Chemical Composition of Natural Juices Combining Lemon and Dates

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***Abstract*—In this work, clarified date juices were produced from three date fruit cultivars. Basic physical properties and chemical composition of dates were experimentally determined. Dates juices were flavored with natural lemon juice, which was added at 0%, 5%, and 10% by weight. All of the produced dates juices were characterized for their chemical composition. The addition of natural lemon juice, particularly at 10% (w/w), significantly affected the composition of dates juices. The analysis of variance of dates juices revealed that the addition of lemon juice had significant impacts ($P<0.05$) and that the effects of the type of dates and the interaction between the type of dates and the addition of lemon juice were insignificant.**

***Index Terms*—dates, lemon juice, natural juice, chemical composition**

I. Introduction

Due to dates' nutritional, economic and distinct medicinal properties, it is a common diet source for millions of people in Middle East and around the world [1]-[3] Dates are rich in sugars (fructose, glucose, and sucrose), minerals (potassium, calcium, magnesium, phosphorous, and manganese), vitamins (particularly A and D), and natural fibers. Several value added products have been prepared from dates such as date confectionaries, bakery products, preserved foods, jams, marmalades and jellies, and breakfast cereals [4]-[9]. Dates are rich in carotenoids, polyphenols especially phenolic acids, isoflavons, lignans, flavonoids, tannins, and sterols [8], they have been used in folk medicine for treatment of various infectious diseases such as atherosclerosis [10] diabetes, hypertension, and cancer, and as antifungal, antibacterial and immunomodulatory [11]-[13]. Saudi Arabia is the second largest date producer in the world. Dates production represents approximately 55% of the total fruit production in the Kingdom and 13.8% of the total world production [14], [15]. There are 450 different date cultivars in the kingdom, with 60 cultivars considered to be the most popular and most predominant.

Citrus (Citrus lemon L.) fruits are very important agricultural products in many countries including the Kingdom of Saudi Arabia. Citrus fruit is very popular due to its distinctive flavor, taste, and aroma as well as multiple health benefits associated with it. The consumption of citrus fruits or their products is believed to have beneficial effects against a number of diseases, the main reason being the presence of bioactive compounds [16], [17]. It is well known that ascorbic acid and carotenoids are found in abundance in citrus fruits [18], which play an important role in causing resistance against many diseases. Ascorbic acid content of some lemon juices has been reported to be as high as 680mg L^{-1} of juice and this trait is affected by growing conditions, maturity of the fruit when picked, and the length of fruit storage period [18]. The international increase in fruit consumption can be considered as a trend that affects fruit processing industry. This increase in consumption of fruits can be attributed to the increase interest in nutritious and healthier food whether in fresh or processed forms [19].

Dates industry in Saudi Arabia is composed of 132 date packaging and processing factories, consuming approximately 370 million Kg of dates annually; this represents 34.52% of the total dates production [20]. Most of these factories produce packaged dates and dates paste. Very few factories produce dates syrup. The dates industry in the kingdom is looking to diversify dates processing activities through the utilization of the overwhelming advances in food technology.

Several researchers investigated the extraction of dates juice and the production of concentrated dates syrup, known in Arabic as dates Dibbs [5], [8], [10]. The extraction of clarified dates juice from dates paste or de-pitted dates flesh is one of the important operations necessary for the production of dates juice. The proper extraction temperatures and mechanical mixing can increase the extraction rates of soluble solids by increasing the mass diffusion coefficient of the solvent (water) inside solid particles. Thus, the efficiency of the extraction process is increased [20], [21].

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Chiara *et al.* [22] had investigated the characteristics of dates juice extracted from Diglet Nour dates. These characteristics were yield, pH, total soluble solid content, minerals, carbohydrates, vitamins, yeast, mold and fungi, and total aerobic microorganisms. The best dates juice produced by the investigators contained 2.13g/l citric acid, 0.08% phosphorous on a dry basis, and 26.5, 39.6 and 185.9g/l of glucose, fructose and sucrose, respectively. All of the produced juices satisfied microbial health requirements. Several attempts were made by El-Shaarawy *et al.* [23] to prepare dates drinks based on dates juices. These authors concluded that dates juices need supplementation with organic acids and various flavors to produce products acceptable to consumers. The mixed juices are produced from mixtures of fruits pulps or juices, they are prepared with the aim of enhancing the nutritional value of a product [19]. This is an area to be investigated thoroughly by those in the dates processing industry. Several studies on mixtures of fruit juices have been carried out over the years [24]-[28].

Dates are characterized by their low ascorbic acid contents and high sugar contents, therefore, it is necessary for developing healthy mixed dates juices, is to determine the ideal ascorbic acid content of the juice. The mixing of the juice may also improve aroma, taste and nutrient content of the drinks. Hence, mixing dates juice with lemon juice which is a good source of vitamin C and other bioactive compounds can be helpful in improving the nutritive value of dates juice.

Therefore, the aim of this study was to develop and evaluate high quality natural dates juices utilizing the nutritional characteristics of both dates and lemon fruits.

II. Materials and Methods

A. Materials

Three commercially popular Saudi dates (Sukkari(S), Khlass(K) and Rezaiz(R)) fresh lemon (Citrus lemon L.) were purchased from local market in the city of Riyadh, Saudi Arabia. Dates were manually sorted, washed and cleaned using distilled water. The cleaned, sorted dates were spread in trays and left to dry at room temperature in the laboratory at the Department of Food Science and Nutrition, College of Food and Agriculture Sciences, King Saud University. The dates were packaged into 3 kg cartons internally lined with a polyethylene bag and were refrigerated at 5±0.5°C.

B. Samples Preparation

For each of the three dates (S, K and R) 15kg of fruits were obtained. Dates were manually de-pitted with sharp knives. The dates' flesh was then transformed to dates' pastes using an electrically driven mincer (Model VEKL 1-IEC-34, Italy). Samples were then transferred to a stainless steel tank equipped with a controlled mechanical mixer and an electrical heater with a temperature controller (Model D B60A, Seitz Enzinger, Germany). Potable water was added to the dates paste at a ratio of 1:2.5 date paste: water, as recommended by Al-Harthi [8]. The dates paste-water mixture was mechanically mixed and heated to 70°C for a period of 30 minutes for homogenization. Then, the homogeneous dates paste-water suspension was filtered using a frame sheet filter (Pilot A 20Z, Seitz-werke Gmbh, Germany). The clarified juices were collected into stainless steel tanks equipped with a controlled mechanical mixer and an electrical heater with a temperature controller. Once the filtration process was complete, the collected clarified dates juices were mechanically mixed. The juices were heated to 90°C and kept at this temperature for 3 minutes to assure manual pasteurization. The pasteurized dates juices were immediately cooled to a final temperature of 25°C in a double jacketed, stainless steel vessels with 10°C water. The juices were poured into pre-sterilized glass jars (1 L capacity) and tightly closed. The juices were then kept in a refrigerator for analysis.

The selected Lemon fruits were at mature stage, they were cut into halves and their juice was squeezed with a squeezer until all the juice was recovered. The juice was passed through a cheese cloth and samples were taken for physicochemical analysis. The bulk of the juice was stored frozen (20°C) until use.

C. Physical Properties of Raw Dates

A random sample of 50 fruits from each type of dates was examined for fruit mass, length, diameter, pit mass and pit mass ratio. A sensitive balance (Mettler Toledo Sensitive Balance, Switzerland) was used to measure fruit and pit mass. A digital caliper with a sensitivity of 0.01mm (Absolute Digimatic, Mitutoyo, Japan) was used to measure length and diameter.

D. Chemical Composition of Dates Flesh and Juice

Basic physical properties of dates from the three cultivars, Sukkari(S), Khlass(K), and Rezaiz(R), were experimentally determined at room temperature (23 ℃). The standard AOAC methods [29] were used to analyze all dates flesh and juice samples.

E. pH, Titratable Acidity and Total Soluble Solids Measurement of Lemon Juice

pH, Titratable Acidity (TA), and Total Soluble Solids (TSS) were evaluated as quality indexes. The pH was measured using a pH meter (Model: pH meter 240, Corning Scientific Products, NY, USA). The TA was determined by titrating 2ml of the mixture (rising 60ml final volume with distilled water) with 0.1 N NaOH (pH 8.1). Results were expressed as g citric acid per 100 ml of sample, in accordance with AOAC [29]. The TSS contents were recorded using a Digital Refractometer (Model: Abbe Mark II, Cambridge Instrument, INC. Buffalo, NY, USA), with values being expressed as Brix. The machine was standardized using purified water before taking readings.

F. Determination of Ascorbic Acid Contents

Ascorbic Acid (AA) and Dehydroascorbic Acid (DHAA) contents were determined by HPLC-UV as described in González-Molina *et al.* [30]. The vitamin C content was calculated by adding ascorbic acid and dehydroascorbic acid values, and results were expressed as mg per 100ml.

G. Statistical Analysis

All parameters were determined in triplicate for each sample. Statistical analysis was performed with SPSS for windows (version I2). All data are expressed as mean ± standard deviation (mean ± sd). Data were analyzed with one-way analysis of variance using a statistical software (SPSS, Version 19.0; IBM Corporation, New York, NY, USA). A difference was considered significant at $p<0.05$.

III. Results and Discussion

A. Basic Physical Properties of Whole Date Fruit

Data are shown in Table I, the mass of dates was significantly different ($P<0.5$); K dates had the greatest mass (9.1 ±1.2g), followed by S (8.9 ±0.9g), and R (6.8 ±0.6g). Fruit length, major diameter, pit mass and pit mass ratio were significantly different ($P<0.5$) between the three date cultivars. Fruit length range was 27.5 ±2.0 - 36.7 ±2.5mm. The major diameters range was 20.7 ±1.0 - 24.0 ±1.3mm. The pit mass of the three types of dates ranged between 0.7 ±0.1 - 1.0 ±0.1 and the pit mass ratios range was 0.1 ±0.0 - 0.2 ±0.0.

The data collected for the basic physical properties for the three types of dates were in agreement with other published data [18]-[20].

TABLE I. Basic Physical Properties and Color Parameters of the Three Date Fruits of Sukkari(S), Khlass(K) and Rezaiz(R) at Final Stage of Maturity*

Property	Date cultivar		
	S	K	R
Date fruit mass (g)	8.9 ±0.9 [b]	9.1 ±1.2 [a]	6.8 ±0.6 [c]
Fruit length (mm)	30.6 ±1.9 [b]	36.7 ±2.5 [a]	27.5 ±2.0 [c]
Fruit major diameter (mm)	24.0 ±1.3 [a]	21.2 ±2.8 [b]	20.7 ±1.0 [b]
Pit mass (g)	1.0 ±0.1 [a]	0.8 ±0.1 [b]	0.7 ±0.1 [c]
Pit mass ratio	0.1 ±0.01 [a]	0.1 ±0.01 [b]	0.1 ±0.01 [a]

*Same letter in row means no significant differences at $p<0.05$.

TABLE II. Chemical Composition of the Date Flesh of the Three Date Fruits of Sukkari(S), Khlass(K) and Rezaiz(R) at Final Stage of Maturity*

Component	S	K	R
Carbohydrate (g/100g)	84.2 ±0.3 [a]	82.1 ±0.2 [b]	78.0 ±0.1 [c]
Total sugars (g/100g)	68.4 ±1.9 [a]	71.1 ±0.4 [a]	67.0 ±1.9 [a]
Fructose (g/100g)	6.3 ±0.00 [b]	33.6 ±0.2 [a]	32.6 ±1.4 [a]
Glucose (g/100g)	7.8 ±0.1 [c]	37.0 ±0.1 [a]	33.9 ±0.6 [b]
Sucrose (g/100g)	54.3 ±1.8 [a]	0.5 ±0.1 [b]	0.5 ±0.1 [b]
Protein (g/100g)	3.1 ±0.1 [a]	2.1 ±0.0 [c]	2.6 ±0.0 [b]
Fat (g/100g)	0.2 ±0.0 [a]	0.2 ±0.0 [a]	0.2 ±0.0 [a]
Moisture (g/100g)	10.3 ±0.2 [c]	11.2 ±0.0 [b]	15.3 ±0.1 [a]
Ash (g/100g)	1.8 ±0.1 [a]	1.8 ±0.2 [a]	1.5 ±0.1 [a]
Crude Fiber (g/100g)	3.7 ±0.1 [a]	2.7 ±0.1 [b]	2.5 ±0.1 [c]
Vitamin C (mg/100g)	1.2 ±0.0 [c]	1.8 ±0.0 [a]	1.6 ±0.0 [b]
Energy (kcal/100g)	315.2 ±0.8 [a]	307.6 ±0.5 [b]	294.6 ±0.3 [c]
Potassium (mg/100g)	585.0 ±7.1 [a]	565.0 ±21.2 [ab]	525.0 ±7.1 [b]
Magnesium (mg/100g)	76.1 ±1.3 [a]	59.9 ±1.6 [b]	46.4 ±0.4 [c]
Calcium (mg/100g)	64.1 ±1.3 [a]	59.7 ±0.6 [b]	55.9 ±0.7 [c]
Phosphorus (mg/100g)	10.8 ±0.3 [a]	5.4 ±0.1 [c]	6.4 ±0.1 [b]
Sodium (mg/100g)	9.1 ±0.1 [a]	11.5 ±2.1 [a]	11.0 ±1.4 [a]

*Data are expressed as mean ± SD (n=3) based on 100g date flesh. Means ± SD followed by the same letter, within a raw, are significantly different at $p<0.05$ level.

B. Chemical Composition of Dates

Proximate and nutritional analysis are essential for assessing health benefits of various fruits. In this study, we determined moisture, carbohydrate, fat, crude fibers, ash, protein, dry matter, and energy contents of dates. The chemical composition of the studied types of dates is presented in Table II as mean ± sd. There were cultivar differences in these parameters. Ismail *et al.* [31] reported that moisture level ranged from 20% to 22% in Khalas growing in UAE, while Saudi Khalas dates showed lower values for moisture content (15.3 to 19.8%).This difference can be attributed to the amount and frequency of irrigation as well as postharvest handling. The moisture content was significantly different between the three types of dates ($P<0.05$). The moisture content was 15.3 ±0.1, 11.2 ±0.0, and 10.3 ±0.2g/100g for R, K, and S dates, respectively. Dates are rich in sugar ranging from 65% to 80% on dry weight basis mostly of reducing sugars (glucose and fructose). Dates carbohydrates content is mainly reducing sugars in the form of glucose, fructose, mannose and maltose and non-reducing sugars (primarily sucrose), as well as small amounts of polysaccharides such as cellulose and starch [32]. The three types of dates were characterized by their high carbohydrates content and a predominance of sugars (Table I). Carbohydrates content was highest in S dates (84.2 ±0.3g/100g), followed by K dates (82.1 ±0.2g/100g) and R dates (78.0 ±0.1g/100g); this measurement was significantly different among the three types of dates ($P<0.05$). Ali *et al.* [33] reported 68.53% to 75.37% range for carbohydrates in Omani dates. Similarly, Myhara *et al.* [34] suggested a mean of 80.6g/100g carbohydrates content for dates. This may indicate genotypic differences between date cultivars in carbohydrates production as well as differences in the effects of the environmental conditions that prevail during the growing season. The amount of total sugars were not significantly different among the three dates; total sugars were 71.1 ±0.40, 68.4 ±1.9, and 67.0 ±1.9g/100g in K, S, and R dates, respectively. Sucrose was the predominant sugar in the S dates (54.3 ±1.8g/100g), which was significantly greater as compared to that of K (0.5 ±0.1g/100g) and R (0.5 ±0.1g/100g) dates. S dates are popular due to their high sucrose content, which confers a pleasant taste to the fruit [23], [35]. Fructose and glucose were predominant in K (33.6 ±0.2 and 37.0 ±0.1g/100g, respectively) and R (32.6 ±1.4 and 33.9 ±0.6g/100g, respectively) dates; between these two dates, the difference in fructose content was not significant, although their difference in glucose content was significant ($P<0.05$). The low sucrose content observed in K and R dates may be due to environmental and genotypic factors that may affect both the qualitative and quantitative composition of the sugar fraction by altering the activity of the enzymes involved in the synthesis and breakdown processes. The S dates had significantly lower fructose (6.3 ±0.0g/100g) and glucose (7.8 ±0.1g/100g) contents. Glucose and fructose are important energy sources [25] and are easily digestible and hydrolysable. Based on these facts, Ismail

et al. [31] suggested that the dates have an important agro-industrial future as a potential source of refined liquid sugar.

Dates are considered as high-energy fruits due to their high sugar content; these fruits are also important sources for fiber and minerals [21], [23]-[25]. The energy measured in the three types of dates was significantly different ($P<0.05$); the highest energy value was found in the S dates (315.2±0.8kcal/100g), followed by the K (307.6±0.5kcal/100g) and R (294.6±0.3kcal/100g) dates.

Protein and crude fiber contents were significantly higher in the S dates (3.1±0.1 and 3.7±0.1g/100g, respectively) as compared to the K dates (2.1±0.0 and 2.7±0.1g/100g, respectively) and R dates (2.6±0.0 and 2.5±0.1g/100g, respectively). Our results showed a similar trend to those found in Iranian dates [26]. With respect to the reported results [22], [27], [28], the studied dates are considered to have higher levels of proteins. Their differences in protein content may be due to genotypic and environmental factors. The protein content of the tested dates was similar as those previously reported in other studies [31]. The results of this study showed that the protein content in S dates is higher than that of the other two types of dates. This protein content was also higher than that reported by Sawaya *et al.* [35] in regards to the dates of different cultivars in Saudi Arabia. Similarly, the protein content of eight different Pakistani dates ranged from 2.0% to 2.7% [36], which are less than the protein contents of the studied dates. It has been estimated elsewhere that protein content of dates range between 1% and 3% [6]. In Deglet Nour and Medjool dates, the protein content is 2.45% and 1.8% respectively which is also less than that found in the tested dates. Our data also support a higher protein content in the tested dates when compared to those mentioned by Al-Shahib and Marshall [32] who reported a range between 1% and 2.5%.

Fat content was small, with insignificant differences between the three tested dates. The fat contents were 0.2±0.0g/100g in S, K, and R dates, respectively. Al-Shahib and Marshall [32] found fats content ranging from 0.1% to 0.2% in Saudi and UAE dates. Our results are in line with those of Al-Hooti *et al.* [10]. who recorded similar fats content in five different UAE dates. The Deglet Nour and Medjool dates contained 0.1% to 0.3% of fats [3]. Thus the differences in fat contents may be for genotypic reasons. The tested dates contained small amounts of vitamin C. Vitamin C content was highest in the K dates (1.8±0.0g/100g), followed by the R (1.6±0.0g/100g) and then S (1.2±0.0g/100g) dates; significant differences were observed between the three dates types in vitamin C contents. Similar results were recorded by Suleiman *et al.* [37] who assessed five different Sudanese dates.

Ash contents were not significantly different between the three dates. The ash contents were 1.8±0.1, 1.8±0.2, and 1.5±0.1g/100g in S, K, and R dates, respectively. Jamil *et al.* [38] in a study on eight different Pakistani dates, showed that the ash content ranged from 1.0% to 2.5% which is in conformity to our findings. A similar study conducted in UAE [31], showed similar range of ash content (1.8% to 2.34%) to that reported in this study. Potassium was the most abundant mineral in the three dates, with contents of 585.0±7.1, 565.0±21.2, and 525.0±7.1mg/100g in the S, K, and R dates, respectively. Magnesium and calcium were also relatively abundant and significantly different between the three dates. In S dates, magnesium and calcium contents were 76.1±1.3 and 64.1±1.3mg/100g, respectively. In K dates, magnesium and calcium contents were 59.85±1.63 and 59.70±0.57mg/100g, respectively. In R dates, magnesium and calcium contents were 46.35±0.35 and 64.05±1.34mg/100g, respectively. In S dates, phosphorous and sodium contents were 10.8±0.3 and 9.1±0.1mg/100g, respectively. In R dates, phosphorous and sodium contents were 6.4±0.1 and 11.0±1.4mg/100g, respectively. In K dates, phosphorous and sodium contents were (5.4±0.1 and 11.5±2.1mg/100g, respectively. All minerals, except sodium, were highest in content in S dates. K dates were the second high in all mineral contents, except for phosphorus, which was higher in R dates. However, Ahmed *et al.* [39] reported in their study on dates from twelve cultivars of date palm, which are widely consumed in the UAE, that dates are exceptionally rich in potassium and extremely low in sodium. The differences in mineral content of dates are mainly due to soil fertility in the fields where date palms, from which the random samples were collected, are grown. It has also been reported that the mineral content of the dates may be influenced by environmental factors, soil characteristic and the amount of fertilizers add to date palms [10].

C. Chemical Composition of Lemon and Dates Juices

Table III shows the results from the chemical analysis of natural S, K, and R dates juices. The analysis of variance showed statistically significant differences in the characteristics of the studied nine juices.

TABLE III. pH, Total Titratable Acidity (TA) and Total Soluble Solids (TSS) of Different Dates and Lemon Juices and Their Mixtures*

Juices	Parameters		
	pH	Titratable acidity (%) as citric (TA)	Total Soluble Solids (TSS) (°Brix)
100% LJ	2.8±0.0c	5.36 ±0.0a	8.2 ±0.0b
100% SJ	6.1±0.0a	0.1±0.0c	22.2±0.0a
SJ+5% LJ	3.9±0.0b	0.5±0.0bc	22.8±0.0a
SJ+10% LJ	3.5±0.0b	0.7±0.0b	22.6±0.0a
100% KJ	6.3±0.0a	0.1±0.0c	21.5±0.0a
KJ+5% LJ	3.9±0.0b	0.4±0.0bc	22.3±0.0a
KJ+10% LJ	3.5±0.0b	0.7±0.0b	22.5±0.0a
100% RJ	5.3±0.0a	0.1±0.0c	21.0±0.0a
RJ+5% LJ	3.8±0.0b	0.4±0.0bc	21.4±0.0a
RJ+10% LJ	3.4±0.0b	0.8±0.0b	21.7±0.0a

*Data are expressed as mean ± SD (n=3). Means followed by the same letter within each column are not significantly different at $p<0.05$ level using Duncan's multiple range test.

D. pH, Titratable Acidity and Total Soluble Solids

The main characteristics of the prepared lemon, dates and mixed juices are given in Table III, Table IV, Table

V and Table VI. Characteristics, such as pH, total Titratable Acidity (TA) and Total Soluble Solids (TSS) that are shown in Table III, were chosen to characterize the overall quality of the tested juices. The data showed significant differences in juice quality traits of mixed and control juices. The results are presented as mean ± standard deviation (Table III). The lowest pH (2.8±0.0) was for lemon juice, the same juice had the lowest total soluble solids, but the highest total acidity. The statistical analysis showed no significant differences in pH between the mixed juices, but they all differ significantly from the control juices. The pH values in the mixed juices decreased with the percentage of LJ added, ranging from 3.4±0.0 for RJ+10% LJ to 3.9±0.0 for KJ and SJ+5% LJ (Table III).

The results of TA in 100% dates juices were found to be 0.1% and 5.36% in 100% LJ. These values were in an agreement with the known percent in dates and lemon fruits used in this study. Consequently, the acidity increase in the mixed juices was proportional to the added LJ.

Regarding the Total Soluble Solid contents (TSS), in case of LJ100 is 8.2 rix (Table III), these were in accordance with reported contents for lemon juices [3]. The TSS contents of the mixed juices were representative of the addition of individual components of each mixture. TSS was insignificantly different in all juices with the exception of LJ. TSS in mixed juices varied between 22.8±0.0 rix in SJ+5% LJ and 21.4±0.0 Brix in RJ+5% LJ.

From these data, significant differences among the 10 types of fruits juices were observed in terms of the three tested quality characteristics. Of all mixed juice types, the SJ+5% LJ showed best quality characteristics in terms of the mentioned parameters.

E. Carbohydrates and Soluble Sugars

The carbohydrates and soluble sugar of the control and mixed juices are presented in Table IV. The results indicated that the carbohydrates contents varied between 23.7±0.4g/100g, for 100% KJ, and 20.6±0.5g/100g, for RJ+10% LJ. The lemon had the lowest amount of carbohydrates (11.7±0.3g/100g). There were insignificant differences ($P<0.05$) in the carbohydrates contents among the mixed juices, but they were all significantly different when compared to LJ.

The total sugars contents in the tested juices showed considerable variations (Table IV), reaching 20.2±0.2g/100g in SJ+10% LJ. This was relatively higher than its counterparts KJ+10% LJ (19.1±0.9g/100g) and RJ+10% LJ (18.6±0.6g/100g). The sucrose content was significantly higher in S J+10% LJ (15.9±0.3g/100g) as compared to its fructose (1.9±0.1g/100g) and glucose (2.4±0.2g/100g) contents (Table IV). The latter sugars were significantly higher in KJ+10% LJ (9.3±0.2, 9.6±0.2, and 0.2±0.0g/100g for fructose, glucose and sucrose, respectively), and RJ+10% LJ (9.2±0.0, 9.2±0.3, and 0.2±0.0g/100g for fructose, glucose and sucrose, respectively) 11.75), however, the lemon juice had the lowest (0.50±0.0, 0.49±0.0, and 0.1±0.0g/100g for fructose, glucose and sucrose, respectively) values (Table IV). From the above data, significant differences among types of mixed and controls juices were observed in terms of these traits. Many factors, such as soil fertility and irrigation may affect carbohydrates and soluble sugars contents of dates and lemon fruits.

TABLE IV. CARBOHYDRATES AND SOLUBLE SUGARS CONTENT OF DIFFERENT DATES AND LEMON JUICES AND THEIR MIXTURES*

Juices	Parameters				
	Carbohydrate	Total Sugars	Fructose	Glucose	Sucrose
100% LJ	11.7±0.3b	1.0±0.0c	0.50±0.0c	0.49±0.0c	0.01±0.0c
100% SJ	22.2±0.4a	19.2±0.7a	1.9±0.0b	2.1±0.0b	15.2±0.6a
SJ+5% LJ	23.5±0.3a	19.5±0.3a	1.9±0.1b	2.3±0.3b	15.3±0.1a
SJ+10% LJ	23.4±0.1a	20.2±0.1a	1.9±0.1b	2.4±0.2b	15.9±0.3a
100% KJ	23.7±0.4a	18.1±0.0a	8.7±0.3a	9.3±0.6a	0.1±0.0b
KJ+5% LJ	22.3±0.3a	18.9±0.8ab	9.1±0.2a	9.5±0.6a	0.3±0.0b
KJ+10% LJ	21.3±0.6a	19.1±0.9ab	9.3±0.2a	9.6±0.2a	0.2±0.0b
100% RJ	21.3±0.5a	16.8±0.3ab	8.4±0.2a	8.3±0.5a	0.1±0.0b
RJ+5% LJ	20.9±0.2a	17.9±0.4b	8.9±0.1a	8.9±0.3a	0.1±0.0b
RJ+10% LJ	20.6±0.5a	18.6±0.6b	9.2±0.0a	9.2±0.3a	0.2±0.0b

All values are in g/100g.

*Data are expressed as mean ± SD (n=3). Means followed by the same letter within each column are not significantly different at $p<0.05$ level using Duncan's multiple range test

F. Protein, Ascorbic Acid, Moisture and Ash

The protein contents of the mixed and the control juices differed significantly, but those of lemon juice were markedly higher (0.8±0.1) (Table V). The KJ mixed and control juices were generally low, varying between 0.52±0.0g/100g in SJ+10% LJ and 0.20±0.0g/100g in 100% KJ. The differences in protein content between the tested juices may be due to analytical, environmental or genotypic differences.

The ascorbic acid (Vitamin C) contents of the tested juices (Table V) differed significantly, however, those of lemon juice were significantly high (23.9±0.2mg/100g). Vitamin C in the mixed juices varied in accordance to the add percentages of LJ to dates juice (Table V). The highest Vitamin C content was recorded in SJ+10% LJ (5.7±0.9mg 100g), followed by KJ+10% LJ (5.4±0.6mg/100g), no significant differences were noticed in Vitamin C content between the mixed juices (Table V). In the present study, we found that vitamin production was cultivar specific, since the genotype of the date cultivar has direct influence on the metabolic pathways of the plant. Also, the ascorbic acid production may be greatly influenced by environmental conditions.

Results of the moisture content of the tested juices are presented in Table V. Moisture contents of the different juices with the exception of moisture content for lemon juice were not significantly different. The moisture contents of the tested juices ranged between 74.8±0.5% in 100% SJ and 89.7±0.2% in 100% LJ (Table V). The variations in moisture content in fruits have been

attributed to many factors e.g. genotypic differences, climatic conditions, cultural practices and postharvest handling measures [40].

Insignificant differences were observed between the tested juices for ash content (Table V). The ash content in the tested juices varied between 0.3±0.0g/100g in 100% LJ and 0.4±0.0g/100g in all other juices (Table V).

TABLE V. PROTEIN, ASCORBIC ACID, MOISTURE AND ASH CONTENTS OF DIFFERENT DATES AND LEMON JUICES AND THEIR MIXTURES*

Juices	Parameters			
	Protein (g/100 g)	Vitamin C (mg/100g)	moisture %	Ash (g/100 g)
100% LJ	0.80±0.1a	23.9± 0.2a	89.7±0.2a	0.3±0.0a
100% SJ	0.40±0.0b	0.4±0.0c	74.8±0.5b	0.4±0.0a
SJ+5% LJ	0.50±0.0b	4.06±0.3b	75.8±0.2b	0.4±0.0a
SJ+10% LJ	0.52±0.0b	5.7±0.9b	75.9±0.7b	0.4±0.0a
100% KJ	0.20±0.0c	0.3±0.0c	75.7±0.6b	0.4±0.0a
KJ+5% LJ	0.25±0.0c	4.5±0.2b	76.5±0.5b	0.4±0.0a
KJ+10% LJ	0.30±0.c	5.4±0.6b	77.9±0.6b	0.4±0.0a
100% RJ	0.30±0.bc	0.3±0.0c	77.9±0.7b	0.4±0.0a
RJ+5% LJ	0.33±0.0bc	4.5±0.5b	78.0±0.1b	0.4±0.0a
RJ+10% LJ	0.40±0.0b	5.2±0.7b	78.5±0.6b	0.4±0.0a

*Data are expressed as mean ± SD (n=3). Means followed by the same letter within each column are not significantly different at p<0.05 level using Duncan's multiple range test.

TABLE VI. CA, MG, P, K AND NA CONCENTRATIONS OF DIFFERENT DATES AND LEMON JUICES AND THEIR MIXTURES*

Juices	Parameters				
	Calcium	Magnesium	Phosphorus	Potassium	Sodium
100% LJ	7.9±0.2bc	6.8 ±0.1d	8.3 ±0.1b	104.2 ±0.3c	4.9±0.1a
100% SJ	12.1±0.1a	12.9±0.1a	12.1±0.1a	115.4±0.5ab	3.9±0.1ab
SJ+5% LJ	12.9±0.1a	13.9±0.1a	12.7±0.1a	119.5±0.8a	4.4±0.1a
SJ+10 % LJ	13.4±0.1a	14.0±0.1a	13.2±0.1a	120.7±0.5a	5.2±0.1a
100% KJ	6.6±0.0c	5.4±0.0d	5.6±0.0c	101.4±0.1c	2.3±0.0c
KJ+5% LJ	8.9±0.6b	8.9±0.1c	6.8±0.1c	109.4±0.1b	2.5±0.1c
KJ+10 % LJ	9.3±0.0b	9.7±0.1b	9.2±0.0b	112.8±0.4b	3.7±0.0ab
100% RJ	9.6±0.1b	8.4±0.1c	12.9±0.0a	115.7±0.9ab	3.9±0.0ab
RJ+5% LJ	9.9±0.1b	9.4±0.1b	13.3±0.1a	117.9±0.4a	3.3±0.0c
RJ+10 % LJ	9.9±0.1b	9.0±0.0bc	13.6±0.0a	120.2±0.4a	3.4±0.0bc

All values are in mg/100g.
*Data are expressed as mean ± SD (n=3). Means followed by the same letter within each column are not significantly different

G. Minerals

The mineral contents of tested juices are presented in Table VI. The Calcium (Ca), Magnesium (Mg), Phosphorus (P) and Sodium (Na) contents were lower than those of Potassium (K). Significant differences were recorded between the tested juices for Ca, Mg, P, K and Na contents (Table VI). Ca content varied between 13.4±0.1mg/100g in SJ+10% LJ and 6.6±0.0mg/100g in100% KJ (Table VI). The Mg content varied between 14.0±0.0mg/100g in SJ+10% LJ and 5.4±0.0mg/100g in 100% KJ (Table VI). The P content varied between 13.6±0.0 in RJ+10% LJ to 5.6±0.0mg/100g in 100% KJ (Table VI). K content varied between 120.7±0.4mg/100g in SJ+10% LJ and 101.4±0.1mg/g in 100% KJ (Table VI). Na content varied between 5.2±0.1 for SJ+10% LJ and 2.3±0.00mg/100g for 100% KJ (Table VI). These results reflect the low mineral content of KJ which may be due to the low soil fertility in the fields where Khlass date palms were planted.

IV. CONCLUSIONS

Dates, one of the most nutritious fruits in Saudi agriculture, is an ideal raw material for different value-added products. There is a growing interest in the kingdom for conducting research and development activities to identify new dates products for commercial utilization. The physical measurement of dates from the three cultivars grown in Saudi Arabia revealed that fruits differed in the physical measurements. According to our chemical analyses, Khlass and Rezaiz dates were rich in reducing sugars (fructose and glucose), while Sukkari dates were rich in sucrose. All three types of dates were rich in proteins and ash, but low in their vitamin C contents.

The results obtained from this study indicated that the addition of LJ to natural dates juices resulted in different nutritional characteristics than the control. Therefore, these products could be potentially valued and may result in diversifying juice production.

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REFERENCES

[1] W. H. Barreveld, *Date Palm Products*, Rome: Food and Agriculture Organization of the United Nations, 1993, p. 268.
[2] J. A. Vinson, L. Zubik, P. N. Bose, J. Samman, and J. Proch, "Dried fruits: Excellent in vitro and in vivo antioxidants," *J. Am. Coll. Nutr*., vol. 24. pp. 44-50, 2005.
[3] P. K. Vayalil, "Date fruits (*Phoenix dactylifera* L.): An emerging medicinal food," *Crit. Rev. Food Sci. Nutr*., vol. 52, pp. 249-271, 2012.
[4] A. K. Yousif and A. S. Al-Ghamdi, "Suitability of nine Saudi date cultivars for candy making," in *Proc. 1st Inter. Conf. on Date Palms*, United Arab Emirates University, 1998, pp. 100-110.
[5] B. M. Ramadan, "Preparation and evaluation of Egyptian date syrup," in *Proc. 1st Inter. Conf. on Date Palms*, United Arab Emirates University, 1998, pp. 86-99.
[6] B. H. Hassan, "Production of date dibbs and high fructose date syrup at an industrial scale level," in *Engineering Aspects in Dates Processing*, A. A. Aljanobi and A. I. Hobani, Ed., Riyadh: King Saud University, Scientific Publishing and Printing Press, 2003, pp. 123-155.
[7] B. H. Hassan, "Future of date derivatives industry," in *Proc. Date Palm Tree Civilization and Life Symposium*, Manamah, Kingdom of Bahrain, 2009, pp. 23-24.
[8] M. N. Al-Harthi, "Production of concentrated date extracts (date dibbs) at a pilot scale level," M.Sc. thesis, Department of Agricultural Engineering, College of Food and Agricultural Sciences, King Saud University, Saudi Arabia, 1999.

[9] W. N. Sawaya, J. K. Khalil, W. J. Safi, and H. A. Khatchadourian, "Date bars fortified with soy protein isolate and dry skim milk," *Journal of Food Science*, vol. 48, pp. 1503-1506, 1983.
[10] S. Al-Hooti, J. S. Sidhu, and H. Qabazard, "Studies on the physicochemical characteristics of date fruits of five UAE cultivars at different stages of maturity," *Arab Gulf J.*, vol. 13, pp. 553-569, 1995.
[11] M. I. Ali, M. M. Waly, S. Essa, and S. Devarajan, "Nutritional and medicinal value of date fruit," in *Dates: Production, Processing, Food, and Medicinal Values*, A. Manickavasagan, M. M. Essa, and E. Sukumar, Eds., New York: CRC Press, 2012, pp. 361-375.
[12] A. Al-Yahyai and A. Manickavasagan, "An overview of date palm production," in *Dates: Production, Processing, Food, and Medicinal Values*, A. Manickavasagan, M. M. Essa, and E. Sukumar, Eds., New York: CRC Press, 2012, pp. 3-12.
[13] S. Besbes, L. Drira, C. Blecker, C. Deroanne, and H. Attia, "Adding value to hard date (*Phoenix dactylifera* L.): Compositional, functional and sensory characteristics of date jam," *Food Chem*., vol. 112, pp. 406-411, 2009.
[14] Ministry of Agriculture, *Statistical Year Book*, Issue # 24. Administration of Studies and Statistical Planning, Riyadh, Kingdom of Saudi Arabia, 2011.
[15] FAOSTAT, *Agro-Statistics*, Rome, Italy: FAO Organization, 2011.
[16] N. Pellegrini, M. Serafini, B. Colombi, D. D. Rio, S. Salvatore, and M. Bianchi, "Total antioxidant capacity of plant foods, beverages and oils consumed in Italy assessed by three different in vitro assays," *J. Nutr*., vol. 133, pp. 2812-2819, 2003.
[17] J. J. Peterson, G. R. Beecher, S. A. Bhagwat, J. T. Dwyer, S. E. Gebhardt, and D. B. Haytowitz, "Flavanone in grapefruit, lemons and limes: A compilation and review of the data from the analytical literature," *J. Food Compos. Anal*., vol. 19, pp. S74-S80, 2006.
[18] C. Dhuique-Mayer, C. C. Veyrat, P. Ollitrault, F. Curk, and M. J. Amiot, "Varietal and inter specific influence on micronutrient contents in citrus from the Mediterranean area," *J. Agric. Food Chem*., vol. 53, pp. 2140-2145, 2005.
[19] D. D. G. C. Freitas and R. D. A. Mattietto, "Ideal sweetness of mixed juices from Amazon fruits," *Ciência e Tecnologia de Alimentos*, vol. 33, pp. 148-154, 2013.
[20] M. Al-Farsi, C. Alasalvar, M. A. Al-Abid, K. Al-Shoaily, M. Al-Amry, and F. Al-Rawahy, "Compositional and functional characteristics of dates, syrups, and their by-products," *Food Chemistry*, vol. 104, pp. 943-947, 2007.
[21] B. H. Hassan and A. I. Hobani, "Cake filtration characteristics of date paste-water suspensions under constant pressure conditions," *Canadian Agricultural Engineering*, vol. 36, pp. 143-149, 1994.
[22] N. Chaira, A. Ferchichi, A. Mrabet, and M. Sghairoun, "Characterization of date juices extracted from the rest of sorting of Deglet Nour variety," *Biotechnology*, vol. 6, pp. 251-256, 2007.
[23] M. I. El-Shaarawy, A. S. Messalam, H. M. El-Nakhal, and A. N. Wahdan, "Preparation of date drinks," in *Proc. 2nd Symp. on the Date Palm in Saudi Arabia*, Al-Hassa, Saudi Arabia, 1989, pp. 273-282.
[24] B. L. Attri, B. B. Lal, and V. K. Joshi, "Physico-Chemical characteristics, sensory quality and storage behaviour of sand pear juice blended with temperate fruit juices/pulp," *Ind. Fd. Packer*, vol. 52, pp. 36-42, 1998.
[25] I. N. D. Gowda, "Studies on blending of mango and papaya pulp for ready-to-serve beverage making," in *Proc. National Seminar on Post-Harvest Technology of Fruits*, Banglore, 1995.
[26] S. K. Jain and D. S. Khurdiya, "Vitamin 'C' enrichment of fruit juice based ready-to-serve beverages through blending of Indian gooseberry (*Emblica officinalis* Gaertn) juice," *Plant Foods Hum. Nutr*., vol. 59, pp. 63-74, 2005.
[27] K. S. Sandhu and J. S. Sindhu, "Studies on the development of multi-fruits ready-to-serve beverage," *J. Plant Sci. Res.*, vol. 8, pp. 87-88, 1992.
[28] A. K. Saxena, M. S. Teotia, and S. K. Berry, "Studies on the development of grape-mango and grape-pineapple beverage blends," *Ind. Fd. Packer*, vol. 50, pp. 26-29, 1996.
[29] *Official Methods of Analysis*, 16th ed., Association of Official Analytical Chemists, Washington, D.C., 2005.
[30] E. González-Molina, D. A. Moreno, and C. García-Viguera, "Genotype and harvest time influence the phytochemical quality of Fino lemon juice (*Citrus limon L.*) for industrial use," *Journal of Agricultural and Food Chemistry*, vol. 56, pp. 1669-1675, 2008.
[31] B. Ismail, I. Haffar, R. Baalbaki, Y. Mechref, and J. Henry, "Physicochemical characteristics and total quality of five date varieties grown in the United Arab Emirates," *Int. J. Food Sci. Tech*., vol. 41, pp. 919-926, 2006.
[32] W. Al-Shahib and R. J. Marshall, "The fruit of the date palm: Its possible use as the best food for the future?" *Int. J. Food Sci. Nutr*., vol. 54, pp. 247-259, 2003.
[33] A. Ali, Y. S. Al-Kindi, and F. Al-Said, "Chemical composition and glycemic index of three varieties of Omani dates," *Int. J. Food Sci. Nutr*., vol. 60, pp. 51-62, 2009.
[34] R. M. Myhara, J. Karkala, and M. S. Taylor, "The composition of maturing Omani dates," *J. Sci. Food Agric*., vol. 79, pp. 1345-1350, 1999.
[35] W. N. Sawaya, W. Safi, J. K. Khalil, and A. S. Mashadi, "Physical measurements, proximate analysis, and nutrient elements content of 25 date cultivars grown in Saudi Arabia at the Khalal and tamer stages," in *Proc. 1st Inter. Sym. Date Palm in Saudi Arabia*, Al-Hassa, Saudi Arabia, 1989, pp. 454-467.
[36] F. M. Anjum, S. L. Bukhat, A. H. El-Ghorab, M. I. Khan, M. Nadeem, and S. Hussain, "Phytochemical characteristics of date palm (*Phoenix dactylifera* L.) fruit extracts," *Pak. J. Food Sci*., vol. 22, pp. 117-12, 2012.
[37] A. M. Suleiman, I. A. Elhafise, and A. M. Abdelrahim, "Comparative study on five Sudanese date (*Phoenix dactylifera* L.) fruit cultivars," *Food Nutr. Sci*., vol. 3, pp. 1245-1251, 2012.
[38] M. S. Jamil, R. Nadeem, M. A. Hanif, M. A. Ali, and K. Akhtar, "Proximate composition and mineral profile of eight different unstudied date (Phoenix dactylifera L.) varieties from Pakistan," *Afr. J. Biotechnol*., vol. 9, pp. 3252-3259, 2010.
[39] I. A. Ahmed, A. W. K. Ahmed, and R. K. Robinson, "Chemical composition of date varieties as influenced by the stage of ripening," *Food Chem*., vol. 54, pp. 305-309, 1995.
[40] S. K. Lee and A. A. Kader, "Preharvest and postharvest factors influencing vitamin C content of horticultural crops," *Postharvest Biology and Technology*, vol. 20, pp. 207-220, 2000.

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