivars contained little or no sucrose, while those of dry cultivars contained a relatively high proportion of sucrose to reducing sugars. The present data on sugar status of the fruits indicate that all the five cultivars, Ajwa, Beid, Burni, Rabeia and Safawi belong to the soft-date group.

Mineral Content

Mineral composition of date palm fruits is presented in Table 2. Data showed that the level of concentration in the five cultivars ranged for N 0.72-1.23%, P 0.120-0.161%, K 0.185-1.51%, Ca 0.25-0.50%, Mg 0.25-0.37%, Na 0.19-32%, Fe 205.1-251.5 ppm, Cu 4.95-6.25 ppm and Zn 27.5-72.70 ppm. The data clearly showed that K is the predominant macro-element in the flesh of the five date palm cultivars, whereas phosphorus was found in smaller quantities than the other macro-elements. With respect to micro-elements, data also showed that Fe is the predominant micro-element, while Cu was found in small quantities (Table 4).

TABLE 4. Mineral composition of Ajwa, Beid, Burni, Rabeia and Safawi date cultivars of various stages of maturity.

Cultivars	Stage of development	N %	P %	K %	Ca %	Mg %	Na %	Fe ppm	Cu ppm	Zn ppm
Ajwa	Kimri	1.23	0.210	1.30	0.32	0.27	0.19	205.1	6.25	72.7
	Khalal	1.03	0.180	1.05	0.20	0.25	0.21	192.5	4.27	27.5
	Rutab	0.93	0.150	0.85	0.19	0.21	0.18	180.3	4.00	25.7
	Tamre	0.82	0.090	0.65	0.18	0.20	0.25	172.0	3.75	24.5
Beid	Kimri	0.72	0.121	1.51	0.39	0.25	0.25	212.2	5.24	42.5
	Khalal	0.52	0.095	1.12	0.29	0.19	0.19	195.7	3.15	39.4
	Rutab	0.44	0.072	1.11	0.25	0.15	0.17	174.5	2.24	39.2
	Tamre	0.40	0.065	1.09	0.19	0.11	0.18	170.3	2.80	30.5
Burni	Kimri	0.94	0.161	1.32	0.50	0.29	0.22	225.2	4.65	50.8
	Khalal	0.82	0.122	0.94	0.32	0.19	0.20	190.5	4.12	45.2
	Rutab	0.65	0.085	0.65	0.25	0.15	0.18	180.4	3.75	40.5
	Tamre	0.45	0.050	0.70	0.22	0.14	0.19	175.5	3.63	34.2
Rabeia	Kimri	1.55	0.144	1.22	0.46	0.37	0.32	251.5	5.24	27.5
	Khalal	1.12	0.095	1.35	0.30	0.224	0.29	200.2	4.50	22.9
	Rutab	0.79	0.054	1.11	0.33	0.145	0.25	177.5	2.75	20.0
	Tamre	0.62	0.044	0.95	0.27	0.120	0.26	174.9	2.72	20.5
Safawi	Kimri	0.99	0.127	0.185	0.25	0.27	0.22	233.5	4.95	44.2
	Khalal	0.62	0.095	1.22	0.11	0.20	0.25	197.3	2.94	31.1
	Rutab	0.59	0.052	0.99	0.12	0.12	0.19	188.5	2.50	29.5
	Tamre	0.47	0.045	0.80	0.18	0.13	0.20	180.3	2.22	20.9

There were significant differences in the dates' mineral contents of the whole season of the five date cultivars, when the averages of all trees were compared (Table 5). Date mineral contents ranged for N 0.520-1.020%, P 0.079-0.157%, K 0.853-1.215%, Ca 0.165-0.280%, Mg 0.175-0.214%, Na 0.197-0.280%, Fe 175.3-201.0 ppm, Cu 2.776-4.037 and Zn 22.723-42.67 ppm. The results were in parallel with those reported by Haas[1], Minessy *et al.*[5], Sawaya *et al.*[8], and Saad *et al.*[10] for many date palms cultivars grown in Saudi Arabia.

TABLE 5. Average of the whole season mineral composition of Ajwa, Beid, Burni, Rabeia and Safawi date cultivars.

Cultivars	N %	P %	K %	Ca %	Mg %	Na %	Fe ppm	Cu ppm	Zn ppm
Ajawa	1.003a*	0.157a	0.963b	0.230b	0.213a	0.208b	175.3c	4.567a	27.612c
Beid	0.520b	0.088b	1.208a	0.280b	0.175b	0.197b	187.2ab	2.776b	36.9ab
Burni	0.715b	0.104ab	0.905b	0.323a	0.193b	0.198b	183.4b	4.037a	42.67b
Rabeia	1.02a	0.084b	0.853b	0.342a	0.214a	0.280a	192.9a	3.852ab	22.723c
Safawi	0.668b	0.079b	1.215a	0.165b	0.180b	0.215b	201.0a	3.152b	31.425a

*Means, within a column followed by the same letter do not differ significantly of the 5% level of probability according to Duncan's Multiple Range Test.

References

[1] **Haas, A.R.C.**, Inorganic composition of date fruits, *Date Grower's Inst. Rep.* **12:** 6-8 (1935).

[2] **Furr, J.R.** and **Cook, J.A.**, Nitrogen content of pinnae, fruit and seed of Deglet Noor and Khadrawy date palms as related to nitrogen fertilization, *Date Grower's Inst. Rep.* **29:** 13-14 (1952).

[3] **Hussein, F., Mustafa, S., Al-Kahtani, M.S., El-Shamiraea, F.** and **Al-Zeid, A.**, Studies on physical and chemical characteristics of eighteen date cultivars grown in Saudi Arabia, *Coll. Agric. Res. Bull., King Saud Univ., Riyadh* **2:** 187-203 (1974).

[4] **Hussein, F.** and **El-Zeid, A.A.**, Chemical composition of Khalas dates grown in Saudi Arabia, *Egypt J. Hort.* **2:** 209-214 (1975).

[5] **Minessy, F.A., Bacha, M.A.** and **El-Azab, E.M.**, Changes in sugars, and nutrient elements content in fruits of four soft date varieties in Egypt, *Alex. J. Agric. Res.* **23:** 301-306 (1975).

[6] **Sawaya, W.N., Khalil, J.K.** and **Safi, W.M.**, Fruit growth and composition of Khudari, Sellej and Sifri date cultivars grown in Saudi Arabia, *Proc. 1st Symp. Date Palm. March 23-25. King Faisal Univ., Al-Hassa, Saudi Arabia,* pp. 202-209 (1982).

[7] **Sawaya, W.N., Khalil, J.K., Khatchadourian, H.A., Safi, W.M.** and **Mashadi, A.S.**, Sugars, tannins and some vitamins contents of twenty date cultivars grown in Saudi Arabia at the Khalal (Mature color) and Tamre (Ripe) stages, *Proc. 1st Symp. Date Palm, King Faisal Univ., Al-Hassa, Saudi Arabia,* pp. 468-478 (1982).

[8] **Sawaya, W.N., Safi, W.M., Khalil, J.K.** and **Mashadi, A.S.**, Physical measurements, prominate analysis and nutrient elements content at twenty-five date cultivars grown in Saudi Arabia at the Khalal (Mature color) and Tamre (Ripe) stages. *Proc. 1st Symp. Date Palm, King Faisal Univ., Al-Hassa, Saudi Arabia,* pp. 454-466 (1982).

[9] **Sawaya, W.N., Khalil, J.K.** and **Safi, W.M.**, Chemical composition and nutritional quality of date seeds, *J. Food Sci.* **49:** 617-619 (1984).

[10] **Saad, F.A., Shaheen, M.A.** and **Bacha, M.A.**, Chemical analysis of fruits of some Saudi grown date palm cultivars with emphasis on their mineral content, *Proc. Saudi Biol. Soc.* **9:** 22-23 (1986).

[11] **Asif, I., Al-Tahir, O.A.** and **Al-Kahtani, M.S.**, Inter-Regional and Inter-Cultivar variations in dates grown in the Kingdom of Saudi Arabia, *Proc. 1st Symp. Date Palm, King Faisal Univ., Al-Hassa, Saudi Arabia,* pp. 234-248 (1982).

[12] **A.O.A.C.,** *Official Methods of Analysis,* 12th ed., Association of Official Analytical Chemists. Washington, D.C. (1975).

[13] **Ragab, M.H.H., El-Tobey Shehata, A.M.** and **Sedky, A.,** Studies on the Egyptian dates. 2. Chemical changes during development and ripening of six varieties, *Food Tech.* **10:** 407-410 (1956).

[14] **Mawlood, E.A.,** *Physiological studies on fruits development of Sammany and Zaghloul date palm cultivars,* Ph.D. Thesis, Hort. Dept., Fac. Agric., Cairo Univ. (1980).

[15] **Haas, A.R.C.** and **Bliss, D.E.,** Growth and composition of Deglet Noor dates in relation to water injury. *Hilgardia* **9:** 295-344 (1935).

[16] **Cook, J.A.** and **Furr, J.R.,** Kinds and relative amounts of sugars and their relation to texture in some American grown date varieties, *Proc. Amer. Soc. Hort. Sci.* **61:** 286-292 (1953).

[17] **Hussein, F.,** Kinds and relative amounts of sugars in some Egyptian date cultivars. *Beitr. Trop. & Subtrop. Landwist and Tropenveterina armedizin* **10**(2): 159-162 (1972); (*Hort. Abst.* **44**(6): 4295).

التغيرات في محتوى السكر وبعض العناصر المعدنية خلال نضج الثمرة في خمسة أصناف من نخيل البلح في المدينة المنورة

عبد العزيز عبد الله قاسم

قسم العلوم الطبيعية ، كلية التربية بالمدينة المنورة ، جامعة الملك عبد العزيز

المملكة العربية السعودية

المستخلص . قدر محتوى السكريات المختزلة وغير المختزلة وتسعة من العناصر المعدنية لثمار أصناف التمور المزروعة بمنطقة المدينة المنورة (عجو ، بيض ، برني ، ربيعة ، والصفاوي) خلال فترة نمو الثمار . وقد أوضحت النتائج أن معظم الصفات الطبيعية والمكونات الكيميائية التي قُدِّرت على أربع فترات مختلفة من نمو الثمار تختلف من صنف إلى آخر . كانت الزيادة أعلى في وزن وطول وعرض الثمار والنوى عند بداية العقد بالمقارنة بمرحلة التمر . كما أن محتويات السكر ازدادت خلال فترة نضج الثمار وكانت تختلف من صنف إلى آخر . وكان عنصر النيتروجين والبوتاسيوم من أكثر العناصر وجودًا مقارنة بالعناصر المعدنية الأخرى التي درست ، ويتواجد الحديد بكميات أكبر من الزنك والنحاس . واتضح أيضًا أن التغير من مرحلة الخلال إلى مرحلة التمر كان مصحوبًا بانخفاض في كميات جميع المعادن بالنسبة لجميع الأصناف .