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Quality assessment and producers' needs analysis for the sustainable development of date palm cultivation in Jericho

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Abstract

Date palms cultivation in the Palestinian territories exists in the regions of Jericho and the Jordan Valley, in the West Bank and in the Gaza Strip. Around 400 date producers operate in the area of Jericho and Jiftlek. Actually, despite the potential high quality of Palestinian dates of the cultivar Medjool, the export to Europe still encounters many difficulties. This research took place within the project "Sostegno alla riorganizzazione produttiva, manageriale e commerciale delle cooperative di datteri palestinesi ed egiziani" (AID 10601), implemented by Jean Paul II Foundation and funded by the Italian Agency for Development Cooperation.

The main objective of the project is to enhance the quality and the sustainability of the management and strategic organisation of the rural enterprises beneficiary correlated to the productions of dates in West Bank. Within a perspective of improving of the technical and productive competencies and procedures of date producers, this study has been focused in particular on the following specific objectives: (1) to understand more about the existing procedures (in particular harvest and selection steps) of a sample of selected farmer part of the cooperative, with the aim to collect relevant information and evaluate the possibilities to share existing best practices among all the members; (2) to explore the main issues that affect the quality of dates production and their linkages with internal and international markets, assessing potential areas of interventions; (3) to conduct analytical evaluation of the content of polyphenolic molecules and the antioxidant properties of two samples of dates collected during the in-field mission, also in comparison of a commercial sample of Medjoul date taken from the GDO in Italy.

This paper presents the results of an in-field research mission conducted in Jericho and Jiftlek in September 2017. In order to achieve the above-mentioned objectives, this study has adopted a robust methodology based on the active involvement of the project stakeholders. In particular, the following activities were conducted: desk-based analysis of reports; on field conduction of semi-structured interviews with a sample of date producers, along with on-site sustainability audit of their fields and farms during the activities of harvest and sorting, as well as with local stakeholders; conduction of analysis to understand if the content in polyphenolic molecules and antioxidant properties of the considered dates is also influenced by actual production procedures. Regarding the production of dates in Jericho, we should remark that some issues on quality are mainly due to the lack of adoption of standardized methods. Thus, Palestinian dates, with a step-by-step implementation of standardized procedure, could really improve the quality and faced in front of potential European markets and opportunities. Finally, the definition of new quality procedures for members of the local cooperative PFCA (Palm Farmers Cooperative Association) will foster more sustainable behaviour and improve commitment among them. In particular, the aim is to obtain a more sustainable chain, i.e. guaranteeing fair access to fundamental rights and conditions of well-being, within the workers and within the community, providing opportunities to create and develop internal and external relations involving the community, and recognizing the cultural value of this food commodity. Furthermore, because the therapeutic implications of date palm fruits and their pharmacological properties, mainly anti-oxidants and anti-inflammatory, we take into consideration the results about the polyphenolic characterization and the biological properties assessed by in vitro tests, to outline additional considerations.

Keywords: Sustainable food commodities, Medjool dates, Agrifood chain, Quality management, Antioxidant compounds.

1. Introduction

The date palm (*Phoenix dactylifera* L., *Arecaceae*), one of the oldest plants cultivated by mankind, is broadly distributed in many regions of the world, including Asia, Africa, Arabian countries, and the Middle East. Date palms cultivation is typical of the Palestinian territories especially in the area of Jericho and the Jordan Valley. The Mediterranean climate, dominant in the area, provides optimal conditions for growth and development of date palm. At present, 2000 or more different cultivars of date palm are known to exist around the world and the date fruit production and consumption are continuously increasing. The worldwide production of *P. dactylifera* fruits is about 7.5 million tons (FAOSTAT, 2016). It is estimated that 5000 tons were produced in Palestine in 2015. Recently, there has been a significant increase in the total harvested area of dates in Palestine, to reach about 725 ha in 2012 (Abu-Reidah I.M. et al., 2017). Several constraints face nowadays date cultivation and development, including high investment costs, lack of market linkages, competition with producers of other countries, limited access to water. There are hundreds of named varieties of *P. dactylifera* date palms, and one of the most famous is the large soft Medjool date palm. Medjool dates are often called the "king of dates", due to their global availability, and are also the "soft" variety of dates, compared to semi-dry and dry varieties. Because it is grown in areas below sea level, there is an increase in the proportion of oxygen available to the palm which aids respiration and that in turn adds flavour and a distinctive colour. The area of Jericho possesses a comparative advantage for growing Medjools. The climate in the region of Jericho, where temperatures range from 12 °C in March up to 50 °C between July and October, is considered ideal for Medjool date production, which requires hot and dry weather. Besides its ability to grow in various climatic conditions, the date palm is a multi-functional tree, with abundant nutritional and therapeutic attributes. Dietary antioxidants, including phenolic compounds, in dates are reported to protect the body from various degenerative disorders by minimizing oxidative stress (Nasir et al., 2015). Further, they help to activate both enzymatic and non-enzymatic antioxidant systems (Borochov-Neori, et al., 2015). Moreover, date extracts possess antioxidant and free radical scavenging capacities and exhibit potent anti-oxidative properties, both in vitro and in vivo (Yasin et al., 2015).

This study took place within the two-year long project "Sostegno alla riorganizzazione produttiva, manageriale e commerciale delle cooperative di datteri palestinesi ed egiziani" (AID 10601), implemented by Jean Paul II Foundation and funded by the Italian Agency for Development Cooperation. The main objective of the project is to enhance the overall quality and sustainability of the managerial and strategic organisation of a target group of dates producers in West Bank, part of the Palm Farmers Cooperative Association (PFCA).

This paper presents the results of an in-field research mission conducted in Jericho and Jiftlek in September 2017 by ARCO, a university action-research centre founded in 2008 at PIN S.c.r.l. (Polo Universitario "Città di Prato") – University of Florence. ARCO integrates the expertise and skills of economists, statisticians, political scientists, sociologists, commodity scientists, and technical professionals. It is organized into five strategic research units: local development, social economy, M&E and impact evaluation, inclusive development, sustainable food commodities.

Within a perspective of improvement of the technical and productive competencies and procedures of the farmers of PFCA, this study has focused in particular on the following specific objectives: i) to understand more about the existing procedures (in particular harvest and selection steps) of a sample of selected farmers part of the cooperative, with the aim to collect relevant information and evaluate the possibilities to share existing best practices among all members; ii) to explore the main issues that affect the quality of dates production and their linkages with internal and international markets, assessing potential areas of interventions; iii) to understand if the content in polyphenolic molecules and antioxidant properties of the investigated fruits is also influenced by actual production procedures. This paper outlines the first findings that will been implemented in the future with further investigations and analyses.

2. Methods

2.1 On field assessment

In order to achieve the above-mentioned objective, this study has adopted a robust methodology based on the active involvement of the project stakeholders. In particular, the following activities were conducted before and during the field mission: a) Desk-based analysis of internal reports (e.g. field mission reports, farmers' profiles) prepared by CNR, Slow Food and Jean Paul II Foundation, as well as publications of studies conducted by national and international research centres. b) On field conduction of semi-structured interviews with a sample of 5 farmers, members of PFCA, along with on-site sustainability audit of their fields and farms during the activities of harvest and sorting. c) Conduction of semi-structured interviews with representatives of Jericho Chamber of Commerce, Industry and Agriculture.

2.2 Extraction of date fruits

Two samples of date fruits have been collected during the field mission. The fruit pulps were manually separated from the seeds and immersed in liquid nitrogen for about 20 minutes, and then ground into a fine powder in a mill (Model M20, IKA® - WERKE). The samples were analysed in triplicate. For each sample, an amount of 16-20 grams of the powder was extracted with a volume of 100 mL of a hydro-alcoholic solution consisting of EtOH (ethanol) 70% and acidic water 30% at pH 3.2 for formic acid (HCOOH). The extraction was carried out for a whole day, including the night. Subsequently, the extract was centrifuged at 5000 rpm for 5 minutes in a centrifuge with temperature control (18°C) to separate the hydroalcoholic supernatant from the solid residue.

2.3 HPLC/DAD qualitative analysis

The characterization and the quali-quantitative evaluation of polyphenol compounds present in two samples of dates collected during the in-field mission, via through standardised methodologies, such as HPLC / DAD (High Performance Liquid Chromatography with Diode Array Detector) analysis, was carried out. The HPLC / DAD analyses were performed with an HP 1100L instrument equipped with an HP DAD (Agilent Technologies, Palo Alto, CA). In particular, the analytical column used was Luna C18 250×4.60 mm, 5µm (Phenomenex). The eluents used were H_2O at pH 3.2 for HCOOH (solvent A) and acetonitrile (CH_3CN, solvent B) for 43-min time of analysis. The flow rate is 0.8 mL / min and the oven temperature was kept 27 ± 0.5 ° C. A sample volume of 25 µL was injected into HPLC. The UV-Vis spectra were recorded in a range of 190-600 nm and the chromatograms acquired at 280, 315, 330 and 350 nm.

2.4 HPLC/DAD quantitative analysis

In order to calibrate the individual polyphenolic compounds, specific calibration curves ($R^2 \geq 0.998$.) of 5-level of concentration were built using standard substances (98-99% of purity). In case of lack of the specific molecule, the calibration was carried out with compounds having similar chromophore, measuring the absorbance at the maximum UV absorption. In details, the amount of ferulic acid was calculated at 330 nm, using pure ferulic acid as a reference; caffeic acid derivatives were evaluated at 330 nm, using chlorogenic acid (5-*O*-caffeoylquinic acid) as standard; gallic acid and the other compounds (tannins) with similar chromophore were evaluated at 280 nm, using a standard solution of gallic acid; finally, the flavonoids were calibrated at 350 nm using a standard of luteolin-7-*O*-glucoside.

2.5 Folin-Ciocalteau assay

Total polyphenols were determined as follows: the hydro-alcoholic date extract (125 µL) was mixed with 500 µL of water and 125 µL of Folin-Ciocalteau reagent and allowed to stand for 6 min; 1250 µL of a solution of sodium carbonate (7%) was added to the mixture. After 85 min, the absorbance of centrifuged samples was measured at 725 nm against water as a blank, by using a DAD 8453 spectrophotometer (Agilent Technologies). The amount of total phenolics is expressed as Gallic Acid

Equivalents (GAE, mg gallic acid / g of sample, on Dry Weight basis), through the calibration curve of gallic acid. The calibration curve range was 20 - 500 µg/mL (R^2 0.9976).

2.6 Diphenyl-picryl-hydrazyl radical (DPPH) test

The antiradical capacity of the extracts was estimated according to a previously reported procedure (Heimler et al., 2005), with slight modifications. More specifically, the extracts are opportunely diluted and an amount equal to 1:1 added to an ethanol solution of DPPH (0.025 mg/mL). Measurements were carried out at 517 nm with a DAD 8453 spectrophotometer (Agilent Technologies) at time 0, after 15 sec, 30 sec, 45 sec, 1 min, 2 min and then every 2 min for the following 20 min. The antiradical activity (AR%) was calculated through the following relationship:

$$[AR\% = 100\ (A_0 - A_{20})/A_0]$$

where A_0 and A_{20} were the absorbance of DPPH, at time 0 and 20 min., respectively, after adding the diluted extract. The EC50 of the extracts was determined through the use of five-point linearized curves [AR%-ln (concentration in polyphenols)], built determining AR% for five different dilutions of each extract and then by calculating the molar concentration in polyphenols of the solution that inhibits the DPPH activity to 50%.

This range of different methods has allowed diversifying the sources of information, digging deeper in all relevant topics and cross-checking findings and results, in order to obtain a comprehensive and consistent picture of the main issues.

3. Results and Discussion

PFCA, formed by 117 members, was funded in 1996, counting a total of around 400 date producers operating in the area of Jericho and Jiftlek. The cooperative aims to collect and to invest the fees of the members in order to build facilities for common use. Main cultivation of the cooperative's members is palm tree, although some of them tried in the past to cultivate other crops in addition to palms, but the salted water was not particularly suitable for other uses. Actually, the cooperative does not own any equipment, construction or property land. No activities of stocking, processing and treatment are directly managed by PFCA and single associates manage the post-harvest steps at their own. Overall, PFCA, does not offer at present any assistance in the field operations and in the post-harvest phases.

At farming level, post-harvest procedures consist in a preliminary sorting of date fruits.

Figure 1. *Medjoul dates sorted by grade*

The selection carries out taking into consideration the residual air inside the skin:

i) If residual air is less than 10%, date is given grade 1 (A), without problems to place it on the market, also if it is smaller than usual Medjool date. For grade A shelf life reaches about 2 years.

ii) With 10-25% residual air, the date obtains grade 2 (B).

iii) In dates with more than 25% air inside the given grade is 3 (C). Dates C are not easy to place in the market. Some possible markets could be in Far East but they are not easy to reach in order to establish trades.

See figure 1 for samples of grade A, B and C dates.

Table 1 outlines the main results of current situation of visited PFCA's planters, emerged by the on field assessment:

Table 1. *Comparison among members based on authors' on field assessment.*

		Planter #1	Planter #2	Planter #3	Planter #4	Planter #5
Environmental issues	**Main environmental strengths**	Willing to introduce eco-friendly fertilisation	//	Try to be like organic	Clean and organized	//
	Main environmental weaknesses	No full technical awareness about fertilisation	Lack of waste disposal	Lack of waste (e.g. leaves and bushes) disposal	//	Lack of waste disposal
Social issues	**Main social strengths**	Good organisation of work time-shifts	Air conditioners in the workspace	Family involvement	Air conditioners in the workspace	//
	Main social weaknesses	Absence of personal protective equipment	Absence of personal protective equipment	Absence of personal protective equipment	//	Absence of personal protective equipment
Economic issues	**Main economic strengths**	Stable financial status	Stable financial status	Stable financial status	Stable financial status	Stable financial status
	Main economic weaknesses	//	//	//	//	//
Management issues	**Main management strengths**	//	Selection step and warehouse are well organized	Accurate final check before sending to packaging house	Workspaces and production lines designed following international standards	//
	Main management weaknesses	Warehouse organization to be improved	Waste (e.g. empty fertilizers bottles) abandoned in the field	//	//	Shed and warehouse organization needs improvement

As previously reported, fruits and vegetables are an important source of dietary antioxidants and several epidemiological studies show that their regular intake in the diet may decrease the risk of several chronic diseases. Date fruits are among the most nourishing natural food available to humankind and are knew to have numerous health benefits. Rich in several vitamins and minerals, the date fruit is a good source of high nutritional value food. In particular, the soft dates have higher moisture content, a mild flavor, relatively low sugar and a fair amount of antioxidants, as the phenolic compounds (hydroxycinnamic acids, tannins and flavonoids). Antioxidant phytochemicals present in foodstuffs are the main responsible for such health benefits.

Samples of date fruits have been analyzed for the quali-quantitative assessment of the antioxidant molecules by applying extraction and fractionation methods, followed by an instrumental analysis with chromatographic technique, as HPLC/DAD

(High Performance Liquid Chromatography with Diode Array Detector). The standardized fractions, obtained by extraction of date fruits (Sample 1 and Sample 2) have been evaluated for their antioxidant and antiradical activity by using UV-Vis spectrophotometric assays (Folin-Ciocalteau and DPPH tests). In particular, hydrolizable tannins (gallic acids and phenolic derivatives), hydroxicinnamic acids (ferulic acid, *p*-coumaric acid, caffeic acid and their derivatives) and flavonoids (mainly luteolin and kaempferol glycosides) were identified in the hydro-alcoholic extracts of date fruit by HPLC/DAD. The quantitative results of each polyphenolic class for the investigated samples and for a reference sample (Palestinian Medjoul dates commercialised, with a premium price, by an Italian large-scale retail trader – Sample 3), are fully reported in Table 2:

Table 2. *HPLC/DAD quali-quantitative results (average values of triplicates) of polyphenol composition of hydro-alcoholic extracts of date fruit collected in field (Sample 1 and 2) and taken from the market (Sample 3). Data are expressed as mg of compound per 100 mL of extract. The numbers in brackets are the percentages of the class of compounds compared to the total polyphenols.*

	Sample 1	*Sample 2*	*Sample 3*
Hydrolizable tannins (as gallic acid at 280 nm)	36.00 (89.1%)	26.16 (88.5%)	27.00 (84.1%)
Hydroxycinnamic acid (as ferulic acid at 330 nm)	2.24 (5.6%)	2.88 (9.7%)	4.44 (13.8%)
Flavonoids (as luteolin 7-O-gluc. at 350 nm)	2.16 (5.3%)	0.52 (1.8%)	0.68 (2.1%)
TOTAL POLYPHENOLS	40.40	29.56	32.12

The date hydro-alcoholic extracts previously analyzed and characterized by HPLC/DAD were then investigated for the antioxidant and antiradical properties, by using two in vitro spectrophotometric tests (Folin-Ciocalteau and DPPH test). Spectrophtometric tests allowed the antioxidant and antiradical properties evaluation of the hydro-alcoholic extracts of dried fruits, harvested in two plantations with different characteristics. In the field from which the Sample 1 comes, the palm trees are younger and their disposition is more sparse, allowing a major sun irradiance of the plants. In the field from which the Sample 2 comes, the trees are closer, creating a thicker network of branches and leaves with the result of plants more shaded.

The average total polyphenol content assessed by the Folin-Ciocalteau test was 198 mg GAE/100g of DW for Sample 1 and 157 mg GAE/100g DW for Sample 2. The reference sample taken from the market (Sample 3) registered a polyphenol content value of 160 mg GAE/100g DW. Hence, the investigated Sample 1 showed a quite higher antioxidant potential with respect the other two samples and this is in accordance with the higher flavonoid content on sun-exposed palms (5.3% of Total Polyphenols, see Table 2), as previously described.

Concerning the DPPH test, the EC_{50} of the hydro-alcoholic extracts was firstly analysed, expressing the values as mM of total polyphenols (i. e. 0.133 mM for Sample 1). Reporting the data of EC_{50} as the quantity in mg of date fruit that inhibits 1 mg of radical, the average value for Samples 1 was 141 mg, quite different from the average value for Sample 2 (215 mg) and Sample 3 (191 mg) respectively. These data, corresponding to the quantity of date pulp that inhibits the 50% of the radical molecule (DPPH), confirm the higher antiradical activity of the sample with a higher concentration of flavonoids.

As an example for Sample 1, Figure 1A reports the kinetic of the radical scavenging in a 20-min time, and the Figure 1B shows the logarithmic curve of the radical inhibition in function of the hydro-alcoholic extract concentration (as mM of Total Polyphenols).

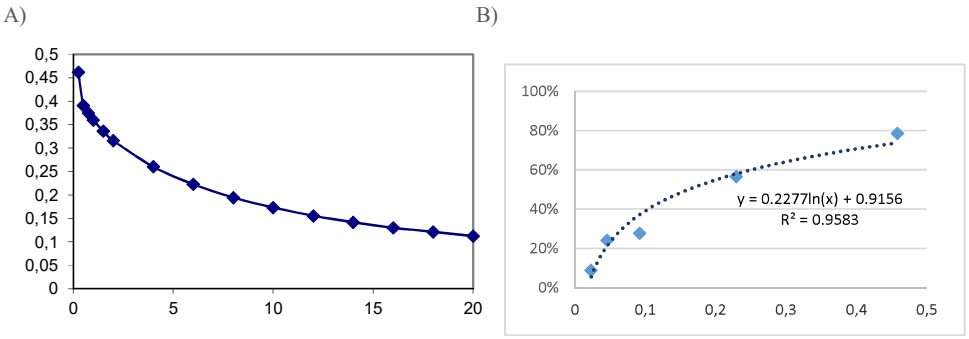

***Figure 1**. A) Kinetic of inhibition of Sample 1 on DPPH radical by measuring the Absorbance at 517 nm during 20-min time. B) Logarithmic curve describing the relation between the total polyphenol concentrations of the hydro-alcoholic extract (Sample 1) and the percentage of inhibition of DPPH radical.*

4. Conclusions

Regarding date production in Jericho, we should remark that despite the potential high quality of Palestinian dates Medjools, marketing to Europe still encounters many difficulties. Some issues on quality are due to the lack of adoption by producers of standardized methods. Thus, Palestinian dates, with a step-by-step implementation of standardized procedures, could really improve their quality to be ready to face potential European markets and opportunities.

Concerning the analytical research, this paper shows that the Medjool date is a good source of natural antioxidant compounds belonging to different polyphenolic classes, and such composition accounts for the antioxidant and antiradical properties of the fruit. Moreover, the biological activity seems to vary in function of a differentiate percentage of each polyphenolic class. As future prospective, a rigorous characterization of the cultivar Medjool with the assessment of its antioxidant properties can be strongly useful in the nutritional valorisation of date fruits and to stimulate other high value applications, i.e. as a functional food and as ingredient in food supplements.

Finally, the definition of new quality procedures for members of PFCA will foster more sustainable behaviour and improve commitment among them. In particular, the aim is to obtain a more sustainable chain, with reference to:

a) Environmental sustainability, i.e. guaranteeing the integrity of ecosystems (e.g. through appropriate irrigation, fertilization, pest control and weeding practices);

b) Economical sustainability, i.e. generating long-term income;

c) Socio-cultural sustainability, i.e. guaranteeing fair access to fundamental rights and conditions of well-being, among the workers and within the community.

In the future, these could contribute to create opportunities and develop positive relations along the chain, able to recognize the cultural value of this commodity.

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