Producers' needs analysis and quality improvement for the sustainable development of cherry cultivation in Lebanon

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Abstract

Cherry is one of the most cultivated stone fruit in Lebanon. Plantations are located in high altitude areas and are mainly constituted of traditional local varieties. Fruits are mainly used for fresh consumption. This study took place within the project "International network for the ecosustainable development and productive, managerial and commercial innovation of the small producers involved in the cherry value chain in Lebanon. 2016-2018", implemented by Jean Paul II Foundation and funded by the Italian Agency for Development Cooperation. The main objective of the project is to enhance management capacities and strategic organization of the rural enterprises and cooperatives involved in the cherry production and supply chain in the Bekaa valley, improving quality and business control of the agricultural supply chain. Within a perspective of improving technical and productive competencies and procedures of cherry producers, this study has been focused on the following specific objectives: i) to understand more about the existing procedures (in particular harvest and selection steps) of a sample of selected local farmers, with the aim to collect relevant information and evaluate the possibilities to share existing best practices at local level; ii) to assess hygiene and quality, according European standards, of the processing unit (cooperative); iii) to explore the main issues that affect the quality of cherry production and the linkages with internal and international markets, assessing potential areas of interventions; iv) to carry out the analytical evaluation of polyphenolic molecules, with special attention to anthocyanosides, and to evaluate the antioxidant properties of cherry samples, collected in the target area. In order to achieve the above-mentioned objectives, this study has adopted a 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 cherry producers, as well as with local stakeholders; conduction of an investigation to understand if the content in polyphenolic molecules and antioxidant properties of the considered cherries is also influenced by actual production and harvest procedures. The project aims to enhance management capacities of farmers and to support the access and openness to international markets. Future perspectives of this intervention will be focused on to the adoption of successful practices, with the aim to bring socio-economic benefits for the involved local communities.

Keywords: Sustainable food commodities, Cherries, Quality management, Antioxidant compounds, HPLC/DAD

Introduction

There are three main species of cherry fruits around the world, sweet (*Prunus avium*), tart or sour (*Prunus cerasus*), and ground (*Prunus fruticosa Pall.*) cherries. Among the three species, of global trading importance are sweet and tart cherries (Iezzoni et al., 2008). Commercial cultivation of sweet cherry is generally more difficult and expensive than tart cherry, as high levels of care must be taken throughout the supply chain to achieve premium quality fruit for serving in the fresh market (Looney & Jackson, 2011).

This study took place within the project "International network for the ecosustainable development and productive, managerial and commercial innovation of the small producers involved in the cherry value chain in Lebanon. 2016-2018", implemented by Jean Paul II Foundation and funded by the Italian Agency for Development Cooperation. The main objective of the project is to enhance management capacities and strategic organization of the rural enterprises and cooperatives involved in cherry production and supply chain in the Bekaa valley, improving quality and business control of the agricultural supply chain. The project will concentrate in two clusters of Bekaa Governorate, one in the North, in Qaa district of Hermel, the other one in the South, in the district of Rashaya. The population of the target area is of around 20,000 people. This paper presents the first results of an in-field research mission conducted in May 2018 by the Sustainable Food Commodities strategic unit of ARCO, a university action-research centre founded in 2008 at PIN S.c.r.l. (Polo Universitario "Città di Prato") – University of Florence. Within a perspective of improvement of the technical and productive competencies and procedures of cherry producers, this study focuses 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 local farmers, with the aim to collect relevant information and evaluate the possibilities to share existing best practices at local level;

ii) to explore the main issues that affect the quality of cherry production and their linkages with internal and international markets, assessing potential areas of interventions;

iii) to carry out the analytical evaluation of polyphenolic molecules, with special attention to anthocyanosides, and to evaluate the antioxidant properties of cherry samples, collected in the target area.

This paper outlines the very first findings that will been implemented in the future with further investigations and analyses.

Methods

2.1 On field assessment

In order to achieve the above-mentioned objectives, this study has adopted a methodology based on the active involvement of the project stakeholders. In particular, the following activities were conducted

before and during the field mission: i) Desk-based analysis of reports (e.g. field mission reports, farmer profiles) elaborated by Jean Paul II Foundation, as well as publications of studies conducted by national and international research centers. ii) On field conduction of semi-structured interviews with seven farmers (involved in the project), along with on-site sustainability audit of their fields and farms during the activities of harvest and sorting. iii) Visit and conduction of semi-structured interviews at Ferzol market. iv) Conduction of semi-structured interviews with representatives of Meeting with Chamber of Commerce, Industry and Agriculture of Zahle (CCIAZ) and of LARI (Lebanese Agronomic Research Institute).

2.2 *Extraction of cherries*

Four cultivars of sweet cherry (*Prunus avium* L.) have been collected during the in-field mission. Three cultivars (Irani, Nawari and Ferawni) are red-fleshed varieties and the last one (cv. Rainbow) is a yellow-fleshed sweet cherry. To compare the antioxidant content of the samples, with particular focus on anthocyanosides, the skins were removed from the fruit, frozen in liquid nitrogen for about 20 minutes, and then ground into a fine powder. The samples were analyzed in triplicate. For each sample, a quantity of 1 gram of the powder was extracted with a volume of 5 mL of a hydro-alcoholic solution consisting of EtOH (ethanol) 70% and acidic water 30% at pH 2.45 by formic acid. The extraction was carried out under stirring for 5 h and taking the samples in the dark. Subsequently, the extract was centrifuged at 5000 rpm for 5 min in a centrifuge with temperature control (10°C) to separate the hydroalcoholic supernatant from the solid residue.

2.3 HPLC/DAD analysis

The characterization and the quali-quantitative evaluation of polyphenol compounds present in cherry samples, was performed by HPLC / DAD analysis, 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 1.8 for HCOOH (solvent A) and acetonitrile (CH_3CN, solvent B) for 25-min time of analysis; flow rate 0.8 mL/min and oven temperature 27±0.5°C. UV-Vis spectra were recorded in a range of 190-900 nm and the chromatograms acquired at 240, 330, 350, 520 and 540 nm. 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 particular, cyaniding 3-*O*-rutinoside or keracyanin (Extrasynthèse, Genay, France) was used for the assessment of the anthocyanosides.

2.4 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 (R2 0.9976).

2.5 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 (0.04 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%.

Results and Discussion

Cherry is a traditional crop in Lebanon, well adapted to Lebanon's agro-climactic conditions that are most suitable for its production. According to CCIAZ, in Lebanon many varieties have been introduced in the past. For the market, they have to find the right balance between old varieties and local ones to be sure to respond to the market demand. Local market may vary according to the demand. The cherry harvesting area has decreased from 6337 ha in 2014 to 5802 ha in 2016 (FAO, FAOSTAT) and the production has consequently reduced from 21542 tonnes to 19384 tonnes.

In Zahle, Baalbek and mountainous regions of Lebanon (altitude ranging from 900 to 1800 m) there are numerous clusters of cherry production. Agriculture is the main economic activity of this region due to fertile lands. Local citizens rely on the agriculture as the main source of income and many of them are continuing a family activity. Local farmers involved in the project suffer from low productivity and high costs of production due to several challenges, including scarce propensity in collaborate within a cooperative, lack of quality control standards, bad pest management, and absence of effective fertilization and irrigation programs, lack of knowledge and scarce application of good agricultural practices, basic postharvest sorting procedures. The actual market situation is generally characterized by buyers and middle-men that buy directly by farmers (or at central big market, e.g. in Ferzol). They pay a minimum price to farmers. Hence, the farmers have the possibility to sell all their harvest, but with minimum income.

A comprehensive SWOT (Strengths, Weaknesses, Opportunities and Threats) Analysis based on our assessment informed by the desk-based analysis, the interviews with relevant stakeholders, the direct

visits conducted in a sample of farmers, as well as by the informal visits conducted in the area, is outlined in Table 1.

Table 1. *SWOT Analysis on cherry production in target area. Source: Authors*

STRENGTHS	WEAKNESSES
- Presence of many varieties allows having different maturation time and availability of cherries. - Existing experiences of collective purchase of fertilizers at fixed price.	- Scarce propensity of the farmers in collaborate within a cooperative. - Lack of adoption of quality control standards. - Lack of knowledge and scarce application of good agricultural practices. - Basic postharvest sorting procedures carried out by unspecialized workers (e.g. Syrian refugees). - Not post-harvest techniques in place and cold chain not maintained. - Farmers are not aware about the correct use of pesticides. - For workers, different salaries according to gender. - Effective traceability system not yet in place. - Sale to buyers and intermediaries is at a fixed minimum price. The farmers have the possibility to sell all their harvest, but with minimum income. - Very variable price of cherries.
OPPORTUNITIES	THREATS
- Very fertile lands in the region. - Existence in the area of training and support projects for the introduction of GAP. - Actual main markets are Gulf countries. - Tentative, at pilot level, to introduce integrated farming in the area. - With young farmers could be easier to introduce new agriculture good practices. - Adoption of certifications (e.g. Global GAP, ISO) are important to enter in new markets.	- About cherries, for the local market, no specific taste needed. - Lebanese consumers do not trust in Lebanese organic. - No laws exist to protect local indications. - No Lebanese workers available. - Some irrigation issues.

During the in-field mission, 4 cultivars of sweet cherry (Irani, Nawari, Ferawni and Rainbow) were collected in different geographical areas, obtaining a group of seven samples, whose harvesting area and physicochemical characteristics are shown in Table 2.

Due to reported epidemiological studies providing data about correlations between fruit consumption and reduced risk of chronic diseases, fruits have gained an important place in human nutrition and even

sweet cherries are an excellent source of many nutrients and phytochemicals in addition to contributing to a healthy diet. Sweet cherry fruits are considered highly nutritious fruits where they have significant levels of important nutrients and bioactive components, including glucose, fructose, vitamin C, anthocyanins, quercetin, flavan-3-ols, flavanols and hydroxycinnamate (Gao & Mazza, 1995).

Table 2. *Geographical areas and physicochemical characteristics of different sweet cherry cultivars harvested in May 2018. Source: Authors*

Cultivar	**IRANI**	**NAWARI**	**FERAWNI**	**FERAWNI**	**FERAWNI**	**RAINBOW**
Harvesting area	Kaa Al Rim (1600 m asl)	Kaa Al Rim (1600 m asl)	Wadi El Araayech (1200 m asl)	Kaa Al Rim (1600 m asl)	Rachaya District (1300 m asl)	Wadi El Araayech (1200 m asl)
Average weight of cherries (g)	7.9	11.8	9.0	7.9	8.0	6.7
Average length of the petiole (mm)	32	33	35	51	44	49
Average diameter of cherries (mm)	25	31	26	26	27	23
Relative Skin Mass RSM (%)	8.2	7.3	9.4	8.6	9.1	7.1
Average °Bx (soluble solids content)	21.4	13.7	17.6	17.5	19.1	17.8

In Phenol-Explorer, a comprehensive database on polyphenol content in foods, including more than 35,000 content values for 500 different polyphenols in over 400 foods, and 60,000 original content values found in more than 1,300 scientific publications, the total polyphenol content in sweet cherry is reported as 174.90 mg/100 g FW (calculated by Folin-Ciocalteau test). Ballistreri et al. (2013) has recently carried out an extensive characterization of bioactive compounds in sweet cherries grown in Italy with the evaluation of their antioxidant capacity. All the investigated varieties possessed a considerable antioxidant activity assessed by the ORAC test. Moreover, with the important drive of health-food sector, the potential of using second class cherries including cherry stems as a source of bioactive compound and health-promoting components has been recently proposed (Chockchaisawasdee et al., 2016).

In our study, we decided to concentrate on the antioxidant content of cherry skins, to have a direct comparison among cultivars with red-fleshed and yellow-fleshed fruits, and these are the very initial findings. In Figure 1, the total polyphenolic content calculated by Folin-Ciocalteau test and the total anthocyanosides content evaluated by HPLC/DAD are reported. The major anthocyanin compound found in all the Lebanese varieties was cyanidin 3-*O*-rutinoside (or keracianin), as already reported for other cherry cultivars (Kim et al., 2005).

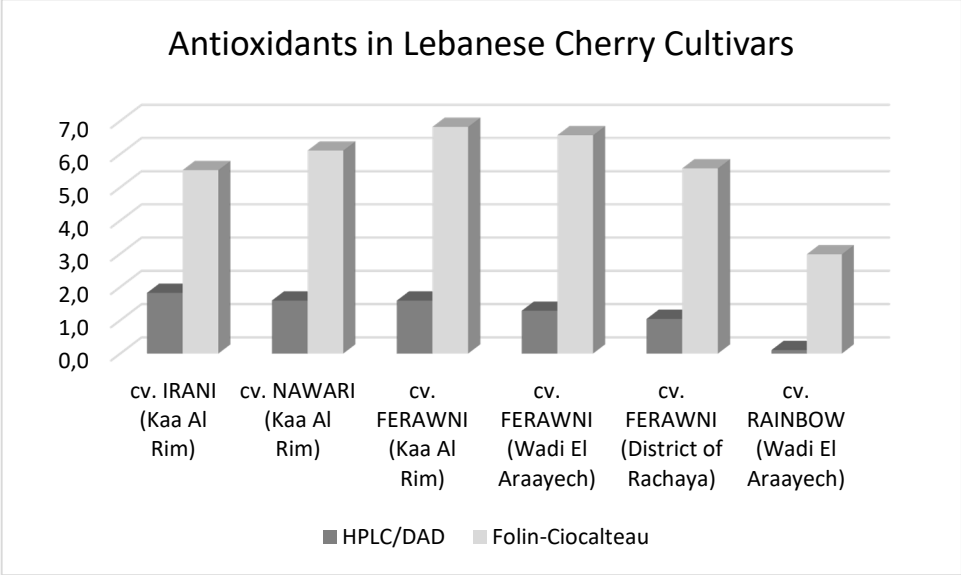

***Figure 1**. Total anthocyanosides content of Lebanese cherry cultivars harvested in May 2018, evaluated by HPLC/DAD and total polyphenolic content calculated by Folin-Ciocalteau test. Data are expressed as mg/g of cherry skins (FW). Source: Authors*

As reported in Figure 1, the data of total polyphenol measured by the spectrophotometric test are in agreement with the results of the HPLC/DAD analysis for the anthocyanosides content. The highest values of antioxidants were registered for the samples coming from Kaa Al Rim, the geographical area at 1600 m altitude. It should be noted that the sampling of cherries was made before the best harvesting time and the main part of fruits were before the optimal grade of ripening, as it is possible to understand also by the Soluble Solid Contents under the value of 19 °Bx (see Table 2), since the mountainous regions are characterized by late-ripening cultivars. Concerning the antiradical activity, we decide to start the evaluation with the yellow-fleshed cherry cv. Rainbow, because it is typical of the region and because it is the sample with the lowest anthocyanosides content, then, its biological activity is presumably not as consistent as in the red-fleshed cherry varieties. Using the UV-Vis spectrophotometric test, the kinetics of scavenging in a 20-min time of the stable radical DPPH was firstly measured by different dilutions of cherry skin extracts (Figure 2A). Secondly, we calculated the EC50, reporting the data as mg of skin fruit that inhibit 1 mg of radical. Figure 2B shows the logarithmic curve of the radical inhibition in function of the hydroalcoholic extract concentration (as mg of skin). The average value calculated for cv. Rainbow was 86.75 mg of skin (FW), and these data correspond to the quantity of cherry skin that inhibits the 50% of the radical molecules. Since the RSM of cv. Rainbow is 7.1% (see Table 2) and the average weight of a single fruit is 6.7 g, it means that the average value of the skin in a single fruit is 480 mg, and then, the registered EC50 corresponds to about a fifth of the weight of a single cherry.

A) B)

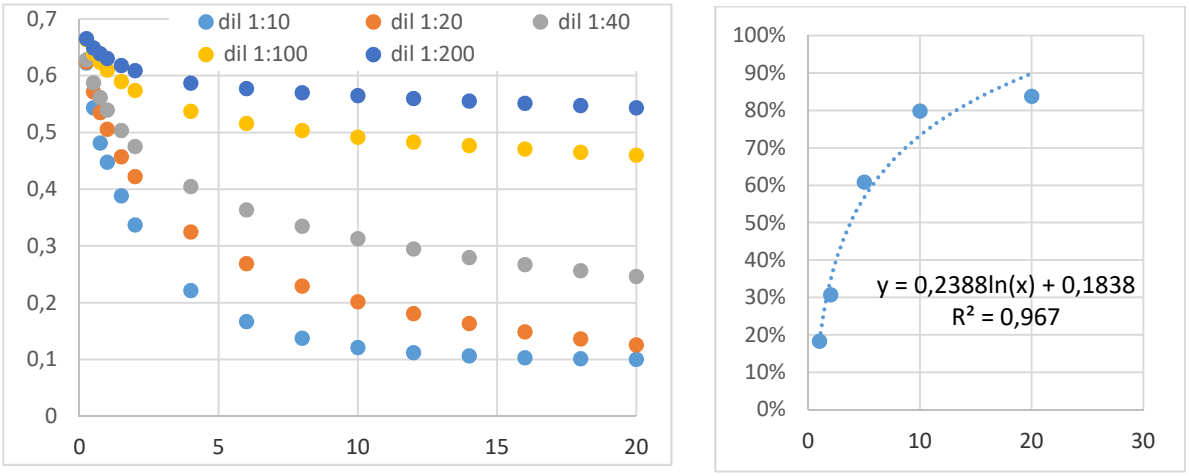

Figure 2. *A) Kinetics of inhibition of different dilutions of cherry skin extracts (cv. Rainbow) on DPPH radical by measuring the Absorbance at 517 nm during 20-min time. B) Logarithmic curve describing the relation between the total polyphenol concentrations of the hydro-alcoholic extract (data are expressed as mg of cherry skin, FW) and the percentage of inhibition of DPPH radical. Source: Authors*

Conclusions

The definition of new quality procedures for Lebanese cherry cultivation will foster more sustainable behavior and improve commitment among the farmers and the other stakeholders. The extensive characterization of polyphenolic antioxidants among local varieties, and the assessment of their biological properties, will be strongly useful for the nutritional valorization of the cherries. This preliminary results, encourage us to follow the investigation also for new applications of Lebanese varieties in dietary and food supplements.

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