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IDENTIFICATION OF FATTY ACIDS IN GRAPE AND TOMATO POMACE – SUSTAINABLE VALORIZATION OF AGRICULTURAL WASTE

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Abstract

Food industry generates large quantities of waste material containing significant amounts of biologically active compounds such as polyphenols, dietary fibers, essential fatty acids etc. Wine industry creates grape pomace during wine manufacturing, whereas tomato derived products industry (ketchup, tomato puree, canned tomatoes, tomato juice, and tomato sauce) produces tomato pomace. Both food wastes contain fruits' seeds as source rich in fatty acids. The aim of this study is to identify fatty acids that are containing in aforementioned types of food waste and to demonstrate the alternative food waste applications other than animal feed. Fatty acids were analyzed using gas chromatography. Grape pomace is richer in linoleic and palmitoleic acid and ω-6 fatty acid in comparison with tomato pomace. Tomato pomace is richer in ω-3 fatty, stearic, palmitic and oleic acids. Grape pomace holds up higher quantity of PUFA and CLA, but lesser amount of SFA and MUFA and cis isomers of oleic acid than tomato pomace.

Key words: *by-product, fatty acid profile, grape pomace, sustainable, tomato pomace*

INTRODUCTION

Roughly, one third from world's annual food production (1.3 metric billion tons) is food waste [25]. European Union countries are given plans to be implemented for proper management with this type of waste, in order to decrease it up to 30% until 2025 and up to 50% until 2030 [7]. Due to the current inefficiency in food economy, there is a constant loss in productivity, energy and ecosystem. Circular Economy encompasses reuse, recovery and recycle of existing materials, briefly, the waste becomes resource at a certain point [14]. It helps in amelioration and optimization of the sustainability of Western food system. According to Rana et al., 2021 [19] valorization of agro industrial waste through green and biotechnological processes is feasible approach for its reduction. Wine and tomato industries generate large and bulky waste, which is challenging to manage. Grape pomace (GP) is a by-product of the wine industry. This waste contains skin, seeds and stalks (Fig. 1a) [24]. Tomato pomace (TP) is a by-product of tomato derived products industry and contains seeds and skin (Fig. 1b) [3].

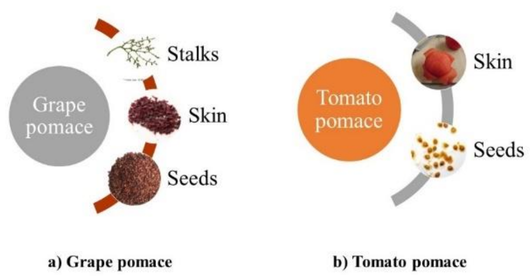

Fig. 1. Constituents of grape and tomato pomace
Source: Own design.

In our previous work, the chemical composition of grape pomace was estimated. [18]. According to many authors, GP by-product is an excellent source of dietary fibers

[11], phenolic compounds [4] and lipids [13]. Moreover, GP has high antioxidant activity [10], whereas grape seed oil is plentiful in linoleic and oleic acids [1]. The chemical composition of grape pomace is grape variety and level of ripeness dependent among other factors [1]. Once tomatoes are transformed in puree, juice, sauces and ketchup, the generated waste is called tomato pomace that is composed of seeds, peels and a little quantity of pulp [26]. Due to the good chemical composition of tomato, tomato waste is characterized as an excellent source of lycopene, dietary fibers, proteins and lipids. This chemical composition relies on the proportion of peels and seeds in the tomato pomace, since the peels are richer in dietary fibers, lycopene and phenols, while the seeds generally contain lipids and proteins [17]. According to the scientifically available information, the dietary fiber content in TP is in the range of 39.11 and 68.04 g per 100 g DM, the protein content is in the range of 16.00 and 24.67 g per100 g DM, the amount of minerals lies between 2.88 and 5.29 g per 100 g DM, while the amount of lipids varies between 2.00 and 16.24 g per 100 g DM [9, 12, 20, 21]. Grape pomace is abundant in unsaturated fatty acids (UFA), linoleic and oleic in particular, which make up more than 68% from the total content of fatty acids [5]. The essential oil of tomato seeds can be used in daily nutrition due to its high nutritional value. This tomato seed oil extract is high in content in palmitic, linoleic, arachidic, oleic and stearic acids, whereas the content of unsaturated fatty acids (UFA) accounts for approximate 80% [17]. Due to the high lipid quantity in GP and TP, the aim of this paper was determine the fatty acid profile and highlight the most important fatty acids. In this manner, we can validate the potential alternative use of these types of food waste as a source of functional foods, nutraceuticals and cosmetics formulation. Their further use will contribute for sustainable agro food waste development.

MATERIALS AND METHODS

Preparation of grape and tomato pomace

Grape pomace was collected after separating the grape juice from the red grapes. The residuals (stalks, seed and skin) were placed on stainless steel pans and were dried for 48 hours at 60 ºC in the UFE 500 oven (Memmert GmbH, Schwabach, Germany). Afterwards the dry grape pomace was ground using an IKA MF10 grinder (IKA®-Werke GmbH & Co. KG, Staufen, Germany). Tomato pomace (seeds and peels) was collected after extracting the juice from technological mature tomatoes. It was dried at 45 ºC in UFE 500 oven (Memmert GmbH, Schwabach, Germany), and subsequently pulverized on an IKA MF10 grinder (IKA®-Werke GmbH & Co. KG, Staufen, Germany). Both types of pomace were placed in vacuum bags and vacuum stored at a temperature of 4ºC.

Lipid extraction form grape and tomato pomace

For the lipid extraction, 25 g from the grape pomace powder and 10 g from tomato pomace powder were used. Static extraction was performed employing chloroform and methanol as an extracting solvent in ratio 1:2. The extraction process was repeated twice. The whole extract was transferred in separating funnel, while water was added for phase separation. After the separation of the aqueous phase, the non-polar phase was transferred into vacuum evaporator, followed by complete drying and evaporation of the extracting solution [6].

Identification of fatty acid profile of grape and tomato pomace

Identification of fatty acids in grape and tomato pomace was performed using gas chromatograph Shimadzu-2010 gas chromatograph (Kyoto, Japan). The assay was performed with a CP7420 capillary column (100 m x 0.25 mm i.d., 0.2 m, Varian Inc., Palo Alto, CA), with carrier gas-hydrogen and make-up gas-nitrogen. A five-stape gas chromatographic oven program has been used.

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Statistical analysis

The presented values are the mean values from three replicates. To determine least significant difference Fisher's test was employed ($p < 0.05$), using the software XL STAT 2019 (Addinsoft Inc. Long Island City, NY, USA).

RESULTS AND DISCUSSIONS

In the food industry, the oil extracted from grape and tomato seeds can be promoted as cheaper oil compared to other types of oil, representing a new source of nutrition in humans' diet at the same time [17, 22]. Nevertheless, tomato pomace contains extensive quantities of lipophilic bioactive compounds (carotenoids and unsaturated fatty acids). Therefore, this food waste can be utilized as a source for manufacturing high quality extracts [23]. Mainly, the fatty acid content in grape and tomato pomace comes from the occurrence of the seeds in the pomace itself. The seeds are highly valued due to the good nutritional characteristics of the extracted oil from them, which are high in unsaturated fatty acids (oleic and linoleic) [5]. In Fig. 2, the quantities of stearic, palmitic, palmitoleic, oleic, linolenic and linoleic fatty acids in grape and tomato pomace are presented. The highest content of unsaturated fatty acids present in pomaces were oleic and linoleic acids. According to Lu et al., 2019 [17] oil extract from tomato seeds had the highest linoleic acid content. The quantity of palmitic acid in tomato pomace was higher than the one in grape pomace. Jin et al., 2019 [13] presented results for the palmitic acid content varying between 7.81 and 10.6 g/100 oil and steric acid content in the range between 2.51 and 6.12 g/100 g oil in their investigation of fatty acids identification in grape pomace produced from different varieties of red grapes. The amount of palmitoleic acid in grape and tomato pomace was estimated to be 0.39 and 0.35 g/100 g oil, respectively, while stearic acid can be found in capacity of 3.75 g/100 g oil in grape pomace and 5.98 g/100 g oil in tomato pomace.

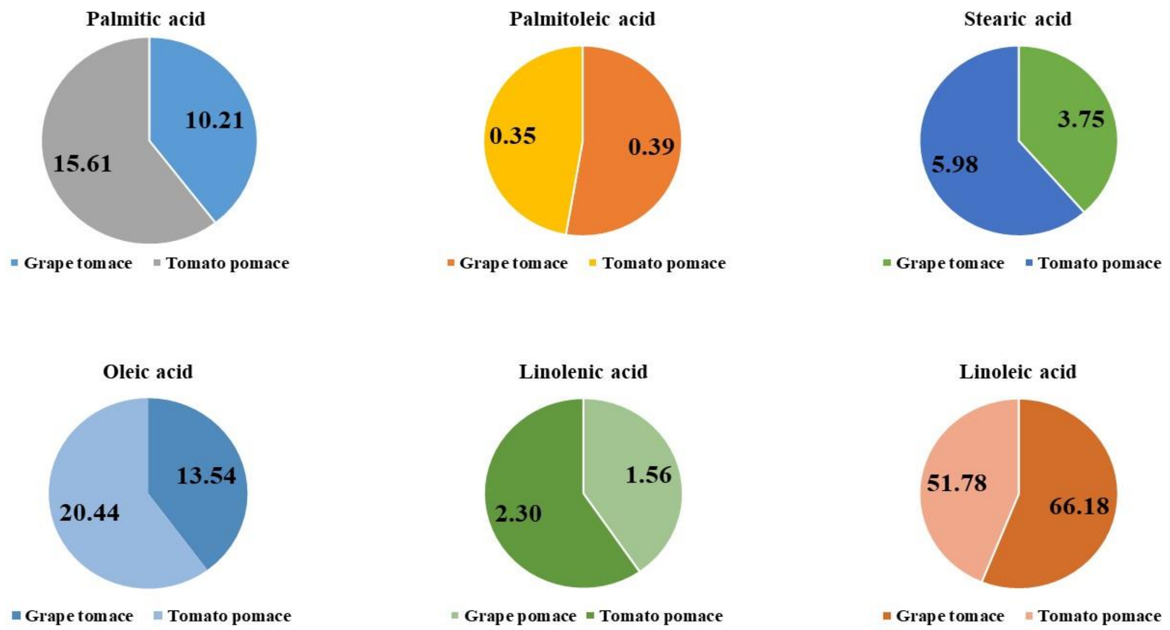

Fig. 2 Different fatty acids (g/100g oil) in grape and tomato pomace
Source: Own design.

According to Beres et al., 2017 [5] saturated stearic fatty acids in grape seeds were present in quantities of 3-6%. α-linolenic acid as a part of essential fatty acids has a role of precursor for long chain fatty acids [22]. This fatty acid is present in quantities of 1.54 g/100 g oil in grape pomace, while in tomato pomace the concentration is higher (2.30

g/100g oil). According to Lazos et al., 1998 [15] tomato pomace is a good source of fatty acids: linoleic, oleic, and palmitic acids present in different ratios, dependant of tomato varieties producing the pomace, the degree of ripeness, and climate conditions during cultivation.

The values of different groups of fatty acids present in the grape and tomato pomace are demonstrated in Table 1. The ANOVA for different groups of fatty acids highlighted significant differences among the two pomaces (grape and tomato) types. The total amount of saturated fatty acids (SFA) in our grape pomace was 14.78% in comparison to 21.97% in tomato pomace.

Table 1. Total groups of fatty acids (%) present in grape and tomato pomace

	Grape pomace	Tomato pomace
Saturated fatty acids (SFA)	$14.78^{e}\pm0.01$	$21.97^{c}\pm0.02$
Monounsaturated fatty acids (MUFA)	$15.38^{d}\pm0.01$	$22.00^{c}\pm0.02$
Polyunsaturated fatty acid (PUFA)	$68.81^{a}\pm0.07$	$55.02^{a}\pm0.05$
Conjugated linoleic acid (CLA)	$0.22^{h}\pm0.00$	$0.15^{g}\pm0.00$
ΣΩ-3 fatty acid	$1.77^{g}\pm0.00$	$2.95^{f}\pm0.00$
ΣΩ-6 fatty acid	$66.84^{b}\pm0.06$	$51.92^{b}\pm0.05$
Σn-6/Σn-3	$37.78^{c}\pm0.01$	$17.58^{e}\pm0.00$
Cis isomers of oleic acid	$14.36^{f}\pm0.01$	$21.02^{d}\pm0.02$

The means are calculated from three repetitions. Values in the same row with different letters are significantly different (p<0.05) following Fisher`s LSD test.

Source: Own results.

Fernandes et al., 2013 [9] determined 14.94% SFA in the seeds of the grape variety Tinta Barroca that is in accordance with our results. In addition, Aksoylu Özbek et al., 2020 [2] discovered 18.06% SFA in tomato pomace acquired from tomatoes cold pressing and their subsequent drying. The quantity of monounsaturated fatty acids (MUFA) in GP was 15.38% and in TP was 22.00%.

In the study of Aksoylu Özbek et al., 2020 [2] the fraction of monounsaturated fatty acids (MUFA) in tomato pomace was 28.84%, while the same fraction was reported in quantities in the range of 14.19 - 21.29% by Fernandes et al., 2013 [8]. These literature data are in accordance with our findings. The amount of monounsaturated fatty acid (MUFA) in grape and tomato pomace was estimated as 15.38% and 22.00%, respectively. In the study of Fernandes et al., 2013 [8] the content of PUFA fraction evaluated in the seeds of different grape varieties was in the range of 63.64% to 73.53% which was significantly higher than our results. In contrast to our results, Aksoylu Özbek et al., 2020 [2] reported 53.10% PUFA in tomato pomace. The occurrence of conjugated linoleic acid (CLA) was determined in grape pomace (0.22%) and in tomato pomace (0.15%). It is assumed that CLA has positive effects on cardio metabolic risk factors, while its positive impact on glycemic index, arteriosclerosis and cancer are already proven with experimental methods [16]. Modern lifestyle differs from what human genetic structure is created. The studies show enormous changes in the nutrition, especially in the type and quantity uptake of essential fatty acids and antioxidants from food [16]. ω-3 and ω-6 are essential fatty acids likewise found in food waste. The total amount of ω-3 fatty acid in GP was 1.77%, while its content in TP was 2.95%. In addition, the quantity of ω-6 fatty acids in GP and TP was found to be 66.84% and 51.92%, respectively. The ratio between essential fatty acids in GP and TP was 37.8/1 and 17.6/1, respectively. Today's human nutrition evolved from nutrition in which ω-6/ω-3 ratio was approximately 1 to a nutrition with ω-6/ω-3 ratio in the range of 15/1 and 16/1. The agribusiness and modern agriculture promote the reduction of ω-3 fatty acids and increase of ω-6 fatty acids. All this causes imbalance of the characteristic food from the past [16]. Cis isomers of oleic acid in grape and tomato pomace was 14.36% and 21.02% respectively.

CONCLUSIONS

Grape and tomato pomace are by-products from the food industry, which have large quantities of biologically active compounds (polyphenols, dietary fibers, vitamins) in their content. They also contain big quantities of fatty acids due to the presence of the fruit seeds in both types of pomace. From the fatty acid profile of both pomaces, it can be concluded that GP is richer in linoleic acid and ω-6 fatty acid in comparison to TP. On the other hand, TP has a higher content of palmitic, stearic, oleic and ω-3 fatty acids then GP. When the comparison is in terms of different groups of fatty acids, grape pomace has more PUFA and CLA in its content than tomato pomace. The latter is richer in SFA, MUFA and cis isomers of oleic acid.

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