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Full Length Research Paper

Biodiversity of date palm in the Sultanate of Oman

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Date palm (*Phoenix dactylifera* L.) is the primary crop in Oman occupying 49% of cultivated area and 82% of all fruit crops grown in the country. Oman is currently the eighth's largest world producer of dates with a production of 238, 000 metric tones (MT) in 2005. Oman has diverse topographical and climatic eco-regions that allow for cultivation of various types of date palm cultivars, particularly in the northern coastal and the interior region. There are approximately 180 female and 48 male cultivated varieties of the 7.8 million trees of date palm. Despite the great diversity of the cultivars, over 78% of the total production is from only 10 commercial cultivars. These cultivars are dominant because of their marketable high fruit quality or early and late season production. Physical phenotypic diversity index of selected date palm cultivars indicated large biodiversity among the population. Similarity matrix also indicated high similarity among date palm cultivars ranging from 74 to 90%. The study highlighted the need for chemical and molecular analyses to explore the genetic linkage among cultivars.

Key words: *Phoenix dactylifera*, diversity index, agro-climatic zones, arid climate, germplasm conservation, phenotypic characterizations.

INTRODUCTION

The Sultanate of Oman is an arid country, located between 26^{o}-16 ^{o} N and 51 ^{o}-59 ^{o} E in the South-Eastern part of the Arabian Peninsula. Oman is predominantly a desert which covers 75% of the total area with little or no vegetation and average annual precipitation of less than 50 mm. Nonetheless, the remaining area varies greatly in the topographic and climatic characteristics, which allow for the cultivation of various types of fruit crops.

Ago-climatic zones

Biodiversity of Oman's fruit crops, including date palm, are influenced by the large variations in topography and climatic conditions. Climate variations including the amount of rainfall (Figure 1), relative humidity, and temperature (Figure 2) are some of the principle factors that divides Oman into four agro-climatic zones (Figure 3). These include: (1) The Coastal Plains of Batinah and Sharqiah with 100 mm annual rainfall, high temperature and relative humidity during the summer months; (2) The interior regions of Dakhlia and Dhahira that are characterized by low relative humidity. The *Hajar* mountain range separates the coastal regions from the interior and receives the highest amount of rainfall with an annual average of 345 mm; (3) The central desert region of Oman (Wusta); (4) The tropical monsoon southern region (Dhofar province).

Biodiversity of date palm in Oman

Date palm is the primary crop in Oman and constitutes 49% of the area under cultivation and represents 82% of all fruit crops grown in the country (MA, 2005). The Sultanate is the eighth's largest producer of dates in the world, producing 4% (or 238,000 MT) of total world production (FAO, 2005). Due to the variability in the topographic and climatic growing conditions, date palm

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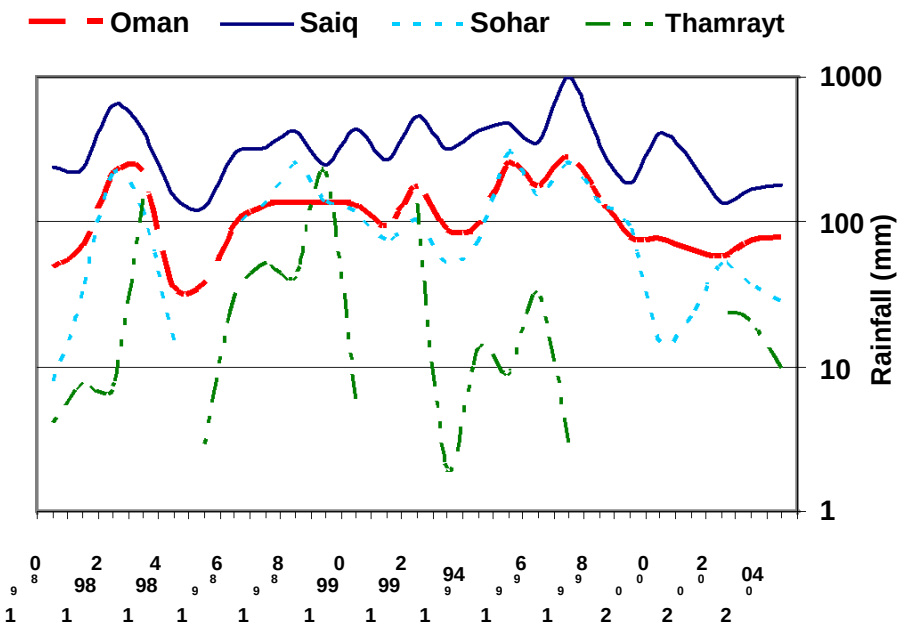

Figure 1. Total annual rainfall (mm) in various regions of the Sultanate of Oman for the years 1980-2004 (Source: Ministry of National Economy, Statistical Year Book 2005).

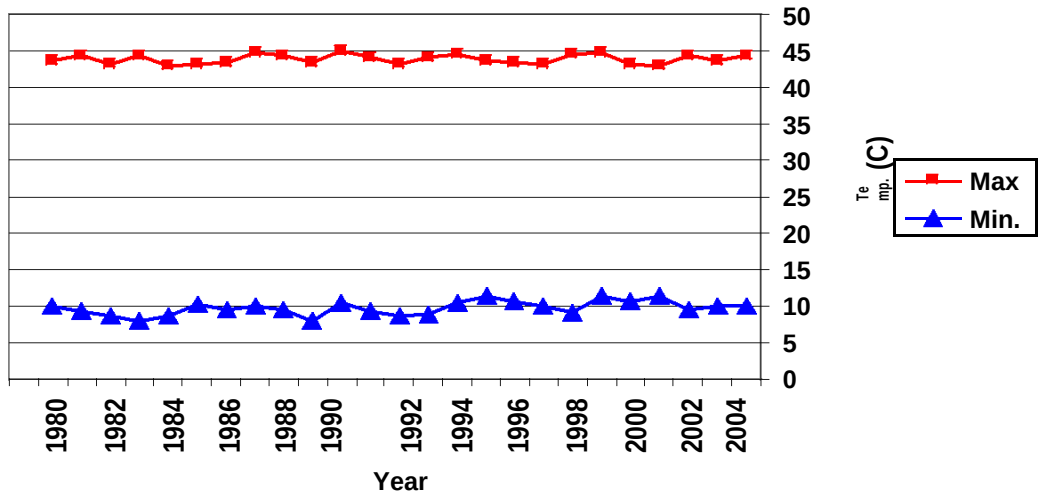

Figure 2. Average maximum and minimum temperature (^{O}C) of the Sultanate of Oman for the years 1980-2004 (Source: Ministry of National Economy, Statistical Year Book 2005).

production season extends from May to November, the longest season of any date-producing country.

Some of the earliest documentations of the diversity of date palm varieties in Arabia were by Crichton (1834) and later by Popene (1913, 1973) and they stated that the Arabian Peninsula contains a large diversity of date palm varieties that originated from seedlings. Planting diverse date palm cultivar is a typical cultural practice in traditional date plantations of Oman. Reproductive phenological cycle varies greatly for various cultivars planted in the same location (Table 1). This allows for extended harvest season with dates suitable for fresh consumption, storage and processing. Variability in climate, topography and cultivation practices have also resulted in numerous selections of male and female cultivars adapted for different regions of the Sultanate. Currently there are 7.8 million date palms cultivated in various part of the Sultanate of which there are approximately 180 female and 48 male cultivated varieties. The date palm gene bank of the Ministry of Agriculture (MA) contains 166 female and 21 male cultivars, of which 81 produce yellow fruits, 24 produce red fruits, and the remaining produce

Table 1. Monthly calendar of fruit development stages of selected date palm varieties grown in Batinah agro-climatic zone, (at the Agricultural Experiment Station, Sultan Qaboos University, Oman) during the fruiting season of 2006. Abbreviations are: P = Pollination, H = Hababok, J = Jamry, K = Khalal (Bisir), R = Rutab, and T = Tamr.

Cultivar	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept
Naghal	P	H	J	K/R	R/T	T		
Khalas	P	P	H	J	K/R	R/T	T	
Khunaizi	P	P	H	J	K/R	R/T	T	
Mabsli	P	P	H	J	K/R	R/T	R/T	
Barni	P	P/H	H	J	J/K	R	T	
Madloki	P	P/H	H/J	J	K/R	R	T	
Bu Naranjah	P	P/H	H	J	J/K	K/R	R/T	
Hilal Oman	P	P/H	H/J	J	J/K	K	K/R	R/T
Fardh	P	P/H	H	J	J/K	K/R	T	
Zabad		P	H	J	J/K	K	R	T
Um al Sila	P	P	H/J	J/K	K/R	T		

Table 2. Top 10 producing date palm cultivars in Oman and their percentage of total production (of 231,034.91MT in 2004).

Top 10/250 Cultivars	2004 Yield (MT)	% of Total	Cumulative %
Um el Sela	32696.48	14.15	14.15
Mabsli	30583.24	13.24	27.39
Khasab	26687.61	11.55	34.94
Naghal	24423.38	10.57	49.51
Fardh	18051.93	7.81	57.33
Shahl	11435.75	4.95	62.28
Khunaizi	11340.99	4.91	67.18
Khalas	11139.04	4.82	72.01
Madloki	5423.58	2.35	74.35
Barni	4966.3	2.15	78.65

Source: MA, 2005

various other fruit colors. Assessment of date palm biodiversity using the vegetative (Elhoumaizi et al., 2002) as well as the reproductive (Jaradat and Zaid, 2004) phenotypic characteristics have been done in various date-palm growing countries. Despite the great diversity of date palm cultivars, 78% of the total date production in Oman is produced by only 10 commercial cultivars (Table 2). Methodological studies of date-palm biodiversity, distribution, germplasm characterization and preservation methods have not been carried out in Oman hence the reason for this study.

MATERIALS AND METHODS

Biodiversity analysis based on physical phenotypic characteristics of dates

In this study, fruit physical attributes were used to determine the relationship among major date palm varieties of Oman. Quantitative and qualitative reproductive characteristics (Tables 3 and 4) of selected cultivars were used to carry out preliminary biodiversity analysis using published information (Royal Court Affairs, 1999). Samples were collected from various date-producing regions of the Sultanate including Dakhlia (DK), Sharqia (SH), Batinah (BT), and Dhahira (DH) (Royal Court Affairs, 1999). Shannon-Weaver biodiversity index (H') was used to assess phenotypic variability of the selected date palm cultivars using NTSYS software (Shannon and Weaver, 1949; Sokal and Sneath, 1963; Johnson and Wichern, 1988; Rohlf, 2002).

RESULTS

The results showed a high level of biodiversity of date palm cultivars in Oman with an average H'= 0.66 for quantitative characteristics (Table 3) and H'= 0.60 for qualitative characteristics (Table 4) of the fruit. The diversity index (DI) of the quantitative characteristics based on the physical dimensions of the fruit and seed was lowest for fruit weight (H' = 0.43) and highest (H' = 0.82) for fruit length, (Table 3). The DI of the qualitative characteristics was lower than that of the quantitative characteristics (H' = 0.60) and ranged from the lowest (H' = 0.23) for fruit

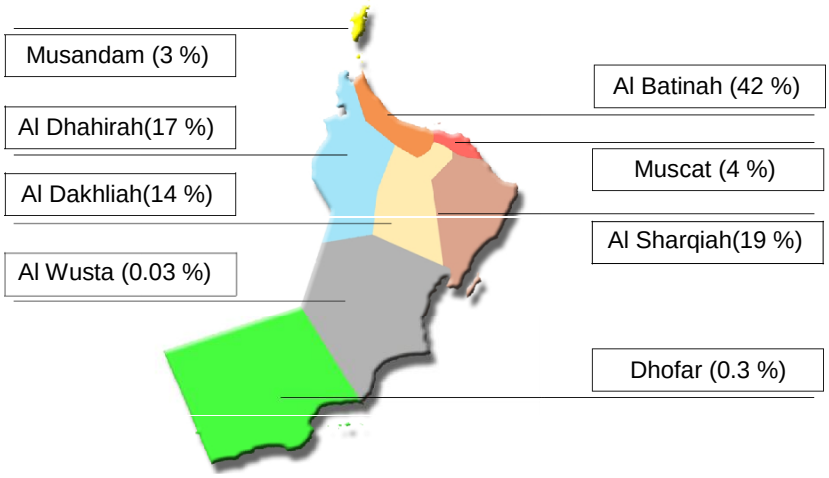

Figure 3. Regional distribution and percentage (from a total number of 7,795,786) of date palm trees in each region of the Sultanate of Oman.

Table 3. Shannon-Weaver diversity index (H') analysis for physical quantitative characteristics of dates across the regions of Oman.

Physical fruit quantitative characteristics	H’
Seed Weight (gm)	0.61
Seed Length (cm)	0.78
Size of Fruit	0.51
Weight of Fruit (gm)	0.43
Length of Fruit (L) (cm)	0.82
Diameter of Fruit (D) (cm)	0.68
L/D of Fruit	0.78
Total	4.61
Average	**0.66**

Table 4. Shannon-Weaver diversity index (H') analysis for physical qualitative characteristics of dates across the regions of Oman.

Physical qualitative characteristics	H’
Fruit Shape	0.23
Fruit Top Shape	0.85
Fruit Base Shape	0.64
Bisir Texture	0.85
Rutab Texture	0.24
Tamr texture	0.80
Total	3.60
Average	**0.60**

shape to the highest (H’ = 0.85) for top shape of the fruit and Bisir stage texture (Table 4).

Dendogram tree of the cultivars showed main 6 sub-groups based on their combined quantitative and qualitative physical attributes (Figure 4) and this was supported by the Principle Component Analysis (Figure 5). The tree showed Umm Al-Silla and Naghal Al Rodha on separate clusters, while two agriculturally unrelated cultivars were grouped together (Figure 4).

DISCUSSION

Preservation of Date palm biodiversity

In recent years since 2001, there has been a decline in the population of dates produced in Oman (FAO, 2005). We speculate that this decline is attributed to one, or a combination, of the following factors: Increased salinity levels in major date palm growing regions of Oman, that is, Batinah and Sharqia; desertification in areas adjacent to the desert in central Oman; heavy insect infestation such as Dubas bug (*Ommatissus lybicus* Bergevin, Homoptera: Tropiduchidae) and Red Palm Weevil of date palm (*Rhynchophorus ferrugineus* Olivier, Coleoptera : Curculionidae); and urbanization of rural areas. These biotic and abiotic factors have led to an increasingly shrinking and depletion of gene pool of the existing cultivars. Conservation of the remaining old cultivars and the introduction of new ones are important for sustainability. However, since the sustainability of *in-situ* gene banks of perennial fruit crops, such as date palm, has been questioned (Citrus and Date Crop Germplasm Committee, 2004), newer approaches for preserving local varieties should be investigated apart from the use of gene-bank and tissue culture laboratory. These approaches may include *in vitro* preservation using cryo-preservation (Finkle et al., 1979; Ulrich et al., 1979; Tisserat et al., 1985; Mater, 1987; Bagniol et al., 1992; Engelmann et al., 1995) and *ex situ* gene- banks based on farmer-participation (Arunachalam, 2000; Jarvis, 2004; Sawadogo et al., 2005) with economic incentives to

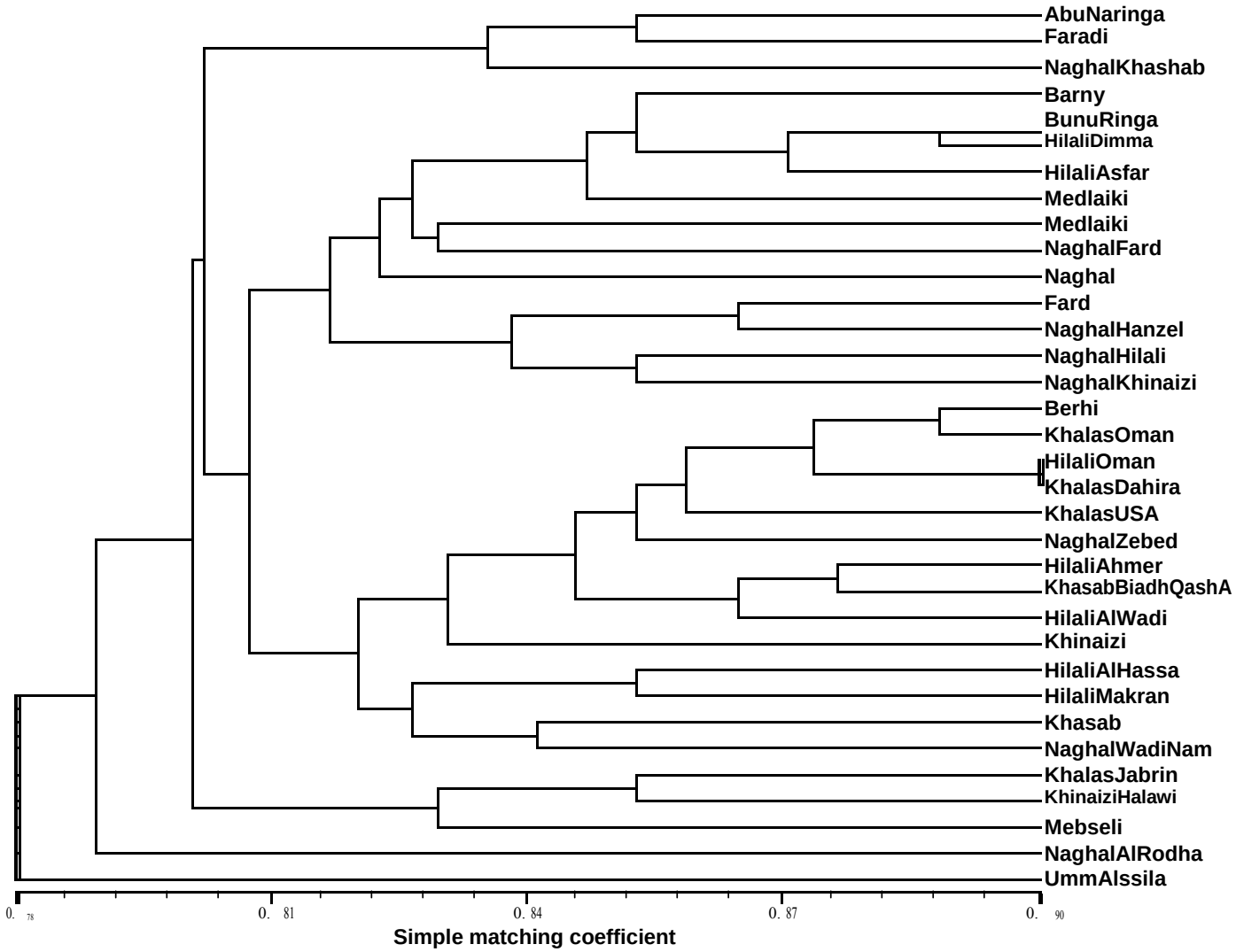

Figure 4. Dendogram tree of Omani date palm cultivars based on the physical quality attributes by simple matching coefficient.

preserve traditional agricultural practices (Siebert, 2004). To aid in the preservation of the extensive genetic diversity of date palm in Oman, morphological and phenological description, chemical (organic and inorganic) analyses, and molecular identification and characterization of various date palm cultivars should be an urgent priority. Various molecular techniques (Corniquel and Mercier, 1994, Cao and Chao, 2002; Zahdi et al., 2004) can be utilized to carry out cultivar identification. This should be complimented with public awareness campaign to highlight the importance of preserving biodiversity of date palm cultivars in the country.

Conclusion

There are over 250 cultivars in Oman producing over 230 thousand MT annually; however, majority of this production (78%) is produced by only 10 cultivars. Biodiversity analyses using the fruit physical quality attributes have shown high degree of diversity among date palm cultivars from different regions of the Sultanate. Fruit physical qualitative and quantitative attributes have also resulted in a high-level of similarity among the cultivars studied ranging from 69 to 90%. Grouping of unrelated date palm cultivars can be attributed to similarity in physical characteristics of the date palm fruit (i.e. shape, color, weight, size). Resemblance of the cultivars was indicated by the similarity matrix (Table 5) that showed a high level of similarity that ranged between 0.74 - 0.90. Another contributing factor to the grouping of cultivars, such as Hilali Oman and Khalas Dhahira (Figure. 4), is the local naming of cultivar, where one cultivar can be given multiple names and different cultivar are given one name. A unified nomenclature of date palm cultivars is needed to eliminate potential errors in biodiversity analysis of

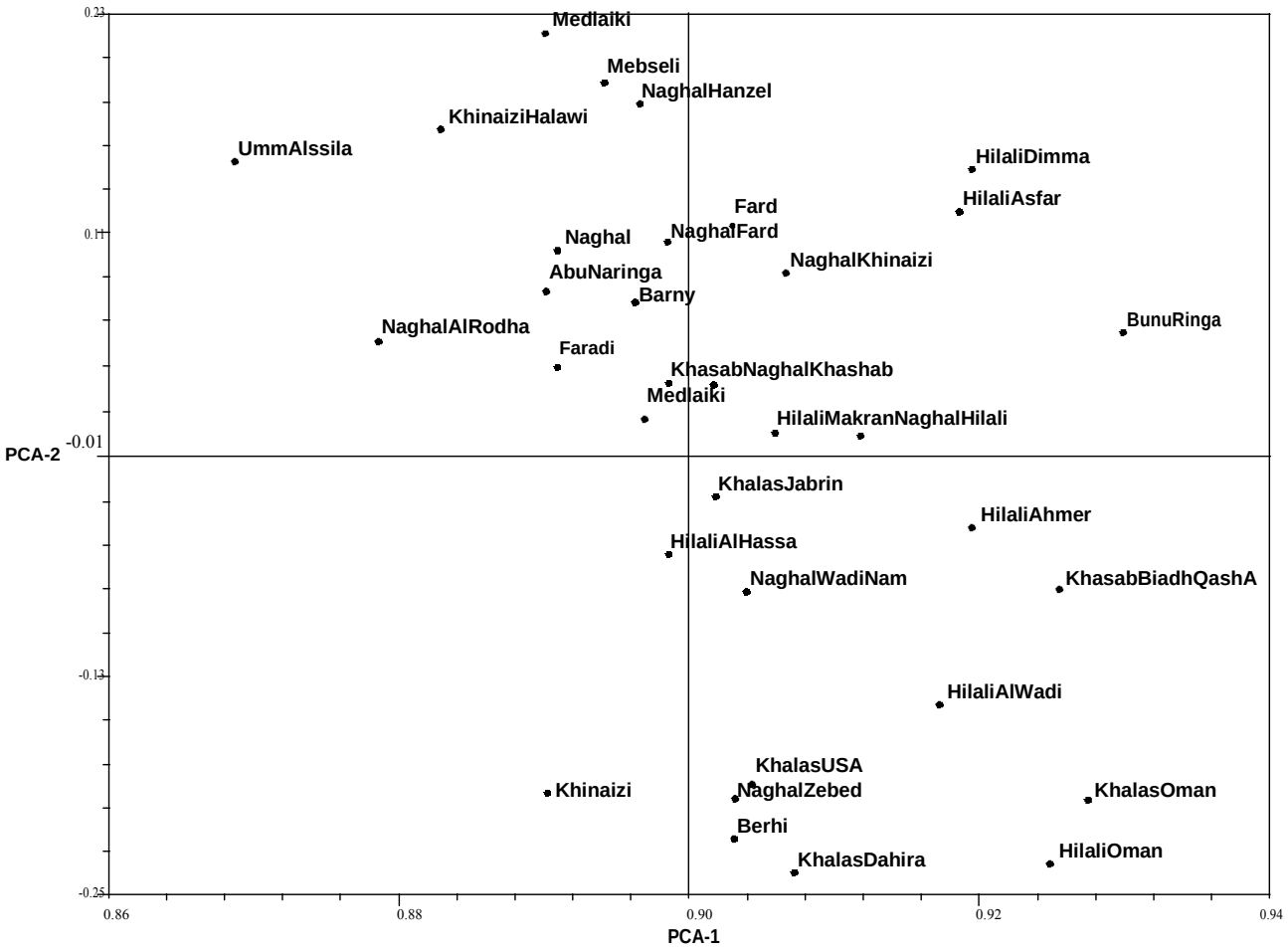

Figure 5. Principle Component Analysis of the physical quality attributes of Omani cultivars.

Table 5. Similarity Matrix simplified to highlight similarities over 0.87 and below 0.75 of Omani cultivars based on physical attributes of the dates.

	Berhi	BunuRinga	HilaliAhmer	HilaliAlWadi	HilaliAsfar	HilaliOman	KhalasDahira	Khinaizi
Fard	0.80	**0.88**						
HilaliDimma	0.78	**0.89**	0.83	0.85	**0.89**			
HilaliOman	0.87	0.85	0.84	**0.88**	0.83			
KhalasDahira	0.87	0.84	0.83	0.85	0.82	**0.90**		
KhalasOman	**0.89**	0.87	0.85	0.87	0.82	**0.89**	**0.88**	
KhalasUSA	0.84	0.82	0.83	0.83	0.80	**0.88**	0.85	
KhasabBiadhQashA	0.83	0.87	**0.88**	0.87	0.84	0.87	0.85	
Medlaiki	0.78	0.84	0.79	0.79	0.83	0.78	0.79	**0.74**
NaghalAlRodha	0.77	0.80	0.79	0.80	0.83	0.80	0.77	**0.74**
UmmAlssila	0.79	0.78	0.78	0.76	0.78	**0.74**	**0.74**	0.79

these cultivars. In addition, characterization based on molecular approach will provide the reference point for the evaluation of all quantitative and qualitative characteristics.

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