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Composition and Functional Properties of the Date Fruit Residue a By-product of Date Syrup/Debis Production

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Abstract

Low quality date fruits are processed to produce date syrup. Date fruit residue is the major by-product of date syrup production and used mainly as animal feed. The aim of this study was to characterize commercial date fruit residue from three date varieties (Khulas, Barhee and Lulu) produced at a local date processing establishment. Microbiological quality, proximate composition, sugars, dietary fiber (soluble and insoluble), minerals content, color and functional properties (water holding capacity, oil-holding capacity, emulsifying activity, emulsion stability, foam capacity and foam stability) were evaluated. The main components of the date fruit residue were dietary fibre total (50.8-56.5%) and sugars (27.7-30.4%). Date fruit residue had similar color, water holding capacity (1.86-2.00 g/g), oil-holding capacity (0.66-0.68 g/g), emulsifying activity (56 %) and emulsion stability (71 %).

Date fruit residue might be an alternative source for dietary fiber that will ultimately result in adding value to the date fruit residue and benefiting palm dates growers and processors.

Keywords: Date fruit residue; Composition; Functional properties

Introduction

Date is one of the most important fruits in The United Arab Emirates (UAE). UAE is the fourth leading country, producing 755 thousand tons of dates annually which represent 12% of the world production [1]. Dates are good source of dietary fiber [2-5]. Dietary fiber content of dates ranged from 4.4 to 11.4% depending on date variety and ripening stage [6-9]. A serving of dates (five to six fruit dates) can provide 14% of the recommended daily intake of the dietary fiber [6].

Consumption of foods containing fibers may prevent or decrease gastrointestinal disorders [10], hypertension, hypercholesterolemia, obesity [11], diabetes [12-14], coronary heart disease [15,16] and cancer [17,18]. The Dietary Guidelines for Americans published jointly by the U.S. Department of Agriculture and Health and Human Services recommend eating foods that have adequate amounts of fiber, The National Cancer Institute recommends 20 to 30 grams of fiber per day with an upper limit of 35 g. To meet these requirements, fibers are added to different food products. Beside the health benefits, fibers are added to increase cooking yield and water holding capacity, reduce lipid retention, improve textural properties and structure, or as bulking agent to reduce caloric content [19].

Low quality dates are processed to produce date syrup. In the UAE, there is several food processing establishments produce date syrup. Large amounts of date fruit residues (DFR), the by-product from syrup extraction, are available. Currently, the sole use of DFR is for animals feeding. DFR has hypolipidemic effects [20]. The addition of 5% DFR to the diet of rats fed cholesterol significantly increased HDL-C, lessened the rise in plasma LDL-C and increased the HDL-C/LDL-C ratio. Proximate composition of dietary fiber extracted from date flesh (press cake) of three sun-dried Omani date varieties (Mabseeli, Um-sellah, and Shahal) were reported [4]. The chemical composition and physicochemical properties of concentrated dietary fiber extracted from Tunisian date flesh cultivars (Deglet-Nour and Allig) were reported [5]. Both studies evaluated dietary fiber and concentrated dietary fiber extracted from date flesh in the laboratories.

To our knowledge, the compositional and functional characteristics of DFR that produced commercially from syrup extraction have not been previously reported. The purpose of this study was to evaluate the microbiological, chemical (proximate composition, soluble dietary fiber (SDF), insoluble dietary fiber (IDF), sugars and minerals) and functional properties (water holding capacity (WHC), oil-holding capacity (OHC), emulsifying activity, emulsion stability, foam capacity and foam stability) of the DFR collected from a date processing factory in UAE. Therefore, the information would be useful for promoting DFR as a potential fiber source in developing functional food products with health benefits.

Materials and Methods

Date fruit residues (DFR)

DFR is a by-product produced when sugar is extracted from dates to produce date syrup. DFR of three date varieties (Khulas, Barhee and Lulu) were obtained from a local date processing factory (Emirates Date Factory - Al Saad, UAE), grinded and kept at room temperature in sealed plastic bags until used for analysis or evaluation.

Microbiological analysis

The presence of the total mesophilic bacteria, coliform bacteria, yeast and mould on DFR were measured. Total Mesophilic Bacterial (TMB) counts were enumerated on standard plate count agar [21] and coliform bacteria

were determined using MacConky agar [22]. Yeast and mould counts were conducted with potato dextrose agar [23]. Plates were incubated for 3 days at 30 ± 1 C, 3 days at 37 ± 1 C and 3-5 days at 25°C for aerobic mesophilic bacteria, coliform bacteria and yeast & mould, respectively.

Color evaluation

Instrumental color analysis of DFR samples was conducted in triplicate with a Color Flex Hunter Color Lab (model No. 45/0, Reston, VA., USA). The CIE values L* (measures the lightness, ranging from 0 (black) to 100 (white)), a* value ranges from -100 (greenness) to +100 (redness) and b* value ranges from -100 (blueness) to +100 (yellowness).

Proximate composition

Moisture, ash and fat were analysed according to AACC methods 44-16, 08-01 and 30-20, respectively [24]. Protein was determined based on the Kjeldahl Method 46-10. The protein content was expressed as nitrogen multiplied by a factor (5.7).

Dietary Fibre (DF)

Soluble (SDF), insoluble (IDF) and total dietary fibre (TDF) contents were quantified using the enzymatic gravimetric procedure of the AACC Method 32-07 [24]. Arabinogalactan from Sigma was used as a standard reference for the determination of total dietary fiber, giving accuracy of 95.3%.

Sugars

Sugar profiles were determined by HPLC according to the AOAC official method 977.20 [25]. Sugars were identified by comparing their retention times with the standards and quantified using their peaks percentage area.

Mineral analysis

Mineral content was determined using the Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) (Varian- VISTA-MPX, Australia) with Coupled Captured Detector (CCD).

Functional properties

Water Holding Capacity (WHC): Water absorption capacity (WHC) was determined following the method described by [26]. The values are expressed as grams of water absorbed by 1 gm of DFR.

Oil Holding Capacity (OHC): The method described by [27] was used for the determination of fat absorption capacity (OHC). The values are expressed as grams of oil absorbed by 1 gm of DFR.

Foam capacity and stability: Foam capacity and stability was determined following the method described by [28].

Emulsifying activity and emulsion stability: Emulsifying activity and emulsion stability were determined following the method described by [29].

Statistical analysis: The data were analyzed by one-way analysis of variance (ANOVA) using SPSS 16.0. Mean separations were performed by Duncan's multiple range test. Differences at $P < 0.05$ were considered to be significant.

Results and Discussion

Microbiological evaluation

Dates retain some of the natural flora while growing plus contamination from soil, insects, and other sources. During the processing to produce date syrup as well as the DFR, some microorganisms associated with dates were removed. Therefore, it is required to determine the microbiological quality of DFR to estimate its suitability for human consumption and its shelf-life.

The microbiological counts of the DFR are presented in (Table 1). Coliform bacteria are used as an indicator for the presence of pathogenic bacteria. Coliform bacteria were not detected in all the samples. DFR were free from coliform bacteria, absence of coliforms were due to thermal processing. The total bacterial counts in DFR ranged from 3.17 to 3.21 log CFU/g. The yeast and mold counts ranged from 2.04 to 2.09 log CFU/g. Total viable count (1.7, 3.0 and 2.0 log CFU/g), yeasts and mold count (2.5, 3.6 and 2.0 log CFU/g) were reported [30] for Khulas, Barhee and Lulu at tamr stage, respectively. While, treating date fruits with ozone (5.0 ppm) for one hour eliminated coliform bacteria and reduced the total mesophilic bacteria as well as yeast and mold to 3.54 and 3.61 log CFU/g respectively [31]. The low bacteria, yeast and mold count as well as the absence of coliform bacteria in all DFR are promising to be included in developing food products.

Color

Color is a quality attribute which plays an important role in food acceptability. If the DFR will be added to different food products, it is important to know its color parameter [lightness (L*), redness (a*), and yellowness (b*)]. The CIE Lab values (L*, a*, b*) of DFR are presented in (Table 2). DFR from different varieties had comparable redness (7.34-8.02) and yellowness (17.78-18.33). Lulu-DFR had a darker color (the lowest L* value 48.64), while the DFR from other varieties had lighter color (L* values 54.25-55.51). Tunisian date DF concentrates had lighter (L* values 61.92-65.25) and less yellow (b* values 14.85-16.28) [5] compared to Emirati DFR. This could be due to the date variety, extraction technique and the composition of the concentrates.

Proximate composition

Proximate composition of DFR is presented on (Table 3). Carbohydrate was the major component of the DFR of all date varieties ranging from 85.9 to 87.56%. Lower values were reported for Omani press cake (81.86-83.33) [4] while higher values were reported for the Tunisian DF concentrates (88.0-92.4) [5]. Moisture content of DFR ranged from 6.14 to 8.73. Lulu DFR had the highest moisture content and Barhee had the lowest value. The moisture content of Omani press cakes (8.3-10.59) were higher [4]. DFR protein ranged from 2.18 (Lulu) to 3.09 (Barhee). Higher valued were reported for the Omani press cakes ranged from 3.62 to 5.23% [4] and Tunisian DF concentrates 8.89-9.12 [5]. Ash content followed the same profile as the protein, in which Lulu had the lowest content (2.15)

DFR	Total bacterial	Yeast and mold	Total coliforms
Lulu	3.20 ± 0.26a	2.04 ± 0.18a	ND
Khulas	3.17 ± 0.12a	2.09 ± 0.15a	ND
Barhee	3.21 ± 0.13a	2.08 ± 0.26a	ND

Table 1: Microbiological quality (given in Log CFU/g) of Date Fruit Residues (DFR)

[1]Means ± SD followed by the same letter, within a column are not significantly different (P> 0.05).

ND not detected.

DFR	Color Values		
	L*	a*	b*
Lulu	48.64 ± 0.15b	7.63 ± 0.08a	17.78 ± 0.12a
Khulas	55.51 ± 0.09a	8.02 ± 0.14a	18.33 ± 0.18a
Barhee	54.76 ± 0.18a	7.34 ± 0.20a	18.22 ± 028a

Table 2: Color of Date Fruit Residues (DFR)

[1]Means ± SD followed by the same letter, within a column are not significantly different (P> 0.05).

and Barhee had the highest content (2.98%). Similar values were reported for Omani press cakes (1.68-2.46%) and Tunisian DF concentrates (2.01%). DFR had comparable fat content ranged from 0.81 (Khulas) to 1.04% (Lulu). Omani press cakes had higher fat content (1.40 – 2.20%). Compositional differences could be related to the date varieties and the extraction techniques.

Dietary Fibre (DF)

Total DF is the main components of DFR ranging from 50.81 to 56.52% (Table 4). Among the three varieties Barhee had significantly higher SDF (9.15%), and lower IDF (41.66%) compared to the other date varieties. The Omani press cakes had lower total DF values ranging from 25.39 to 33.81% [5] while the Tunisian date DF concentrates had higher values ranging between 88 and 92% [5]. This could be due to the date variety, extraction technique and the composition of the DF.

Sugars

Sugar content of Khulas, Barhee and Lulu at tamer stage were reported, glucose ranged from 29.7 to 30.5% and fructose ranged from 26.5 to 27.6 [32]. While, higher values were reported for Khulas and Barhee dates stored under commercial and industrial conditions, glucose (33.1 - 37.8) and fructose (35.2 - 38.3) [33].

Sugar content of DFR is presented on (Table 4). The results indicated the presence of equal concentrations of both glucose and fructose in DFR. Again Barhee had the highest concentration of glucose and fructose (16.4-16.1%), while Lulu and Khulas had slightly lower values (15.9 -15.5%) and (15.6-15.2%). This indicated that 50% of the glucose and fructose were extracted during syrup production. Sugar content of Omani press cakes was not reported [4] while Tunisian date DF concentrates were sugar free [5]. The presence of simple sugars in the DFR could be an advantage if used as an ingredient in baked products.

Mineral contents

(Table 5) presents minerals content of DFR. All DFRs had similar Mn and Zn content. Khulas and Barhee DFRs had similar Ca, Fe, Mg and Na content. Lulu DFR contained the highest amount of Mg, P, Fe and Mn and the lowest amount of K and Ca. DFRs differ significantly on K and P content. Barhee contained the highest K level and Lulu contained the highest P level.

Functional properties

Functional properties of DFR are presented in (Table 6). Water absorption characteristics represent the ability of a product to associate with water under conditions where water is limiting, like in dough and pastes [34]. The results showed that water absorption were similar for all the DFR. This might suggest that DFR would be useful in baked products that require hydration to improve handling characteristics. Fat absorption was similar for all types of DFR. Fat absorption capacity of DFR was ranging between 0.66 g/g and 0.68 g/g which are considered higher than that of soy flour [34]. The fat binding capacity of DFR would find useful application in ground beef products such as patties and sausages. Higher values were reported for DF concentrate (15.5 g/g for WHC and 9.7 g/g for OHC) which have different composition [5]. DFR did not show foam capacity. This is might be due to amount of the protein (low content 2-3%) and the effect of heat treatment during processing that might denature the protein and consequently destructed the foam capacity. DFR showed

DFR	Moisture	Ash	Protein	Fat	Carbohydrate
Lulu	8.73 ± 0.23a	2.15 ± 0.06a	2.18 ± 0.06a	1.04 ± 0.05a	85.90 ± 0.76a
Khulas	7.16 ± 0.11b	2.82 ± 0.10a	2.65 ± 0.11a	0.81 ± 0.04a	86.56 ± 052a
Barhee	6.14 ± 0.14c	2.98 ± 0.15a	3.09 ± 0.12a	0.95 ± 0.03a	86.84 ± 068a

Table 3: Proximate composition (%) of Date Fruit Residues (DFR)[1]

[1]Means ± SD followed by the same letter, within a column are not significantly different (P>0.05).

DFR	Sucrose	Fructose	Glucose	Dietary fibre	
				Soluble	Insoluble
Lulu	ND	15.5a	15.9a	6.19b	48.32a
Khulas	ND	15.2a	15.6a	6.53b	49.99a
Barhee	ND	16.1a	16.4a	9.15a	41.66b

Table 4. Sugars, soluble and insoluble dietary fibre (%) of date fruit residues (DFR)

[1] Means followed by the same letter, within a column are not significantly different (P> 0.05).

Mineral	DFR		
	Barhee	Khulas	Lulu
Ca	192.92a	194.39a	119.45b
Fe	8.66b	10.73b	21.60a
K	515.75a	443.38b	342.28c
Mg	92.77b	97.41b	170.70a
Mn	1.30a	1.26a	2.02a
Na	16.61b	20.77b	30.71a
P	99.03b	77.69c	163.96a
Zn	1.12a	1.00a	2.47a

Table 5: Minerals content (mg/100g) of Date Fruit Residues (DFR)

[1]Means followed by the same letter, within a row are not significantly different (P> 0.05).

DFR	Water Absorption g/g	Fat Absorption g/g	Foam Capacity MI %	Foam Stability min	Emulsifying Activity %	Emulsion Stability %
Lulu	1.96 ± 0.05a	0.66 ± 0.07a	0.00	0.00	56.17 ± 1.07a	71.46 ± 1.28a
Khulas	1.98 ± 0.09a	0.67 ± 0.05a	0.00	0.00	56.17 ± 1.71a	71.46 ± 1.49a
Barhee	2.00 ± 0.09a	0.67 ± 0.04a	0.00	0.00	56.14 ± 1.90a	71.48 ± 0.98a

Table 6: Functional properties of Date Fruit Residues (DFR)

[1] Means ± SD followed by the same letter, within a column are not significantly different (P> 0.05).

emulsifying activity about 56 % and emulsion stability 71 %. Functional properties results suggested that DFR might have great potential for addition to food, not only as a nutrient supplement but also as a functional agent in food.

Conclusions

DFR, date by product produced during date syrup extraction, appears as a suitable source for dietary fiber with functional properties. The results indicated that DFR could be considered as an alternative dietary fiber source for different food products. This will provide benefits to the date industry and a solution for disposing date processing by products.

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