**Original Paper** 

# Fatty acid profile analysis of grape by-products from Slovakia and Austria

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The objective of the present study was to determine the fatty acid profile of grape pomace, grape stem and grape bunch of three different cultivars of *Vitis vinifera* sp. (Green Veltliner, Pinot Blanc and Zweigelt) from two countries as a possible sources for animal nutrition. Fatty acid profile analysis was performed using the Agilent 6890 A GC machine. Significant differences (P < 0.05) in fatty acid content of analyzed samples were detected between the countries, as well as between the cultivars within countries. Grape pomaces and grape bunches were rich in polyunsaturated fatty acids (70.91–71.86%), represented mainly by linoleic acid (69.79–70.32%), and low in saturated fatty acids (12.42–12.96%). Grape stems were characterized by a high saturated fatty acids content (24.46–30.85%), but on the other hand, these samples had the highest  $\alpha$ -linolec acid concentration (9.98–14.52%). Oleic acid (12.24–15.17%) was the most abundant from monounsaturated fatty acids (12.69–15.33%) in all the analyzed samples. These results indicate a strong impact of the grape variety and location on the fatty acid profile of grape by-products and their potential to be evaluated as feed additives with high polyunsaturated fatty acids concentration in animal nutrition.

**Keywords:** grape pomace, grape stalk, fatty acids, PUFA, SFA

## 1 Introduction

Grape industry generates a large amount of by-products with problematic disposal which can cause serious environmental issues (Botella et al., 2005, Rondeau et al., 2013, Bekhit et al., 2016). The two most abundant by-products of grape processing are pomace and stalks (Makris et al., 2007). Grape pomace represents about 20–25% of the weight of wine grapes (Yu and Ahmedna, 2013), the amount of stems can vary between 1.4–7% (Souquet et al., 2000). The nutritional value and the digestibility of these by-products is, due to high fiber content, generally low, but many experiments showed, that these products can be used a substantial source of certain nutrients and biologically active compounds in animal nutrition (Viveros et al., 2011, Teixeira et al., 2014, Chamorro et al., 2015, Domínguez et al., 2016, Kerasioti

el al., 2017). They can also help to reduce production costs and to create innovative feed mixtures in order to increase the quality of animal products (Tangolar et al., 2009, Fontana et al., 2013, Guerra-Rivas et al., 2016, Kafantaris et al., 2018). According to Botella et al. (2005) the incorporation of winery by-products in livestock feeds may also positively affect the environment by reducing the toxic impact of their inappropriate disposal by leaving on open spaces or burning. Fatty acids of grape by-products, particularly those of grape pomace, are characterized with high concentrations of linoleic and oleic acids (Yi et al., 2009). Due to this fact, by-products of wine industry could positively influence the fatty acid profile of milk and meat, with a perspective of obtaining less saturated and healthier animal products (Nistor et al., 2014, Guerra-Rivas et al., 2016, Chedea et al., 2018). On this regard the objective

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of this study was to determine and compare the fatty acid profile of grape pomace, grape stems and grape bunches from two countries as possible sources of these nutrients for animal nutrition.

#### 2 Material and methods

The pomace, as a by-product of juice pressing in wine industry, mainly contained of residual grape skin, seeds and pulps. Grape stems were only rachis, peduncle and pedicels after removing grape berries. In total, 54 samples from 3 varieties from 6 different locations were analysed. Laboratory samples were processed in the Laboratory of Quality and Nutritive Value of Feeds (Department of Animal Nutrition, Slovak University of Agriculture in Nitra) using standard laboratory procedures and principles (EC No 152/2009). Prior to evaluating the fatty acid profile of analyzed samples, triglycerides in their lipid fraction to glycerol and free fatty acids were hydrolyzed. Free fatty acids were then converted to methylesters (FAMEs) according to the following procedure. Solution was diluted by hexane (10 ml) and 2 N potassium hydroxide in methanol (1 ml). Analytic tube was heated in water bath (30 seconds at 60 °C). After 1 minute 1 N hydrochloric acid (2 ml) was added. The top layer was transmitted (2 ml) to autosampler vial containing ninhydrin (Na<sub>2</sub>SO<sub>4</sub>). On a specialized analytical column (Supelco 47885-U) the separation of FAMEs, based on the carbon number and level of saturation, took place. FAMEs with the shortest carbon chain (the lowest boiling point) were separated first. Subsequently, the individual fatty acids were identified by a flame ionization detector (FID). Analyis were performed on gas chromatograph Agilent 6890A GC (Agilent Technologies, USA). The fatty acids profile of grape by-products was determined as percentage of crude fat. Results were statistically evaluated with IBM SPSS v. 20.0. Descriptive statistics using one-way ANOVA were generated. Then, statistical significance of results were separated using Tukey test.

### 3 Results and discussion

The analyzed grape by-products were characterized by their specific fatty acid (FA) profiles (Table 1 and Table 2). Despite the significant (P < 0.05) differences between the countries, as well as between the cultivars within countries, some similarities in the fatty acid composition of grape pomace, stems and bunches were detected. The samples mainly composed of polyunsaturated fatty acids (PUFA), mostly represented by linoleic acid, especially in grape pomace and grape bunches. This result is consistent with the grape seed content of these products as a source of linoleic acid rich grape oil (Fernandes et al., 2013, Yousefi et al., 2013, Hussein and Abdrabba, 2015, Ovcharova et al., 2016). In grape stems

interesting content of  $\alpha$ -linoleic acid was detected. Oleic acid, as a monounsaturated fatty acid (MUFA), was the most abundant in all the studied by-products. Grape stems contained the highest amount of saturated fatty acids (SFA), mainly palmitic and stearic acid. The high content of palmitic acid in pomaces may be due to surplus saturated compounds in their waxy structure (Gülcü et al., 2019). Arachidonic and behenic acid were present in pomaces below 1%, whereas in bunches these fatty acids, except two samples (Pinot Blanc and Zweigelt from Slovakia), were not found. This corresponds with low levels of SFA in grape seeds (Tangolar et al., 2009; Gül et al., 2013, Mironeasa et al., 2016, García-Lomillo and Gonzáles-San José, 2017).

The FA profile of grape pomace is well documented in the literature, but only a limited number of papers has been published on the content of FA in grape stem and grape bunch. In red grape pomace Yi et al. (2009) found average values of 21.2% SFA, 14.4% MUFA and 62.7% PUFA. Ribeiro et al. (2015) reported an average PUFA concentration in grape pomaces around 72.86% with the predominance of linoleic (60.04%) and  $\alpha$ -linolenic (13.64%) acid, followed by oleic (12.97%) and palmitic (6.72%) acid. Stearic acid was present in the analyzed pomaces below 5%. In comparison with Guerra-Rivas et al. (2016) lower amounts of all the FA were detected for grape pomaces. On the other hand, Tsiplakou and Zervas (2008) and Gülcü et al. (2019) measured higher content of the same FA, except for linoleic acid. Russo et al. (2017) studied the FA profile of six grape pomaces with very similar results as obtained in this experiment. These authors also reported that grape stalk contained 21% palmitic, 4.6% stearic, 10.7% oleic, 35.4% linoleic, 13.4%  $\alpha$ -linoleic and 11.3% behenic acid.

The total comparison of FA profile of grape by-products from Slovakia and Austria is shown in Table 3. The grape pomace samples from both countries had significantly different (P < 0.05) content of all the studied FA. In the case of grape stems significant differences (P < 0.05) for oleic, α-linoleic, arachidic and behenic acids concentration, as well as overall MUFA content, were found. The grape bunches from two counties significantly differed (P < 0.05) in stearic, oleic, linoleic and  $\alpha$ -linoleic acids content. A justification for this differences between the FA content of grape-by products could be related to different agro-climatic conditions of the growing regions (García-Lomillo and Gonzáles-San José, 2017). Bennemann et al. (2016) state, that the quality of grapes is greatly influenced by factors such as soil, weather, temperature, humidity and solar radiation.

 Table 1
 Fatty acid profile of grape by-products from Slovakia (% fat-1)

Palmittic acid   pomace   8.64 ± 0.11*   8.13 ± 0.01*   7.69 ± 0.02*   stems   15.80 ± 0.45*   10.68 ± 0.49*   13.14 ± 0.08*   pomace   3.56 ± 0.05*   3.95 ± 0.00*   4.03 ± 0.00*   3.56 ± 0.05*   3.95 ± 0.00*   4.03 ± 0.00*   4.	,	. 3.77	Green Veltliner	Pinot Blanc	Zweigelt
Palmitic acid stems 15.80 ±0.45° 10.68 ±0.49° 13.14 ±0.68 bunch 8.85 ±0.02° 8.57 ±0.10° 7.47 ±0.05° pomace 3.56 ±0.05° 3.95 ±0.00° 4.03 ±0.00° 3.56 ±0.05° 3.95 ±0.00° 4.03 ±0.00° 3.56 ±0.05° 3.95 ±0.00° 4.03 ±0.00° 3.68 ±0.05° 3.95 ±0.00° 4.03 ±0.00° 3.50 ±0.00° 4.00 ±0.00° 5.00 ±			Mean ±Standard Deviati	on	1
bunch   8.85 ±0.02*   8.57 ±0.10*   7.47 ±0.05*     pomace   3.56 ±0.05*   3.95 ±0.00*   4.03 ±0.00*     stems   3.52 ±0.21*   4.03 ±0.18*   3.86 ±0.05*     bunch   3.42 ±0.02*   4.06 ±0.03*   4.17 ±0.01*     pomace   10.91 ±0.07*   17.52 ±0.02*   16.34 ±0.02*     collected   stems   14.34 ±0.92*   16.12 ±0.12*   15.04 ±0.31*     bunch   10.21 ±0.01*   17.09 ±0.15*   17.03 ±0.06*     bunch   10.21 ±0.01*   17.09 ±0.15*   17.03 ±0.06*     tems   3.68 ±1.14*   57.19 ±1.21*   45.47 ±1.05*     bunch   74.40 ±0.03*   67.66 ±0.25*   68.90 ±0.04*     tems   15.17 ±0.62*   5.74 ±0.13*   9.03 ±0.62*     bunch   2.38 ±0.03*   1.22 ±0.06*   1.01 ±0.05*     bunch   2.38 ±0.03*   1.22 ±0.06*   1.01 ±0.05*     bunch   ND*   0.24 ±0.00*   0.24 ±0.00*     Arachidic acid   stems   3.21 ±0.07*   1.21 ±0.03*   2.89 ±0.09*     bunch   ND*   ND   ND   ND     pomace   0.19 ±0.01*   0.11 ±0.00*   0.11 ±0.00*     bunch   ND   ND   ND   ND     pomace   74.83 ±0.25*   68.37 ±0.02*   69.52 ±0.02*     bunch   76.78 ±0.03*   68.88 ±0.18*   69.91 ±0.08*     bunch   76.78 ±0.03*   68.88 ±0.18*   69.91 ±0.08*     bunch   10.21 ±0.01*   17.39 ±0.15*   15.04 ±0.31*     bunch   10.21 ±0.01*   17.39 ±0.15*   17.34 ±0.06*     bunch   1	Palmitic acid	pomace	8.64 ±0.11a	8.13 ±0.01 <sup>b</sup>	7.69 ±0.02°
Stearic acid   Stems   3.56 ± 0.05°   3.95 ± 0.00°   4.03 ± 0.05°     bunch   3.42 ± 0.02°   4.06 ± 0.03°   4.17 ± 0.01°     bunch   3.42 ± 0.02°   4.06 ± 0.03°   4.17 ± 0.01°     pomace   10.91 ± 0.07°   17.52 ± 0.02°   16.34 ± 0.02°     bunch   10.21 ± 0.01°   17.09 ± 0.15°   17.03 ± 0.06°     bunch   10.21 ± 0.01°   17.09 ± 0.15°   17.03 ± 0.06°     bunch   5.21°   5.02°   66.75 ± 0.01°     bunch   5.21°   5.02°   67.59 ± 0.02°   66.75 ± 0.01°     bunch   74.40 ± 0.03°   67.66 ± 0.25°   68.90 ± 0.04°     bunch   74.40 ± 0.03°   67.66 ± 0.25°   68.90 ± 0.04°     bunch   2.38 ± 0.03°   1.22 ± 0.06°   1.01 ± 0.05°     bunch   2.38 ± 0.03°   1.22 ± 0.06°   1.01 ± 0.05°     bunch   8.23 ± 0.03°   1.22 ± 0.06°   1.01 ± 0.05°     bunch   ND°   0.24 ± 0.00°   0.25 ± 0.00°     bunch   ND°   0.24 ± 0.00°   0.25 ± 0.00°     bunch   ND°   ND°   ND°     pomace   74.83 ± 0.25°   68.37 ± 0.02°   69.52 ± 0.02°     bunch   76.78 ± 0.03°   68.88 ± 0.18°   69.91 ± 0.08°     bunch   76.78 ± 0.03°   68.88 ± 0.18°   69.91 ± 0.08°     bunch   10.21 ± 0.01°   17.39 ± 0.15°   17.34 ± 0.06°     bunch   10.21 ± 0.01°   17.39 ± 0.15°   17.34 ± 0.06°     stems   28.87 ± 0.78°   18.45 ± 0.73°   26.06 ± 0.71°     bunch   10.21 ± 0.01°   17.39 ± 0.15°   17.34 ± 0.06°     stems   28.87 ± 0.78°   18.45 ± 0.73°   26.06 ± 0.71°     bunch   10.21 ± 0.01°   17.39 ± 0.15°   17.34 ± 0.06°     stems   28.87 ± 0.78°   18.45 ± 0.73°   26.06 ± 0.71°     bunch   10.21 ± 0.00°   0.11 ± 0.00°     stems   28.87 ± 0.78°   18.45 ± 0.73°   26.06 ± 0.71°     bunch   10.21 ± 0.00°   0.11 ± 0.00°     bunch   0.03 ± 0.00°   0.01 ± 0.00°     bunch   0.03 ± 0.00°   0.02 ± 0.00°     bunch   0.03 ± 0.00°   0.01 ± 0.00°     bunch   0.03 ± 0.00°   0.09 ± 0.03°     bunch   0.03 ± 0.00°   0.09 ± 0.03°     bunch   0.03 ± 0.00°   0.0		stems	15.80 ±0.45°	10.68 ±0.49b	13.14 ±0.68°
Stearic acid         stems         3.52 ± 0.21°         4.03 ± 0.18°         3.86 ± 0.05°           bunch         3.42 ± 0.02°         4.06 ± 0.03°         4.17 ± 0.01°           Oleic acid         stems         10.91 ± 0.07°         17.52 ± 0.02°         16.34 ± 0.02°           bunch         10.21 ± 0.01°         17.09 ± 0.15°         15.04 ± 0.31°           bunch         10.21 ± 0.01°         17.09 ± 0.15°         17.03 ± 0.06°           bunch         36.86 ± 1.14°         57.19 ± 1.21°         45.47 ± 1.05°           bunch         74.40 ± 0.03°         67.59 ± 0.02°         68.90 ± 0.04°           a-linoleic acid         stems         36.86 ± 1.14°         57.19 ± 1.21°         45.47 ± 1.05°           bunch         74.40 ± 0.03°         67.66 ± 0.25°         68.90 ± 0.04°         0.77 ± 0.01°           α-linoleic acid         stems         15.17 ± 0.62°         5.74 ± 0.13°         9.03 ± 0.62°           bunch         2.38 ± 0.02°         1.22 ± 0.00°         1.01 ± 0.05°           bunch         2.38 ± 0.03°         1.22 ± 0.00°         1.01 ± 0.05°           bunch         ND°         0.24 ± 0.00°         0.25 ± 0.02°           bunch         ND°         0.24 ± 0.00°         0.25 ± 0.02°           stems		bunch	8.85 ±0.02°	8.57 ±0.10 <sup>b</sup>	7.47 ±0.05°
Dunch   3.42 ±0.02*   4.06 ±0.03*   4.17 ±0.01*	Stearic acid	pomace	3.56 ±0.05°	3.95 ±0.00b	4.03 ±0.00°
Domace   10.91 ±0.07*   17.52 ±0.02*   16.34 ±0.02*   16.34 ±0.02*   16.12 ±0.12*   15.04 ±0.31**   17.09 ±0.15*   17.03 ±0.06*   17.09 ±0.15*   17.03 ±0.06*   17.09 ±0.15*   17.03 ±0.06*   17.09 ±0.15*   17.03 ±0.06*   17.09 ±0.15*   17.03 ±0.06*   17.09 ±0.15*   17.03 ±0.06*   17.09 ±0.15*   17.03 ±0.06*   17.09 ±0.15*   17.03 ±0.06*   17.09 ±0.15*   17.03 ±0.06*   17.09 ±0.15*   17.03 ±0.06*   17.09 ±0.15*   17.03 ±0.06*   17.09 ±0.15*   17.03 ±0.06*   17.09 ±0.15*   17.03 ±0.06*   17.09 ±0.15*   17.03 ±0.05*   17.09 ±0.15*   17.09 ±0.15*   17.09 ±0.15*   17.09 ±0.15*   17.09 ±0.15*   17.09 ±0.15*   17.09 ±0.15*   17.09 ±0.15*   17.09 ±0.15*   17.09 ±0.15*   17.09 ±0.15*   17.09 ±0.15*   17.09 ±0.15*   17.09 ±0.05*   17.09 ±0		stems	3.52 ±0.21°	4.03 ±0.18 <sup>b</sup>	3.86 ±0.05ab
Oleic acid         stems         14.34 ± 0.92²         16.12 ± 0.12²         15.04 ± 0.31²²           bunch         10.21 ± 0.01²         17.09 ± 0.15²         17.03 ± 0.66²           pomace         73.08 ± 0.23²         67.59 ± 0.02²         68.75 ± 0.01²           stems         36.86 ± 1.14²         57.19 ± 1.21²         45.47 ± 1.05²           bunch         74.40 ± 0.03²         67.66 ± 0.25²         68.90 ± 0.04²           φomace         1.75 ± 0.02²         0.78 ± 0.00²         0.77 ± 0.01²           stems         15.17 ± 0.62²         5.74 ± 0.13²         9.03 ± 0.62²           bunch         2.38 ± 0.03²         1.22 ± 0.06²         1.01 ± 0.05²           pomace         0.28 ± 0.01²         0.24 ± 0.00²         0.24 ± 0.00²           pomace         3.21 ± 0.07²         1.21 ± 0.03²         2.89 ± 0.09²           bunch         ND°         0.24 ± 0.00²         0.25 ± 0.00²           Behenic acid         stems         3.62 ± 0.11²         1.95 ± 0.08²         4.76 ± 0.15²           bunch         ND         ND         ND         ND           pomace         74.83 ± 0.25²         68.37 ± 0.02²         69.52 ± 0.02²           PUFA         stems         54.26 ± 1.81²         62.93 ± 1.15²         54.		bunch	3.42 ±0.02 <sup>a</sup>	4.06 ±0.03 <sup>b</sup>	4.17 ±0.01°
bunch   10.21 ±0.011   17.09 ±0.151   17.03 ±0.061     pomace   73.08 ±0.232   67.59 ±0.022   68.75 ±0.011     stems   36.86 ±1.144   57.19 ±1.211   45.47 ±1.052     bunch   74.40 ±0.033   67.66 ±0.253   68.90 ±0.044     pomace   1.75 ±0.022   0.78 ±0.009   0.77 ±0.011     α-linoleic acid   stems   15.17 ±0.622   5.74 ±0.133   9.03 ±0.622     bunch   2.38 ±0.033   1.22 ±0.066   1.01 ±0.052     bunch   2.38 ±0.031   1.22 ±0.066   1.01 ±0.052     bunch   ND   0.24 ±0.009   0.25 ±0.009     Arachidic acid   stems   3.21 ±0.079   1.21 ±0.033   2.89 ±0.099     bunch   ND   0.24 ±0.009   0.25 ±0.009     Behenic acid   stems   3.62 ±0.119   1.95 ±0.088   4.76 ±0.155     bunch   ND   ND   ND     PUFA   stems   54.26 ±1.819   62.93 ±1.159   54.51 ±0.467     bunch   76.78 ±0.033   68.88 ±0.189   69.91 ±0.089     MUFA   stems   14.34 ±0.922   16.31 ±0.433   15.04 ±0.021     bunch   10.21 ±0.011   17.39 ±0.155   17.34 ±0.065     bunch   12.28 ±0.029   16.97 ±0.029   11.99 ±0.155     bunch   12.28 ±0.029   0.01 ±0.009   0.01 ±0.005     bunch   12.28 ±0.029   0.01 ±0.005   0.01 ±0.005     bunch   0.03 ±0.000   0.01 ±0.005   0.01 ±0.005     bunch   0.03 ±0.000   0.02 ±0.005   0.01 ±0.005     bunch   0.03 ±0.005   0.01 ±0.005   0.01 ±0.005     bunch   0.03 ±0.005   0.02 ±0.005   0.01 ±0.005     bunch   0.03 ±0.005   0.01 ±0.005   0.01 ±0.005     bunch   0.03 ±0.005   0.02 ±0.005   0.01 ±0.005     bunch		pomace	10.91 ±0.07°	17.52 ±0.02 <sup>b</sup>	16.34 ±0.02°
Domace   73.08 ±0.23   67.59 ±0.02   68.75 ±0.01     Stems   36.86 ±1.14   57.19 ±1.21   45.47 ±1.05     Dunch   74.40 ±0.03   67.66 ±0.25   68.90 ±0.04     Domace   1.75 ±0.02   0.78 ±0.00   0.77 ±0.01     Stems   15.17 ±0.62   5.74 ±0.13   9.03 ±0.62     Dunch   2.38 ±0.03   1.22 ±0.06   1.01 ±0.05     Dunch   2.38 ±0.03   1.22 ±0.06   1.01 ±0.05     Dunch   ND   0.24 ±0.00   0.25 ±0.00     Dunch   ND   ND   ND     Dunch   ND   ND   ND     Domace   74.83 ±0.25   68.37 ±0.02   69.52 ±0.02     PUFA   Stems   54.26 ±1.81   62.93 ±1.15   54.51 ±0.46     Dunch   10.21 ±0.01   17.39 ±0.15   17.34 ±0.06     Dunch   10.21 ±0.01   17.39 ±0.15   17.34 ±0.06     Stems   28.87 ±0.78   18.45 ±0.73   26.06 ±0.71     Dunch   12.28 ±0.02   12.98 ±0.29   11.99 ±0.15     Dunch   12.28 ±0.02   12.98 ±0.29   11.99 ±0.15     Dunch   12.28 ±0.02   12.98 ±0.29   11.99 ±0.15     Dunch   10.31 ±0.00   0.01 ±0.00   0.01 ±0.00     Ratio Σn3/n6   stems   44.72 ±0.47   86.60 ±0.13   89.59 ±0.75     Ratio Σn3/n6   stems   23.4 ±0.03   9.96 ±0.39   5.05 ±0.47     Domace   44.72 ±0.47   86.60 ±0.13   89.59 ±0.75     Ratio Σn3/n6   stems   23.4 ±0.03   9.96 ±0.39   5.05 ±0.47     Domace   44.72 ±0.47   86.60 ±0.13   89.59 ±0.75     Domace   44.72 ±0.47   86.6	Oleic acid	stems	14.34 ±0.92°	16.12 ±0.12 <sup>b</sup>	15.04 ±0.31ab
Linoleic acid         stems         36.86 ± 1.14*         57.19 ± 1.21*         45.47 ± 1.05*           bunch         74.40 ± 0.03*         67.66 ± 0.25*         68.90 ± 0.04*           ρomace         1.75 ± 0.02*         0.78 ± 0.00*         0.77 ± 0.01*           δunch         2.38 ± 0.03*         5.74 ± 0.13*         9.03 ± 0.62*           bunch         2.38 ± 0.03*         1.22 ± 0.06*         1.01 ± 0.05*           Arachidic acid         stems         3.21 ± 0.07*         1.21 ± 0.03*         2.89 ± 0.09*           bunch         ND*         0.24 ± 0.00*         0.25 ± 0.00*           bunch         ND*         0.24 ± 0.00*         0.25 ± 0.00*           Behenic acid         stems         3.62 ± 0.11*         1.95 ± 0.08*         4.76 ± 0.15*           bunch         ND         ND         ND         ND           PUFA         stems         3.62 ± 0.11*         1.95 ± 0.08*         4.76 ± 0.15*           bunch         ND         ND         ND         ND           PUFA         stems         5.426 ± 1.81*         62.93 ± 1.15*         54.51 ± 0.46*           bunch         76.78 ± 0.03*         68.88 ± 0.18*         69.91 ± 0.08*           MUFA         stems         14.34 ± 0.92* <td></td> <td>bunch</td> <td>10.21 ±0.01°</td> <td>17.09 ±0.15<sup>b</sup></td> <td>17.03 ±0.06°</td>		bunch	10.21 ±0.01°	17.09 ±0.15 <sup>b</sup>	17.03 ±0.06°
bunch   74.40 ± 0.03°   67.66 ± 0.25°   68.90 ± 0.04°		pomace	73.08 ±0.23 <sup>a</sup>	67.59 ±0.02 <sup>b</sup>	68.75 ±0.01°
$ \alpha - \text{linoleic acid} \qquad \begin{array}{c} \text{pomace} & 1.75 \pm 0.02^{\circ} & 0.78 \pm 0.00^{\circ} & 0.77 \pm 0.01^{\circ} \\ \text{stems} & 15.17 \pm 0.62^{\circ} & 5.74 \pm 0.13^{\circ} & 9.03 \pm 0.62^{\circ} \\ \text{bunch} & 2.38 \pm 0.03^{\circ} & 1.22 \pm 0.06^{\circ} & 1.01 \pm 0.05^{\circ} \\ \text{bunch} & 2.38 \pm 0.03^{\circ} & 1.22 \pm 0.06^{\circ} & 1.01 \pm 0.05^{\circ} \\ \text{pomace} & 0.28 \pm 0.01^{\circ} & 0.24 \pm 0.00^{\circ} & 0.24 \pm 0.00^{\circ} \\ \text{bunch} & ND^{\circ} & 0.24 \pm 0.00^{\circ} & 0.24 \pm 0.00^{\circ} \\ \text{bunch} & ND^{\circ} & 0.24 \pm 0.00^{\circ} & 0.25 \pm 0.00^{\circ} \\ \text{bunch} & ND^{\circ} & 0.24 \pm 0.00^{\circ} & 0.25 \pm 0.00^{\circ} \\ \text{bunch} & ND^{\circ} & 0.24 \pm 0.00^{\circ} & 0.11 \pm 0.00^{\circ} \\ \text{bunch} & ND^{\circ} & 0.24 \pm 0.00^{\circ} & 0.15 \pm 0.00^{\circ} \\ \text{bunch} & ND^{\circ} & 0.11 \pm 0.00^{\circ} & 0.11 \pm 0.00^{\circ} \\ \text{bunch} & ND^{\circ} & ND^{\circ} & ND^{\circ} & ND^{\circ} \\ \text{bunch} & ND^{\circ} & ND^{\circ} & ND^{\circ} & ND^{\circ} \\ \text{pomace} & 74.83 \pm 0.25^{\circ} & 68.37 \pm 0.02^{\circ} & 69.52 \pm 0.02^{\circ} \\ \text{bunch} & 76.78 \pm 0.03^{\circ} & 68.88 \pm 0.18^{\circ} & 69.91 \pm 0.08^{\circ} \\ \text{bunch} & 76.78 \pm 0.03^{\circ} & 68.88 \pm 0.18^{\circ} & 69.91 \pm 0.08^{\circ} \\ \text{bunch} & 10.21 \pm 0.01^{\circ} & 17.95 \pm 0.02^{\circ} & 16.72 \pm 0.02^{\circ} \\ \text{bunch} & 10.21 \pm 0.01^{\circ} & 17.39 \pm 0.15^{\circ} & 17.34 \pm 0.06^{\circ} \\ \text{pomace} & 12.93 \pm 0.18^{\circ} & 12.57 \pm 0.02^{\circ} & 12.30 \pm 0.01^{\circ} \\ \text{SFA} & \text{stems} & 28.87 \pm 0.78^{\circ} & 18.45 \pm 0.73^{\circ} & 26.06 \pm 0.71^{\circ} \\ \text{bunch} & 12.28 \pm 0.02^{\circ} & 12.98 \pm 0.29^{\circ} & 11.99 \pm 0.15^{\circ} \\ \text{bunch} & 0.03 \pm 0.00^{\circ} & 0.01 \pm 0.00^{\circ} & 0.01 \pm 0.00^{\circ} \\ \text{bunch} & 0.03 \pm 0.00^{\circ} & 0.01 \pm 0.00^{\circ} & 0.01 \pm 0.00^{\circ} \\ \text{bunch} & 0.03 \pm 0.00^{\circ} & 0.02 \pm 0.00^{\circ} & 0.01 \pm 0.00^{\circ} \\ \text{bunch} & 0.03 \pm 0.00^{\circ} & 0.02 \pm 0.00^{\circ} & 0.01 \pm 0.00^{\circ} \\ \text{bunch} & 0.03 \pm 0.00^{\circ} & 0.02 \pm 0.00^{\circ} & 0.01 \pm 0.00^{\circ} \\ \text{bunch} & 0.03 \pm 0.00^{\circ} & 0.02 \pm 0.00^{\circ} & 0.01 \pm 0.00^{\circ} \\ \text{bunch} & 0.03 \pm 0.00^{\circ} & 0.02 \pm 0.00^{\circ} & 0.01 \pm 0.00^{\circ} \\ \text{bunch} & 0.03 \pm 0.00^{\circ} & 0.02 \pm 0.00^{\circ} & 0.01 \pm 0.00^{\circ} \\ \text{bunch} & 0.03 \pm 0.00^{\circ} & 0.02 \pm 0.00^{\circ} & 0.01 \pm 0.00^{\circ} \\ \text{bunch} & 0.03 \pm 0.00^{\circ} & 0.02 \pm 0.00^{\circ} & 0.01 \pm 0.00^{\circ} \\ \text{bunch} & 0.03 \pm 0.00^{\circ} & 0.02 \pm 0.00^{\circ} & 0.01$	Linoleic acid	stems	36.86 ±1.14°	57.19 ±1.21 <sup>b</sup>	45.47 ±1.05°
α-linoleic acid stems 15.17 ±0.62° 5.74 ±0.13° 9.03 ±0.62° bunch 2.38 ±0.03° 1.22 ±0.06° 1.01 ±0.05° pomace 0.28 ±0.01° 0.24 ±0.00° 0.24 ±0.00° 0.24 ±0.00° 0.24 ±0.00° 0.25 ±0.00° pomace 0.19 ±0.01° 0.12 ±0.00° 0.11 ±0		bunch	74.40 ±0.03°	67.66 ±0.25 <sup>b</sup>	68.90 ±0.04°
bunch   2.38 ±0.03°   1.22 ±0.06°   1.01 ±0.05°     pomace   0.28 ±0.01°   0.24 ±0.00°   0.24 ±0.00°     stems   3.21 ±0.07°   1.21 ±0.03°   2.89 ±0.09°     bunch   ND°   0.24 ±0.00°   0.25 ±0.00°     bunch   ND°   0.11 ±0.00°   0.11 ±0.00°     pomace   0.19 ±0.01°   0.11 ±0.00°   0.11 ±0.00°     stems   3.62 ±0.11°   1.95 ±0.08°   4.76 ±0.15°     bunch   ND   ND   ND     pomace   74.83 ±0.25°   68.37 ±0.02°   69.52 ±0.02°     stems   54.26 ±1.81°   62.93 ±1.15°   54.51 ±0.46°     bunch   76.78 ±0.03°   68.88 ±0.18°   69.91 ±0.08°     pomace   11.32 ±0.08°   17.95 ±0.02°   16.72 ±0.02°     stems   14.34 ±0.92°   16.31 ±0.43°   15.04 ±0.31°     bunch   10.21 ±0.01°   17.39 ±0.15°   17.34 ±0.06°     stems   28.87 ±0.78°   18.45 ±0.73°   26.06 ±0.71°     bunch   12.28 ±0.02°   12.98 ±0.29°   11.99 ±0.15°     Ratio Σn3/n6   stems   0.43 ±0.00°   0.01 ±0.00°   0.01 ±0.00°     pomace   41.72 ±0.47°   86.60 ±0.13°   89.59 ±0.75°     Ratio Σn3/n6   stems   2.34 ±0.03°   9.96 ±0.39°   5.05 ±0.47°		pomace	1.75 ±0.02°	0.78 ±0.00 <sup>b</sup>	0.77 ±0.01 <sup>b</sup>
Pomace   0.28 ± 0.01°   0.24 ± 0.00°   0.24 ± 0.00°     stems   3.21 ± 0.07°   1.21 ± 0.03°   2.89 ± 0.09°     bunch   ND°   0.24 ± 0.00°   0.25 ± 0.00°     pomace   0.19 ± 0.01°   0.11 ± 0.00°   0.11 ± 0.00°     stems   3.62 ± 0.11°   1.95 ± 0.08°   4.76 ± 0.15°     bunch   ND   ND   ND     PUFA   Stems   54.26 ± 1.81°   62.93 ± 1.15°   54.51 ± 0.46°     bunch   76.78 ± 0.03°   68.88 ± 0.18°   69.91 ± 0.08°     bunch   76.78 ± 0.03°   17.95 ± 0.02°   16.72 ± 0.02°     MUFA   Stems   14.34 ± 0.92°   16.31 ± 0.43°   15.04 ± 0.31°     bunch   10.21 ± 0.01°   17.39 ± 0.15°   17.34 ± 0.06°     SFA   Stems   28.87 ± 0.78°   18.45 ± 0.73°   26.06 ± 0.71°     bunch   12.28 ± 0.02°   12.98 ± 0.29°   11.99 ± 0.15°     bunch   0.02 ± 0.00°   0.01 ± 0.00°   0.01 ± 0.00°     bunch   0.03 ± 0.00°   0.02 ± 0.00°   0.01 ± 0.00°     bunch   0.03 ± 0.00°   0.02 ± 0.00°   0.01 ± 0.00°     pomace   41.72 ± 0.47°   86.60 ± 0.13°   89.59 ± 0.75°     Ratio Σn3/n6   Stems   2.34 ± 0.03°   9.96 ± 0.39°   5.05 ± 0.47°	$\alpha$ -linoleic acid	stems	15.17 ±0.62°	5.74 ±0.13 <sup>b</sup>	9.03 ±0.62°
Arachidic acid         stems         3.21 ±0.07°         1.21 ±0.03°         2.89 ±0.09°           bunch         ND°         0.24 ±0.00°         0.25 ±0.00°           pomace         0.19 ±0.01°         0.11 ±0.00°         0.11 ±0.00°           stems         3.62 ±0.11°         1.95 ±0.08°         4.76 ±0.15°           bunch         ND         ND         ND           PUFA         stems         54.26 ±1.81°         62.93 ±1.15°         54.51 ±0.46°           bunch         76.78 ±0.03°         68.88 ±0.18°         69.91 ±0.08°           pomace         11.32 ±0.08°         17.95 ±0.02°         16.72 ±0.02°           MUFA         stems         14.34 ±0.92°         16.31 ±0.43°         15.04 ±0.31°           bunch         10.21 ±0.01°         17.39 ±0.15°         17.34 ±0.06°           SFA         pomace         12.93 ±0.18°         12.57 ±0.02°         12.30 ±0.01°           SFA         stems         28.87 ±0.78°         18.45 ±0.73°         26.06 ±0.71°           bunch         12.28 ±0.02°         12.98 ±0.29°         11.99 ±0.15°           bunch         20.22 ±0.00°         0.01 ±0.00°         0.01 ±0.00°           Ratio Σn3/n6         stems         0.43 ±0.00°         0.10 ±0.00°		bunch	2.38 ±0.03 <sup>a</sup>	1.22 ±0.06 <sup>b</sup>	1.01 ±0.05°
Dunch   ND®   0.24 ±0.00%   0.25 ±0.00%		pomace	0.28 ±0.01°	0.24 ±0.00 <sup>b</sup>	0.24 ±0.00 <sup>b</sup>
Pomace   0.19 ± 0.01a   0.11 ± 0.00b   0.11 ± 0.00b     Stems   3.62 ± 0.11a   1.95 ± 0.08b   4.76 ± 0.15c     bunch   ND   ND   ND     PUFA   Stems   54.26 ± 1.81a   62.93 ± 1.15b   54.51 ± 0.46c     bunch   76.78 ± 0.03a   68.88 ± 0.18b   69.91 ± 0.08c     MUFA   Stems   11.32 ± 0.08a   17.95 ± 0.02c   16.72 ± 0.02c     bunch   10.21 ± 0.01a   17.39 ± 0.15b   17.34 ± 0.06c     SFA   Stems   28.87 ± 0.78a   18.45 ± 0.73b   26.06 ± 0.71c     bunch   12.28 ± 0.02a   12.98 ± 0.29b   11.99 ± 0.15c     bunch   0.03 ± 0.00b   0.01 ± 0.00b     consideration   Domace   41.72 ± 0.47a   86.60 ± 0.13b   89.59 ± 0.75c     Ratio Σn3/n6   Stems   23.44 ± 0.03a   9.96 ± 0.39b   5.05 ± 0.47c     Ratio Σn3/n6   Stems   23.44 ± 0.03a   9.96 ± 0.39b   5.05 ± 0.47c     Stems   23.44 ± 0.03a   9.96 ± 0.39b   5.05 ± 0.47	Arachidic acid	stems	3.21 ±0.07 <sup>a</sup>	1.21 ±0.03 <sup>b</sup>	2.89 ±0.09°
Behenic acid         stems         3.62 ±0.11³         1.95 ±0.08⁵         4.76 ±0.15°           bunch         ND         ND         ND           PUFA         pomace         74.83 ±0.25°         68.37 ±0.02⁵         69.52 ±0.02°           stems         54.26 ±1.81°         62.93 ±1.15⁵         54.51 ±0.46°           bunch         76.78 ±0.03°         68.88 ±0.18⁵         69.91 ±0.08°           pomace         11.32 ±0.08°         17.95 ±0.02⁵         16.72 ±0.02°           MUFA         stems         14.34 ±0.92°         16.31 ±0.43⁵         15.04 ±0.31°           bunch         10.21 ±0.01°         17.39 ±0.15⁵         17.34 ±0.06°           stems         12.93 ±0.18°         12.57 ±0.02⁵         12.30 ±0.01°           SFA         stems         28.87 ±0.78°         18.45 ±0.73⁵         26.06 ±0.71°           bunch         12.28 ±0.02°         12.98 ±0.29⁵         11.99 ±0.15°           pomace         0.02 ±0.00°         0.01 ±0.00⁵         0.01 ±0.00⁵           Ratio Σn3/n6         stems         0.43 ±0.00°         0.10 ±0.00⁵         0.01 ±0.00⁵           pomace         41.72 ±0.47°         86.60 ±0.13⁵         89.59 ±0.75°           Ratio Σn3/n6         stems         2.34 ±0.03°		bunch	NDa	0.24 ±0.00 <sup>b</sup>	0.25 ±0.00°
Dunch   ND   ND   ND	Behenic acid	pomace	0.19 ±0.01°	0.11 ±0.00 <sup>b</sup>	0.11 ±0.00 <sup>b</sup>
PUFA         pomace         74.83 ±0.25³         68.37 ±0.02⁵         69.52 ±0.02⁵           stems         54.26 ±1.81³         62.93 ±1.15⁵         54.51 ±0.46⁵           bunch         76.78 ±0.03³         68.88 ±0.18⁵         69.91 ±0.08⁵           MUFA         pomace         11.32 ±0.08³         17.95 ±0.02⁵         16.72 ±0.02⁵           MUFA         stems         14.34 ±0.92²         16.31 ±0.43⁵         15.04 ±0.31²⁵           bunch         10.21 ±0.01³         17.39 ±0.15⁵         17.34 ±0.06⁵           SFA         stems         28.87 ±0.78³         18.45 ±0.73⁵         26.06 ±0.71⁵           bunch         12.28 ±0.02³         12.98 ±0.29⁵         11.99 ±0.15⁵           pomace         0.02 ±0.00³         0.01 ±0.00⁵         0.01 ±0.00⁵           Ratio Σn3/n6         stems         0.43 ±0.00³         0.10 ±0.00⁵         0.20 ±0.02⁵           Ratio Σn3/n6         tems         2.34 ±0.03³         9.96 ±0.39⁵         5.05 ±0.47⁵		stems	3.62 ±0.11 <sup>a</sup>	1.95 ±0.08 <sup>b</sup>	4.76 ±0.15°
PUFA stems $54.26 \pm 1.81^{\circ}$ $62.93 \pm 1.15^{\circ}$ $54.51 \pm 0.46^{\circ}$ bunch $76.78 \pm 0.03^{\circ}$ $68.88 \pm 0.18^{\circ}$ $69.91 \pm 0.08^{\circ}$ pomace $11.32 \pm 0.08^{\circ}$ $17.95 \pm 0.02^{\circ}$ $16.72 \pm 0.02^{\circ}$ $16.72 \pm 0.02^{\circ}$ stems $14.34 \pm 0.92^{\circ}$ $16.31 \pm 0.43^{\circ}$ $15.04 \pm 0.31^{\circ}$ bunch $10.21 \pm 0.01^{\circ}$ $17.39 \pm 0.15^{\circ}$ $17.34 \pm 0.06^{\circ}$ pomace $12.93 \pm 0.18^{\circ}$ $12.57 \pm 0.02^{\circ}$ $12.30 \pm 0.01^{\circ}$ stems $28.87 \pm 0.78^{\circ}$ $18.45 \pm 0.73^{\circ}$ $26.06 \pm 0.71^{\circ}$ bunch $12.28 \pm 0.02^{\circ}$ $12.98 \pm 0.29^{\circ}$ $11.99 \pm 0.15^{\circ}$ pomace $0.02 \pm 0.00^{\circ}$ $0.01 \pm 0.00^{\circ}$ $0.01 \pm 0.00^{\circ}$ stems $0.43 \pm 0.00^{\circ}$ $0.10 \pm 0.00^{\circ}$ $0.01 \pm 0.00^{\circ}$ bunch $0.03 \pm 0.00^{\circ}$ $0.02 \pm 0.00^{\circ}$ $0.01 \pm 0.00^{\circ}$ $0.01 \pm 0.00^{\circ}$ $0.01 \pm 0.00^{\circ}$ stems $0.03 \pm 0.00^{\circ}$ $0.02 \pm 0.00^{\circ}$ $0.01 \pm 0.00^$		bunch	ND	ND	ND
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	PUFA	pomace	74.83 ±0.25°	68.37 ±0.02 <sup>b</sup>	69.52 ±0.02°
MUFA $ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		stems	54.26 ±1.81°	62.93 ±1.15 <sup>b</sup>	54.51 ±0.46 <sup>a</sup>
MUFA		bunch	76.78 ±0.03°	68.88 ±0.18 <sup>b</sup>	69.91 ±0.08°
bunch $10.21 \pm 0.01^a$ $17.39 \pm 0.15^b$ $17.34 \pm 0.06^b$ pomace $12.93 \pm 0.18^a$ $12.57 \pm 0.02^b$ $12.30 \pm 0.01^a$ stems $28.87 \pm 0.78^a$ $18.45 \pm 0.73^b$ $26.06 \pm 0.71^a$ bunch $12.28 \pm 0.02^a$ $12.98 \pm 0.29^b$ $11.99 \pm 0.15^a$ pomace $0.02 \pm 0.00^a$ $0.01 \pm 0.00^b$ $0.01 \pm 0.00^b$ stems $0.43 \pm 0.00^a$ $0.10 \pm 0.00^b$ $0.20 \pm 0.02^a$ bunch $0.03 \pm 0.00^a$ $0.02 \pm 0.00^b$ $0.01 \pm 0.00^b$ pomace $41.72 \pm 0.47^a$ $86.60 \pm 0.13^b$ $89.59 \pm 0.75^a$ Ratio $\Sigma$ n3/n6stems $2.34 \pm 0.03^a$ $9.96 \pm 0.39^b$ $5.05 \pm 0.47^a$	MUFA	pomace	11.32 ±0.08 <sup>a</sup>	17.95 ±0.02 <sup>b</sup>	16.72 ±0.02°
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		stems	14.34 ±0.92°	16.31 ±0.43 <sup>b</sup>	15.04 ±0.31ab
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		bunch	10.21 ±0.01°	17.39 ±0.15 <sup>b</sup>	17.34 ±0.06 <sup>b</sup>
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	SFA	pomace	12.93 ±0.18 <sup>a</sup>	12.57 ±0.02 <sup>b</sup>	12.30 ±0.01°
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		stems	28.87 ±0.78 <sup>a</sup>	18.45 ±0.73 <sup>b</sup>	26.06 ±0.71°
Ratio $\Sigma$ n3/n6         stems $0.43 \pm 0.00^{\circ}$ $0.10 \pm 0.00^{\circ}$ $0.20 \pm 0.02^{\circ}$ bunch $0.03 \pm 0.00^{\circ}$ $0.02 \pm 0.00^{\circ}$ $0.01 \pm 0.00^{\circ}$ pomace $41.72 \pm 0.47^{\circ}$ $86.60 \pm 0.13^{\circ}$ $89.59 \pm 0.75^{\circ}$ Ratio $\Sigma$ n3/n6         stems $2.34 \pm 0.03^{\circ}$ $9.96 \pm 0.39^{\circ}$ $5.05 \pm 0.47^{\circ}$		bunch	12.28 ±0.02°	12.98 ±0.29 <sup>b</sup>	11.99 ±0.15°
bunch $0.03 \pm 0.00^a$ $0.02 \pm 0.00^b$ $0.01 \pm 0.00^b$ pomace $41.72 \pm 0.47^a$ $86.60 \pm 0.13^b$ $89.59 \pm 0.75^a$ Ratio Σn3/n6stems $2.34 \pm 0.03^a$ $9.96 \pm 0.39^b$ $5.05 \pm 0.47^a$	Ratio $\Sigma$ n3/n6	pomace	0.02 ±0.00 <sup>a</sup>	0.01 ±0.00 <sup>b</sup>	0.01 ±0.00 <sup>b</sup>
pomace $41.72 \pm 0.47^a$ $86.60 \pm 0.13^b$ $89.59 \pm 0.75^c$ Ratio Σn3/n6         stems $2.34 \pm 0.03^a$ $9.96 \pm 0.39^b$ $5.05 \pm 0.47^c$		stems	0.43 ±0.00 <sup>a</sup>	0.10 ±0.00 <sup>b</sup>	0.20 ±0.02°
Ratio $\Sigma$ n3/n6 stems 2.34 $\pm$ 0.03° 9.96 $\pm$ 0.39° 5.05 $\pm$ 0.47°		bunch	0.03 ±0.00a	0.02 ±0.00 <sup>b</sup>	0.01 ±0.00 <sup>b</sup>
	Ratio $\Sigma$ n3/n6	pomace	41.72 ±0.47°	86.60 ±0.13 <sup>b</sup>	89.59 ±0.75°
bunch $31.31 \pm 0.37^{a}$ $55.34 \pm 2.88^{b}$ $68.26 \pm 3.48^{c}$		stems	2.34 ±0.03 <sup>a</sup>	9.96 ±0.39 <sup>b</sup>	5.05 ±0.47°
		bunch	31.31 ±0.37°	55.34 ±2.88 <sup>b</sup>	68.26 ±3.48°

ND – value below detection limit, MUFA – monounsaturated fatty acids, PUFA – polyunsaturated fatty acids, SFA – saturated fatty acids. Values followed by different letters within a row are significant at the level 0.05

**Table 2** Fatty acid profile of grape by-products from Austria (% fat<sup>-1</sup>)

Mean ±Standard Deviation           pomace         8.85 ±0.01³           stems         19.13 ±0.15           bunch         9.89 ±0.28           pomace         3.25 ±0.01³           stems         3.92 ±0.11           bunch         3.60 ±0.07³           pomace         9.80 ±0.04³           oleic acid         stems         9.43 ±0.74³           bunch         10.96 ±0.10³           pomace         73.85 ±0.09³           Linoleic acid         stems         38.92 ±1.07           bunch         72.98 ±0.39³           pomace         1.81 ±0.01³           α-linoleic acid         stems         18.73 ±1.05°           bunch         1.84 ±0.02°           pomace         0.23 ±0.01°           Arachidic acid         stems         2.41 ±0.09°           bunch         ND	ot Blanc	Zweigelt
Palmitic acid         stems         19.13 ±0.15           bunch         9.89 ±0.28           pomace         3.25 ±0.01³           stems         3.92 ±0.11           bunch         3.60 ±0.07³           pomace         9.80 ±0.04³           stems         9.43 ±0.74³           bunch         10.96 ±0.10³           pomace         73.85 ±0.09³           stems         38.92 ±1.07           bunch         72.98 ±0.39³           pomace         1.81 ±0.01³           stems         18.73 ±1.05³           bunch         1.84 ±0.02²           pomace         0.23 ±0.01²           stems         2.41 ±0.09³           bunch         ND	'	
bunch $9.89 \pm 0.28$ pomace $3.25 \pm 0.01^a$ stems $3.92 \pm 0.11$ bunch $3.60 \pm 0.07^a$ pomace $9.80 \pm 0.04^a$ stems $9.43 \pm 0.74^a$ bunch $10.96 \pm 0.10^a$ pomace $73.85 \pm 0.09^a$ stems $38.92 \pm 1.07$ bunch $72.98 \pm 0.39^a$ pomace $1.81 \pm 0.01^a$ stems $18.73 \pm 1.05^a$ bunch $1.84 \pm 0.02^a$ pomace $0.23 \pm 0.01^a$ stems $2.41 \pm 0.09^a$ bunch         ND	7.96 ±0.03 <sup>b</sup>	8.70 ±0.03°
Stearic acid       pomace $3.25 \pm 0.01^a$ stems $3.92 \pm 0.11$ bunch $3.60 \pm 0.07^a$ pomace $9.80 \pm 0.04^a$ Stems $9.43 \pm 0.74^a$ bunch $10.96 \pm 0.10^a$ pomace $73.85 \pm 0.09^a$ stems $38.92 \pm 1.07$ bunch $72.98 \pm 0.39^a$ pomace $1.81 \pm 0.01^a$ stems $18.73 \pm 1.05^a$ bunch $1.84 \pm 0.02^a$ pomace $0.23 \pm 0.01^a$ Arachidic acid       stems $2.41 \pm 0.09^a$ bunch       ND	16.79 ±0.31	19.62 ±5.85
Stearic acid       stems $3.92 \pm 0.11$ bunch $3.60 \pm 0.07^a$ pomace $9.80 \pm 0.04^a$ pomace $9.43 \pm 0.74^a$ bunch $10.96 \pm 0.10^a$ pomace $73.85 \pm 0.09^a$ stems $38.92 \pm 1.07$ bunch $72.98 \pm 0.39^a$ pomace $1.81 \pm 0.01^a$ stems $18.73 \pm 1.05^a$ bunch $1.84 \pm 0.02^a$ pomace $0.23 \pm 0.01^a$ Arachidic acid       stems $2.41 \pm 0.09^a$ bunch       ND	7.69 ±0.03	9.86 ±1.56
bunch $3.60 \pm 0.07^a$ pomace $9.80 \pm 0.04^a$ stems $9.43 \pm 0.74^a$ bunch $10.96 \pm 0.10^a$ pomace $73.85 \pm 0.09^a$ stems $38.92 \pm 1.07$ bunch $72.98 \pm 0.39^a$ pomace $1.81 \pm 0.01^a$ stems $18.73 \pm 1.05^a$ bunch $1.84 \pm 0.02^a$ pomace $0.23 \pm 0.01^a$ Arachidic acid       stems $2.41 \pm 0.09^a$ bunch       ND	3.44 ±0.01 <sup>b</sup>	3.77 ±0.01°
Oleic acid       pomace $9.80 \pm 0.04^a$ stems $9.43 \pm 0.74^a$ bunch $10.96 \pm 0.10^a$ pomace $73.85 \pm 0.09^a$ stems $38.92 \pm 1.07$ bunch $72.98 \pm 0.39^a$ pomace $1.81 \pm 0.01^a$ stems $18.73 \pm 1.05^a$ bunch $1.84 \pm 0.02^a$ pomace $0.23 \pm 0.01^a$ stems $2.41 \pm 0.09^a$ bunch       ND	4.35 ±0.11	5.75 ±2.05
Oleic acid       stems $9.43 \pm 0.74^a$ bunch $10.96 \pm 0.10^a$ pomace $73.85 \pm 0.09^a$ stems $38.92 \pm 1.07$ bunch $72.98 \pm 0.39^a$ pomace $1.81 \pm 0.01^a$ stems $18.73 \pm 1.05^a$ bunch $1.84 \pm 0.02^a$ pomace $0.23 \pm 0.01^a$ Arachidic acid       stems $2.41 \pm 0.09^a$ bunch       ND	3.36 ±0.02 <sup>a</sup>	4.42 ±0.51 <sup>b</sup>
bunch $10.96 \pm 0.10^a$ pomace $73.85 \pm 0.09^a$ stems $38.92 \pm 1.07$ bunch $72.98 \pm 0.39^a$ pomace $1.81 \pm 0.01^a$ stems $18.73 \pm 1.05^a$ bunch $1.84 \pm 0.02^a$ pomace $0.23 \pm 0.01^a$ Arachidic acid       stems $2.41 \pm 0.09^a$ bunch       ND	15.98 ±0.03 <sup>b</sup>	15.86 ±0.01°
Linoleic acid       pomace $73.85 \pm 0.09^a$ stems $38.92 \pm 1.07$ bunch $72.98 \pm 0.39^a$ pomace $1.81 \pm 0.01^a$ stems $18.73 \pm 1.05^a$ bunch $1.84 \pm 0.02^a$ pomace $0.23 \pm 0.01^a$ Arachidic acid       stems $2.41 \pm 0.09^a$ bunch       ND	12.04 ±0.23 <sup>ab</sup>	15.26 ±2.69 <sup>b</sup>
Linoleic acid       stems $38.92 \pm 1.07$ bunch $72.98 \pm 0.39^a$ pomace $1.81 \pm 0.01^a$ stems $18.73 \pm 1.05^a$ bunch $1.84 \pm 0.02^a$ pomace $0.23 \pm 0.01^a$ Arachidic acid       stems $2.41 \pm 0.09^a$ bunch       ND	16.39 ±0.05 <sup>b</sup>	16.86 ±0.51 <sup>b</sup>
	68.89 ±0.10 <sup>b</sup>	66.61 ±0.04°
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	36.06 ±0.29	38.40 ±6.70
$α$ -linoleic acid $\frac{18.73 \pm 1.05^{a}}{bunch}$ $\frac{18.73 \pm 1.05^{a}}{1.84 \pm 0.02^{a}}$ $\frac{pomace}{stems}$ $\frac{0.23 \pm 0.01^{a}}{bunch}$ $\frac{2.41 \pm 0.09^{a}}{bunch}$	70.63 ±0.11ª	66.82 ±2.41 <sup>b</sup>
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	1.15 ±0.03 <sup>b</sup>	1.21 ±0.02°
Arachidic acid         pomace         0.23 ±0.01a           stems         2.41 ±0.09a           bunch         ND	15.65 ±0.21°	9.17 ±2.47 <sup>b</sup>
Arachidic acid         stems         2.41 ±0.09°           bunch         ND	1.09 ±0.07 <sup>b</sup>	1.13 ±0.08 <sup>b</sup>
bunch ND	0.34 ±0.01 <sup>b</sup>	0.27 ±0.01°
	3.52 ±0.07 <sup>b</sup>	2.30 ±0.24 <sup>a</sup>
	ND	ND
pomace 0.17 ±0.00 <sup>a</sup>	0.24 ±0.00 <sup>b</sup>	0.17 ±0.00°
Behenic acid stems $3.81 \pm 0.20^{a}$	5.73 ±0.16 <sup>b</sup>	3.71 ±0.48 <sup>a</sup>
bunch ND	ND	ND
pomace 75.66 ±0.10 <sup>a</sup>	70.04 ±0.10 <sup>b</sup>	67.82 ±0.04°
PUFA stems 57.66 ±0.39	51.71 ±0.42	47.57 ±9.10
bunch 74.83 ±0.39 <sup>a</sup>	71.72 ±0.09ª	67.95 ±2.48 <sup>b</sup>
pomace 10.09 ±0.05°	16.50 ±0.03 <sup>b</sup>	16.60 ±0.01°
MUFA stems 9.43 ±0.74a	12.04 ±0.23ª	16.61 ±2.48 <sup>b</sup>
bunch 10.96 ±0.10 <sup>a</sup>	16.39 ±0.05 <sup>b</sup>	17.00 ±0.39 <sup>c</sup>
pomace 12.89 ±0.01 <sup>a</sup>	12.38 ±0.04 <sup>b</sup>	13.37 ±0.04°
SFA stems 29.27 ±0.34	30.39 ±0.29	32.88 ±7.35
bunch 13.49 ±0.31 <sup>ab</sup>	11.06 ±0.04°	14.28 ±2.07 <sup>b</sup>
pomace 0.02 ±0.00 <sup>a</sup>	0.02 ±0.00b	0.02 ±0.00°
Ratio $\Sigma$ n3/n6 stems 0.48 $\pm$ 0.04 <sup>a</sup>	0.43 ±0.01ª	0.24 ±0.03 <sup>b</sup>
bunch 0.03 ±0.00°	0.02 ±0.00 <sup>b</sup>	0.02 ±0.00 <sup>b</sup>
pomace 40.778 ±0.27 <sup>a</sup>	60.16 ±1.34 <sup>b</sup>	55.25 ±0.77°
Ratio $\Sigma$ n3/n6 stems 2.08 $\pm$ 0.18 <sup>a</sup>	2.30 ±0.03°	4.28 ±0.56 <sup>b</sup>
bunch 39.56 ±0.59 <sup>a</sup>	65.07 ±4.09 <sup>b</sup>	59.20 ±2.07 <sup>b</sup>

ND – value below detection limit, MUFA – monounsaturated fatty acids, PUFA – polyunsaturated fatty acids, SFA – saturated fatty acids. Values followed by different letters within a row are significant at the level 0.05

 Table 3
 Comparison of fatty acid profile of grape by-products from Slovakia and Austria

			Ι	I	
		Slovakia	Austria	Significance	
		Mean ±Standard deviati			
Palmitic acid	pomace	8.15 ±0.41	8.50 ±0.41	0.000	
	stems	13.21 ±2.27	18.51 ±3.21	0.578	
	bunch	8.30 ±0.64	9.15 ±1.35	0.041	
	pomace	3.84 ±0.22	3.49 ±0.23	0.000	
Stearic acid	stems	3.80 ±0.26	4.67 ±1.32	0.223	
	bunch	3.88 ±0.35	3.79 ±0.54	0.012	
	pomace	14.92 ±3.06	13.88 ±3.06	0.000	
Oleic acid	stems	15.17 ±0.92	12.24 ±2.89	0.013	
	bunch	14.77 ±3.43	14.74 ±2.85	0.000	
	pomace	69.81 ±2.51	69.79 ±3.21	0.000	
Linoleic acid	stems	46.51 ±8.89	37.80 ±3.64	0.656	
	bunch	70.32 ±3.11	70.14 ±2.96	0.005	
	pomace	1.10 ±0.49	1.39 ±0.32	0.000	
$\alpha$ -linoleic acid	stems	9.98 ±4.17	14.52 ±4.44	0.001	
	bunch	1.54 ±0.64	1.35 ±0.37	0.000	
	pomace	0.25 ±0.02	0.28 ±0.05	0.000	
Arachidic acid	stems	2.44 ±0.93	2.74 ±0.60	0.000	
	bunch	0.16 ±0.12	ND	ND	
Behenic acid	pomace	0.14 ±0.04	0.20 ±0.03	0.000	
	stems	3.44 ±1.23	4.41 ±1.02	0.000	
	bunch	ND	ND	ND	
PUFA	pomace	70.91 ±2.99	71.17 ±3.50	0.000	
	stems	57.23 ±4.41	52.31 ±6.33	0.140	
	bunch	71.86 ±3.72	71.50 ±3.24	0.003	
MUFA	pomace	15.33 ±3.06	14.40 ±3.23	0.000	
	stems	15.23 ±1.01	12.69 ±3.40	0.003	
	bunch	14.98 ±3.58	14.78 ±2.89	0.000	
SFA	pomace	12.60 ±0.29	12.88 ±0.43	0.000	
	stems	24.46 ±4.71	30.85 ±4.02	0.594	
	bunch	12.42 ±0.47	12.94 ±1.79	0.039	
Ratio $\Sigma$ n3/n6	pomace	0.02 ±0.01	0.02 ±0.00	0.000	
	stems	0.24 ±0.15	0.38 ±0.12	0.000	
	bunch	0.02 ±0.01	0.19 ±0.00	0.000	
Ratio $\Sigma$ n3/n6	pomace	72.64 ±23.23	52.06 ±8.76	0.000	
	stems	5.78 ±3.36	2.89 ±1.09	0.000	
	bunch	51.64 ±16.40	54.61 ±11.80	0.000	
				I	

ND – value below detection limit, MUFA – monounsaturated fatty acids, PUFA – polyunsaturated fatty acids, SFA – saturated fatty acids. The level of significance was set at *P* < 0.05

## 4 Conclusions

The results of this experimnet indicate a significant impact of the grape variety and location on the FA profile of grape by-products. But despite these differences some similarities can be found. Grape pomaces and grape bunches were rich in PUFA, especially linoleic acid, and low in SFA. Grape stems were characterized by a high SFA content, but on the other hand, these samples had the highest *H*-linolec acid concentration. Overall it can ce concluded that the by-products of wine industry, primarily grape pomace, could find application in animal nutrition as feed additives with high PUFA content. However, further research in the future in needed.

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