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Chemical composition of date varieties as influenced by the stage of ripening

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The chemical analysis of fruits from twelve varieties of date palm (*Phoenix dactylifera*) which are widely consumed in the United Arab Emirates was undertaken, and figures showed that glucose and fructose increase rapidly with maturation from Kimri through Khalal and Rutab to Tamr. Total sugars may represent over 50% of the fresh weight at Tamr, and these values, together with low moisture contents, encourage resistance to fungal spoilage after harvest. Minerals accumulated in the fruits as well, and the date could be an important source of potassium for regular consumers.

INTRODUCTION

The date palm (*Phoenix dactylifera*) is considered to be the most important fruit tree in most of the Arabian countries (Mustafa *et al.*, 1983). In the gulf region and the United Arab Emirates (UAE) in particular, the date was, before the discovery of oil, the main source of food together with camel milk and fish. Even today, in spite of the dramatic socio-economic changes in the UAE, dates continue to play an essential role in the diet of the local inhabitants.

The date palm starts to produce fruits at an average age of 5 years, and continues production with an average yield of 400–600 kg/tree/year for up to 60 years (Shinwari, 1993). Each fruit is a one-seeded berry consisting of a fleshy mesocarp covered by a thin epicarp; a hard endocarp surrounds the seed, and these stones (pits) are often used as an animal feed. The fruits are arranged on spikelets bearing 20–60 individual dates, and a number of such spikelets are attached to a central stalk to form a bunch (5–30 bunches per tree).

Some fruits ripen early in the season, whilst others are not mature until the end of the season (August/September), and the mature fruits can vary widely in their organoleptic, physical and chemical characteristics (Dowson, 1982). All edible varieties of date pass through four distinct stages of ripening and, in the UAE, the Arabic terms — Kimri, Khalal, Rutab and Tamr — are used to represent, respectively, the immature green, the mature full coloured, the soft brown and the hard raisin-like stages of development.

Dates are commonly consumed as fresh, short shelf-life fruits at the Khalal and Rutab stages, or they may be left to dry to the low moisture, Tamr stage characterised by its good storability. In addition, Dowson (1982) recounted the usage of the Kimri stage by poor people, usually after the fruits had been beaten with sticks to remove the astringent juice. Besides the direct consumption of the fruit, dates are utilised locally in many ways, including the production of date extract and syrup (El-Shaarawy *et al.*, 1989) and the preparation of fruit cakes and salami-like rolls (Shinwari, 1993). Moreover, the utilisation of dates in modern industries has been reported by many workers (Dowson & Aten, 1962; Hamad *et al.*, 1983; Mikki *et al.*, 1983; El-Nakhal *et al.*, 1989; Sawaya *et al.*, 1989).

However, in spite of this extensive exploitation of the date, little information has been published about the chemical composition of the fruit. Ragab *et al.* (1956) surveyed some cultivars growing in Egypt, while other reports from Iran (Rouhani & Bassiri, 1976), Iraq (Bukaev *et al.*, 1987), Saudi Arabia (Sawaya *et al.*, 1982) and Sudan (Mustafa *et al.*, 1986) considered some of the changes in chemical composition that accompany development. Ba-Angood and Ahmed (1984) studied the chemical composition of some varieties of date

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Table 1. Proximate chemical composition (g/100 g fresh weight[a]) of some commercial varieties of date at different stages of ripening

Variety	Ripening stage	Moisture	Protein (crude)	Lipid	Ash
Naghal	Kimri	80·1	1·1	0·1	0·8
	Khalal	54·5	1·6	0·1	1·0
	Rutab	44·1	2·0	0·2	1·2
	Tamr	9·2	2·7	0·2	1·9
Buchibal	Kimri	83·7	1·0	0·1	0·7
	Khalal	76·5	0·9	0·1	0·5
	Rutab	35·9	2·1	0·1	1·1
	Tamr	18·0	2·2	0·2	1·5
Khunaizy	Kimri	84·2	1·1	0·1	0·7
	Khalal	66·5	1·1	0·1	0·8
	Rutab	37·9	1·9	0·1	1·2
	Tamr	25·1	3·0	0·1	1·4
Khulas	Kimri	83·7	0·8	0·1	0·7
	Khalal	58·9	1·1	0·1	0·9
	Rutab	41·3	1·1	0·1	1·0
	Tamr	22·3	2·1	0·1	1·4
Gush	Kimri	85·1	0·7	0·1	0·6
Rabei	Khalal	64·1	1·0	0·1	1·0
	Rutab	44·7	1·4	0·1	1·1
	Tamr	25·5	2·0	0·2	1·6
Hilali	Kimri	84·6	0·9	0·1	0·7
Ahmr	Khalal	74·0	0·9	0·0	0·6
	Rutab	45·8	1·5	0·1	1·0
	Tamr	31·1	2·2	0·1	1·6
Barhi	Kimri	83·2	1·1	0·1	0·8
	Khalal	62·6	0·4	0·1	0·9
	Rutab	39·7	1·8	0·2	1·1
	Tamr	29·5	2·3	0·1	1·5
Lulu	Kimri	81·7	1·3	0·1	0·8
	Khalal	62·2	1·1	0·1	0·7
	Rutab	45·2	1·6	0·2	1·0
	Tamr	21·3	2·4	0·2	1·3
Fard	Kimri	82·7	0·9	0·1	0·8
	Khalal	72·1	1·0	0·0	1·0
	Rutab	37·6	1·5	0·2	1·3
	Tamr	27·7	2·1	0·1	1·8
Naghal	Kimri	85·5	0·8	0·1	0·6
Hilali	Khalal	57·0	1·3	0·1	1·0
	Rutab	48·9	1·2	0·1	0·8
	Tamr	32·1	1·9	0·1	1·3
Khasab[b]	Kimri	84·6	0·8	0·1	0·6
	Khalal	72·6	1·0	0·1	0·8
	Rutab	50·4	1·1	0·1	1·0
Hilali	Kimri	84·2	1·0	0·1	0·6
Pakistan[b]	Khalal	70·5	0·9	0·1	0·6
	Rutab	44·2	1·4	0·1	1·1

[a]Means of three replicates of fruits of two consecutive seasons.
[b]This variety does not produce Tamr stage.

Table 2. Sugar content (g/100 g fresh weight[a]) of some commercial varieties of date at different stages of ripening

Variety	Ripening stage	Total sugars[b]	Glucose (G)	Fructose (F)	Sucrose	G/F ratio
Naghal	Kimri	5·1	3·2	1·9	0·0	1·7
	Khalal	30·6	16·1	14·5	0·0	1·1
	Rutab	44·2	23·4	20·8	0·0	1·1
	Tamr	44·3	23·2	21·2	0·0	1·1
Buchibal	Kimri	5·1	3·2	2·0	0·0	1·6
	Khalal	18·8	8·1	6·3	4·3	1·3
	Rutab	49·0	25·5	23·3	0·1	1·1
	Tamr	55·1	27·6	27·6	0·0	1·0
Khunaizy	Kimri	6·4	4·0	2·4	0·0	1·7
	Khalal	23·4	12·4	11·0	0·0	1·1
	Rutab	46·2	24·7	21·5	0·0	1·2
	Tamr	53·9	28·5	25·4	0·0	1·1
Khulas	Kimri	7·0	4·5	2·5	0·0	1·8
	Khalal	31·9	16·9	15·0	0·0	1·1
	Rutab	46·1	24·5	21·7	0·0	1·2
	Tamr	57·0	30·5	26·5	0·0	1·1
Gush	Kimri	5·3	3·4	1·9	0·0	1·8
Rabei	Khalal	24·9	13·2	11·7	0·0	1·1
	Rutab	48·1	25·5	22·7	0·0	1·1
	Tamr	49·9	26·1	23·7	0·0	1·1
Hilali	Kimri	3·4	2·2	1·1	0·0	1·9
Ahmr	Khalal	23·0	8·5	7·7	6·8	1·1
	Rutab	43·6	23·3	20·6	0·0	1·1
	Tamr	64·1	32·5	31·5	0·0	1·0
Barhi	Kimri	7·7	4·9	2·8	0·0	1·6
	Khalal	31·1	13·1	11·8	6·2	1·1
	Rutab	40·8	21·4	19·4	0·0	1·1
	Tamr	57·2	29·7	27·6	0·0	1·1
Lulu	Kimri	7·6	4·8	2·9	0·0	1·7
	Khalal	29·7	15·6	14·1	0·0	1·1
	Rutab	43·9	22·0	21·9	0·0	1·0
	Tamr	57·7	30·5	27·1	0·0	1·1
Fard	Kimri	5·6	3·5	2·1	0·0	1·6
	Khalal	27·1	14·6	12·6	0·0	1·1
	Rutab	50·1	26·1	24·1	0·0	1·1
	Tamr	59·5	29·8	29·8	0·0	1·0
Naghal	Kimri	7·0	4·1	2·6	0·1	1·7
Hilali	Khalal	31·8	16·5	15·1	0·0	1·1
	Rutab	44·8	23·7	21·0	0·0	1·1
	Tamr	52·7	29·1	23·6	0·0	1·2
Khasab[c]	Kimri	7·6	5·0	2·6	0·1	1·9
	Khalal	22·9	12·6	10·3	0·1	1·2
	Rutab	41·7	21·9	19·8	0·0	1·1
Hilali	Kimri	6·6	4·5	2·5	0·0	2·2
Pakistan	Khalal	23·8	13·0	10·8	0·0	1·1
	Rutab	44·1	23·2	21·0	0·0	1·1
	Tamr	51·4	27·7	23·7	0·0	1·2

[a]Means of three replicates of fruits of two consecutive seasons.
[b]Total sugars estimated by summation.
[c]This variety does not produce a Tamr stage.

grown in the UAE at Rutab stage only, and yet major alterations in the chemical composition of the fruits might be expected to run in parallel with the visible physical changes during maturation.

It was decided, therefore, that as the fruits of a number of varieties of date palm are widely consumed in the UAE at all stages of ripening, it might be of interest to

(a) select, on the basis of commercial importance and date of full maturation (Tamr stage), a range of varieties popular in the UAE; and

(b) analyse typical samples of dates at each ripening stage to determine the extent to which the levels of the major components, notably those of potential nutritional value for humans, changed over the growing season.

MATERIALS AND METHODS

Twelve commercially important varieties of date were

Table 3. Trace metals content of different varieties of dates at different stages of ripening (mg/100 g dry weight)

Variety	Stages	Zn	Cu	Fe	Mn	Mg	Ca	Na	K
Naghal	Kimri	0·7	0·5	1·1	1·1	114	70	87	1082
	Khalal	0·2	0·5	1·5	0·6	83	23	95	872
	Rutab	0·3	0·3	0·6	0·7	60	14	302	806
	Tamr	0·2	0·2	1·2	0·5	47	15	287	788
Buchibal	Kimri	0·7	0·4	1·9	0·8	149	47	28	1037
	Khalal	0·6	0·3	0·8	1·2	61	20	183	658
	Rutab	0·3	0·3	1·2	0·3	57	13	130	696
	Tamr	0·2	0·4	1·2	0·5	57	19	153	700
Khuneizy	Kimri	0·9	0·9	1·3	1·1	190	86	109	986
	Khalal	0·3	0·3	1·2	0·6	88	17	133	926
	Rutab	0·2	0·3	1·1	0·5	78	8·2	200	752
	Tamr	0·2	0·1	1·5	0·4	59	15	197	704
Khalas	Kimri	0·5	0·6	2·2	0·7	151	101	52	1101
	Khalal	0·3	0·4	1·6	0·4	89	60	83	789
	Rutab	0·3	0·4	1·4	0·3	62	18	212	588
	Tamr	0·3	0·4	1·7	0·3	62	16	82	630
Gush	Kimri	0·8	0·5	1·4	0·8	112	86	28	1041
Rabie	Khalal	0·8	0·3	1·0	1·3	81	15	65	841
	Rutab	0·5	0·5	1·4	0·5	71	15	140	809
	Tamr	0·3	0·5	1·2	0·6	64	15	104	797
Hilali	Kimri	0·6	0·5	1·4	0·6	103	54	99	1201
Ahmr	Khalal	0·5	0·3	1·1	1·1	58	15	94	849
	Rutab	0·2	0·1	1·5	0·3	47	13	142	702
	Tamr	0·1	0·3	1·1	0·4	50	10	113	916
Barhi	Kimri	0·8	0·4	1·1	1·7	209	88	29	1163
	Khalal	0·4	0·2	0·9	1·0	45	10	204	796
	Rutab	0·2	0·3	1·4	0·3	89	12	209	799
	Tamr	0·1	0·2	0·3	0·5	82	12	75	855
Lulu	Kimri		0·6	1·8	1·1	144	48	28	1070
	Khalal	0·4	0·6	1·1	1·1	88	9·7	62	498
	Rutab	0·3	0·3	1·3	0·3	78	8·3	139	697
	Tamr	0·1	0·3	0·6	0·5	71	9·5	64	565
Fard	Kimri	0·7	0·5	1·5	0·7	121	53	66	1243
	Khalal	0·6	0·5	1·3	1·3	97	18	64	1106
	Rutab	0·3	0·3	1·2	0·5	68	14	282	1414
	Tamr	0·2	0·4	1·2	0·5	63	14	141	914
Naghal	Kimri	0·8	0·2	1·6	0·7	123	52	46	682
Hilali	Khalal	0·4	0·2	1·0	1·3	45	14	41	683
	Rutab	0·2	0·2	1·1	0·3	53	10	147	622
	Tamr	0·6	0·3	1·2	0·3	56	9·7	55	704
Khasab	Kimri	0·9	0·9	1·7	1·7	147	88	96	1121
	Khalal	0·6	0·4	1·5	1·3	90	19	54	816
	Rutab	0·4	0·3	1·1	0·5	62	17	216	820
Hilali	Kimri	1·0	0·7	2·0	2·0	119	59	43	1085
Pakistan	Khalal	0·4	0·4	1·5	0·4	66	16	49	890
	Rutab	0·3	0·2	1·2	0·4	51	11	213	804
	Tamr	0·2	0·2	1·6	0·4	62	12	153	770

selected, and fruits were collected, for two consecutive seasons, directly from trees in three commercial farms and one experimental orchard representing the four major date-producing regions in the UAE. At each stage of ripening, around 10 spikelets of fruits — around 20 fruits/spikelet — were cut from a selection of bunches chosen at random from trees growing at the same location. On each occasion, the fruits were brought to the laboratory on the day of harvesting and, after the removal of a sub-sample for moisture determination, were stored in a freezer at –20°C for subsequent analysis.

The preparation of any given sub-sample involved the selection of ten intact dates from a spikelet(s) — dates showing insect or mechanical damage were discarded — and then macerating the fruits in a high-speed blender. The samples were allowed to thaw at room temperature before grinding.

The moisture content was determined by the method described by Shukur (1983), while the values for crude protein, total fat and ash were obtained by the methods of the AOAC (1990). Glucose, fructose and sucrose were determined by HPLC using a Hewlett Packard (HP) 1090 Liquid Chromatograph (LC) equipped with a PV5 ternary SDS, three-channel pump. A manual injector with a Rheodyne (TM 7010 model) valve was built into the LC main frame, together with a thermo-controlled column compartment. The LC was connected to a HP-1047A RI detector and HP-3395 Integrator. The column was a HP 5 μm stainless-steel

unit (200 × 4·6 mm) heated to 40°C, and the stationary phase consisted of Hypersil NH_2. The mobile phase was acetonitrile (HPLC grade) and water (80 + 20, v/v) delivered at a flow rate of 2 ml/min. The RI detector temperature was set at 40°C, and the inlet tube was insulated to ensure temperature stability in the flow system.

The integrator was calibrated with external standards consisting of solutions of glucose (2%), fructose (2%) and sucrose (1%). The test samples were obtained by blending 20 g of destoned date fruits with 80 g of distilled water, and then filtering the liquid through a double layer of cheesecloth. The solution was finally passed through a 0·2 μm disposable filter (EP030 BS, Schleicher & Schuell, Germany) before injection; the figure for total sugars is the sum of these individual values.

Analysis of the trace metals was carried out with a Perkin-Elmer 3030 Model Atomic Absorption Spectrophotometer. About 1 g of dry, ground fruit (minus the stone) was weighed in a crucible and ashed at 550°C. The ash was then dissolved in 5 ml of AnalaR grade hydrochloric acid (20%), and the solution transferred to a 50 ml volumetric flask; the final volume was achieved with distilled water.

RESULTS AND DISCUSSION

The results of the analyses are shown in Tables 1–3 and, as the principal interest was in the broad pattern of components across the growing season and/or between varieties, detailed statistical analyses of the results have not been included. Thus, the decline in moisture content during maturation is shown clearly in all varieties (Table 1), and the values at Tamr, along with the elevated sugar contents (Table 2), render the date extremely resistant to fungal spoilage. Earlier in the season, and particularly at the Khalal stage, the water levels in the fruits are still high enough to allow fungi introduced by bird or insect damage to proliferate freely at the expense of the available sugars.

The rapid build-up of glucose and fructose from Khalal onwards clearly indicates that the date is an excellent source of readily available carbohydrates. The high values for all varieties at Rutab and Tamr, the most widely consumed stages, are of especial note, since the average daily consumption of dates in Saudi Arabia, for example, may be 100 g/person (El-Shaarawy *et al.*, 1989). given that this intake of dates (mainly Tamr) is likely to go alongside fish, milk or yoghurt, it is clear that such a diet provides a good balance between protein and carbohydrate. It is also of note that fructose represents around 50% of the total sugars. This high level is of dietary significance, since fructose tends to lead to a lower level of post-prandial hyperglycaemia than would the same intake of glucose (Johnson, 1993).

Although fish provides a valuable source of trace minerals in the typical Arabian diet, it is of note that dates, in common with some other fruits like the grape, retain high levels of potassium — a mineral essential for controlling the salt balance in human tissues.

Although the vitamin contents of the varieties were not monitored in the present study, it was noticed in a work camp in Saudi Arabia that Arab workers living on a diet of dates, rice and fish remained healthy, while Indian workers who did not eat dates developed scurvy and beri-beri (Lambiote, 1983). The same author also surveyed around 4000 male desert-dwellers in Saudi Arabia — all regular consumers of dates — and found not a single case of deficiency disease. Whether or not the dates alone were responsible for these observations was not fully established, but it is evident that the date fruit with its excellent storage-life and nutrient resources provides the Arab world with a remarkable dietary component.

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