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Evaluation of Protein and Antioxidant Content in Apricot Kernels as a Sustainable Additional Source of Nutrition

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Abstract: Apricot fruits are a favorite for consumption; however, their kernels are a rich source of nutritionally interesting substances, too. Nevertheless, in processing of apricots, the kernels remain often unused. In this study, 32 cultivars of different origin were analyzed for their protein content and content of secondary metabolites (phenolics and flavonoids). The weight and taste of kernels were assessed and these data were summarized for an evaluation of the attractiveness of the studied apricot kernels. Results showed that the protein content of kernels ranged from 14.56% to 28.77% and did not depend on the origin or weight of kernel, or taste. In addition, total phenolic (63.5–1277.3 mg GAE/100 g DW) and total flavonoid (0–153.1 mg CE/100 g DW) contents and antioxidant capacity (483.4–2348.4 mg TE/100 g DW) were measured in kernels. In conclusion, the Czech hybrids LE-5959, LE-5500 and French cultivar Koolgat are prospective for kernel processing and consumption because of their high protein content and sweet taste. Hybrid LI-3-6, originating in China, showed high protein content as well but because of bitter taste could be useful rather in medicine.

Keywords: *P. armeniaca*; seed; phenolic; flavonoid; nutrition

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1. Introduction

Apricot is a fruit species grown mainly for fresh fruit, but also for fruit processing (drying, canning, jams or distillation) [1]. However, in recent years, the demand for alternative plant sources of proteins and lipids has been rising. At the same time, there has been emphasis on sustainability of the production of these nutritional resources, suggesting sweet apricot kernels could be a delicacy in the same way as sweet almonds. The developmental anatomy/physiology/biochemistry of apricot kernels (seeds) and those of related species such as almond and cherry has been studied and the reader is referred to Famiani et al. (2020) for details [2].

World production of fresh apricots attained 4.1 million tons in 2019 [3]. In the Czech Republic, the average annual apricot production is about 6 thousand tons [4]. Apricots are known for their attractive orange color, juiciness and sweet taste. They contain many important nutritional substances, vitamins (A, C and E), polyphenolic substances (chlorogenic acid, catechin, epicatechin, rutin) and minerals (especially K, Fe, Mg, P) [5]. Thus, apricots have positive effects on human health due to their antioxidant, anticancer, antiaging and antiparasitic cardio/hepato/renoprotective effects [6–10].

Nutritional substances of apricot kernel have been studied as well. Turan et al. (2007) [11] reported that the total oil content in apricot kernels ranges from 40.23% to 53.19% and is mostly composed of oleic acid (70.83%). Other substances in apricot kernels are proteins, fibers, phenolic compounds, vitamins and minerals [12–14]. Overall, apricot kernels have antioxidant, antibacterial and antiparasitic effects [15,16]. Depending on the variety, they contain toxic cyanogenic glycoside amygdalin [17,18]; the sweet kernels contain ten times less amygdalin than the bitter ones [19]. Thus, it is recommended to avoid consumption of bitter kernels due to possible cyanide poisoning.

Numerous reports mention a substantial amount of dietary protein in apricot kernels [13,20–24], which ranges from 14.1% to 45.3% [12]. The main proteins are albumin (84.7%), globulin (7.65%), gluteline (3.54%) and prolamin (1.17%). Apricot kernels could represent a good potential source of proteins with the ability of generation of bioactive peptides with angiotensin-converting enzyme (ACE) inhibitory activity. ACE plays a central role in the regulation of blood pressure [25]. The prevalent method used for protein measurement in the food industry is the Kjeldahl method [26], which relies on total nitrogen determination, from which the protein content is estimated [27,28] via the nitrogen-to-protein conversion factor. Some studies have reported a phenolic content of apricot kernels, too [14,29]. Phenolic substances increase antioxidant activity and are required in food. The aim of this study was to determine the total protein content in apricot kernels and to compare measured data with respect to physical properties of kernels and antioxidant content of each cultivar. The secondary metabolites, such as total phenolic content, total flavonoid content and antioxidant capacity, were determined to obtain information about the composition of apricot kernels. Finally, their attractiveness was determined by the taste and size measurements. In addition, modern and newly introduced apricot varieties were studied (Koolgat, Kioto, Samourai, Meligat, Mediabel, Congat and Luizet from France, Bora from Italy, and Flavorcot and Early Blush from the USA).

2. Materials and Methods

2.1. Site of Planting and Plant Material

In total, 32 apricot cultivars of different origin were analyzed in this study (Table 1): ten cultivars from the Czech Republic, seven from France, four from Ukraine, three from the USA, two from Slovakia, two from China and one each from Moldova, Canada, Italy and Hungary. Trees of these cultivars were grown in the experimental orchard at the Faculty of Horticulture in Lednice, Mendel University in Brno (site coordinates 48.80 °N/16.80 °E, at an altitude of 172 m).

Table 1. The cultivars used in this study and their origin.

Cultivar	Origin	Cultivar	Origin
Ackerman	Czech Republic	LI-3-6	China
Beta	Czech Republic	Luizet	France
Bora	Italy	M52	Ukraine
Congat	France	Hungarian Best	Hungary
Dovrtělova	Czech Republic	Marlen	Czech Republic
Early Blush	USA	Mediabel	France
Flavorcot	USA	Meligat	France
H-848	Czech Republic	Moldavskij Olimpik	Moldova
Harostar	Canada	Orangered	USA
Kioto	France	Pastyryk	Slovakia
Kompakta	Czech Republic	Poljus Južnyj	Ukraine
Koolgat	France	Pozdní chrámová	Czech Republic
LE-5500	Czech Republic	Priusadebnyj	Ukraine
LE-5959	Czech Republic	Samourai	France
Leronda	Czech Republic	Velikyj	Ukraine
LI-13-6	China	Veselka	Slovakia

Ten fruits from each variety were harvested at their optimum maturity and transported to the laboratory for pomological analyses. The weight of the stone and the kernel was measured and the taste of each kernel was qualified (sweet, bittersweet, bitter).

2.2. Determination of Total Protein Content (TPC)

The analysis of total protein content was accomplished in three replications for each variety by the Kjeldahl method [26]. Ten dried kernels were crushed in a mill (Fritsch Pulverisette 2 Mortar Grinder). Approximately 0.3 g of crushed kernels, weighed accurately on a scale, were placed in a 250 mL Erlenmeyer flask, mixed with the catalyst (7 g K_2SO_4 + 0.4 g $CuSO_4$ + 0.0035 Se) and mineralized in 10 mL of concentrated H_2SO_4 when heated. The prepared mix was alkalized with 50 mL of 30% NaOH and distilled into 25 mL of 0.05 M H_2SO_4. The final sample was colored by Tashiro indicator and titrated with 0.01 M NaOH to the equivalence point. The final volume of 0.01 M NaOH was used for the calculation of the nitrogen content (1). The whole procedure was performed also without the kernel sample and the volume of NaOH was used as a titration blank (1).

The nitrogen content (x) in% was determined by Equation (1):

$$x = (V - V_1) \times m^{-1} \times 0.14008 \quad (1)$$

where V is the volume of NaOH of blank titration, V_1 is the volume of NaOH of sample titration, m is the weight of the sample (g).

The TPC (%) was determined by Equation (2):

$$\text{TPC} = x \times f \quad (2)$$

where x is the nitrogen content and f is the nitrogen-to-protein conversion factor (6.25), based on the assumption that proteins consistently contain 16% nitrogen and that all nitrogen is allocated in proteins.

2.3. Determination of Total Phenolic (TPHC and Flavonoid (TFC) Contents and Antioxidant Activity

The samples were prepared for analyses by extraction of crushed kernels in 25 mL of 75% methanol for 24 h. The weight of each sample was recorded. Then the extract was filtered through filter paper into a 50 mL measuring flask and methanol was added up to the required volume. Samples were placed into 20 mL plastic bottles and kept at −20 °C until the analyses [30].

The secondary metabolites TPHC and TFC and antioxidant activity were determined according to the methods of Zloch et al. (2004) [31] by using a Specord 50 Plus spectrophotometer (Analytik, Jena, DE). TPHC was determined after reaction of sample methanol extracts with Folin–Ciocalteu reagent at a wavelength of 765 nm. The results were calculated from a calibration curve (y = 0.0009x + 0.0034) and expressed in gallic acid equivalents (GAE) per 100 g of dry extract weight (DW). TFC was determined after reaction of sample methanol extracts with $AlCl_3$ and $NaNO_2$ at a wavelength of 510 nm. The results were calculated from a calibration curve (y = 1.3286x + 0.0295) and expressed in catechin equivalents (CE) per 100 g DW. Antioxidant activity was determined after reaction of DPPH (1,1-diphenyl-2-picrylhydrazyl) (Sigma) and methanol extracts at a wavelength of 515 nm. The method is based on the decolorizing property of the hydrogen radical of DPPH with hydrogen donors. The results were calculated from a calibration curve (y = −1.2346x + 0.7143) and expressed in Trolox equivalents (TE) per 100 g DW. Trolox (6-hydroxy-2.5.7.8-tetramethylchroman-2-cyrboxylic acid) was used as a standard.

2.4. Statistical Analysis

Statistical analysis was performed with Statistica 12 (TIBCO, Palo Alto, CA, USA) and Microsoft Excel software. Single-factor ANOVA analysis (level of significance $\alpha = 0.05$) was used for statistical processing, the Fisher LSD test and Tukey HSD test were subsequently used to evaluate the statistical significance of differences between the individually measured content values.

3. Results

The average weight of a fresh apricot kernel was 1.0 ± 0.2 g; the highest weight was measured in Moldavskij Olimpik (1.7 ± 0.3 g) and the lowest in LI-13-6 (0.6 ± 0.2 g). The ratio of kernel to stone weight was 31 ± 1% on average. The highest ratio value was calculated in Meligat (45 ± 4%) and the lowest in the Bora (19 ± 7%) cultivar. A sweet taste was determined in kernels of 17 cultivars; kernels of 7 cultivars had a bitter taste and 8 cultivars had bittersweet kernels. All data are displayed in the Table 2.

Table 2. The physical properties and taste of apricot kernels. The data are displayed as the mean ± standard deviation of ten replications.

Cultivar	Weight of Kernel (g)	Kernel-to-Stone Weight Ratio (%)	Taste	Cultivar	Weight of Kernel (g)	Kernel-to-Stone Weight Ratio (%)	Taste
Ackerman	0.76 ± 0.01	29.5 ± 0.7	bitter	LI-3-6	0.7 ± 0.06	35 ± 3	bitter
Beta	1.04 ± 0.07	25 ± 2	bittersweet	Luizet	1.26 ± 0.01	36.1 ± 0.6	sweet
Bora	0.7 ± 0.4	12 ± 7	bittersweet	M52	0.97 ± 0.06	27 ± 2	bitter
Congat	1.22 ± 0.07	32 ± 1	sweet	Hungarian Best	0.72 ± 0.02	27.3 ± 0.8	sweet
Dovrtělova	0.8 ± 0.1	21 ± 4	sweet	Marlen	1.1 ± 0.1	27 ± 1	sweet
Early Blush	0.90 ± 0.09	33 ± 1	sweet	Mediabel	0.84 ± 0.05	30.2 ± 0.5	sweet
Flavorcot	1.02 ± 0.08	36 ± 4	bittersweet	Meligat	1.1 ± 0.1	45 ± 2	sweet
H 848	1.07 ± 0.05	34 ± 1	bitter	Moldavský Olimpik	1.7 ± 0.1	34 ± 2	sweet
Harostar	0.98 ± 0.09	31 ± 1	bittersweet	Orangered	1.02 ± 0.05	37 ± 1	sweet
Kioto	0.89 ± 0.04	33 ± 2	bitter	Pastyryk	1.2 ± 0.1	19 ± 1	bittersweet
Kompakta	1.20 ± 0.09	25.9 ± 0.9	bittersweet	Poljus Južnyj	1.12 ± 0.05	37.4 ± 0.7	sweet
Koolgat	0.78 ± 0.07	35 ± 2	sweet	Pozdní chrámová	1.02 ± 0.08	24 ± 1	sweet
LE—5500	0.84 ± 0.06	36 ± 2	sweet	Priusadebnyj	0.80 ± 0.04	42 ± 1	sweet
LE—5959	1.0 ± 0.1	36 ± 3	sweet	Samourai	0.83 ± 0.04	32 ± 2	bittersweet
Leronda	0.71 ± 0.05	35 ± 2	bitter	Velikyj	1.3 ± 0.1	36 ± 2	bittersweet
LI-13-6	0.57 ± 0.07	31 ± 4	bitter	Veselka	1.2 ± 0.2	27 ± 3	sweet

The average total protein content (TPC) in apricot kernels was 22 ± 4% of the kernel weight. The highest value was measured in the Czech hybrid LE-5959 (28.8 ± 0.2%) and the lowest in the Czech cultivar Marlen (14.6 ± 0.4%). The origin of the cultivar had no significant influence on the TPC of the kernel (data not shown). The average TPC of cultivars from the Czech Republic was 23 ± 4%, from Ukraine 19 ± 4%, France 22 ± 4% and the USA 24 ± 3%. The results are shown in Table 3 and Figure 1.

Table 3. Total protein content in kernels of apricot cultivars. The data are displayed as the mean ± standard deviation of three replications; a . . . p refer to the grouping based on Fisher LSD test.

Cultivar	Total Protein Content (%)	Cultivar	Total Protein Content (%)
Ackerman	21.6 ± 0.5 fg	LI-3-6	27.7 ± 0.6 op
Beta	23.5 ± 0.2 hij	Luizet	15.3 ± 0.6 ab
Bora	22.9 ± 0.7 gh	M52	18.60 ± 0.07 de
Congat	24.3 ± 0.2 ijk	Hungarian Best	17.4 ± 0.2 cd
Dovrtělova	19.2 ± 0.2 e	Marlen	14.6 ± 0.4 a
Early Blush	20.7 ± 0.6 f	Mediabel	23.9 ± 0.4 hijk
Flavorcot	27.0 ± 0.5 no	Meligat	24.1 ± 0.6 hijk
H-848	23.34 ± 0.06 hi	Moldavskij Olimpik	21.52 ± 0.08 f
Harostar	21 ± 1 f	Orangered	24.3 ± 0.3 ijk
Kioto	26.6 ± 0.1 no	Pastyryk	26.9 ± 0.5 no
Kompakta	26.1 ± 0.8 mn	Poljus Južnyj	16.9 ± 0.3 c
Koolgat	26.5 ± 0.4 mno	Pozdní chrámová	21.6 ± 0.4 fg
LE-5500	25.9 ± 0.3 lmn	Priusadebnyj	15.5 ± 0.3 ab
LE-5959	28.8 ± 0.2 p	Samourai	17 ± 1 cd
Leronda	23.2 ± 0.1 hi	Velikyj	25.2 ± 0.3 klm
LI-13-6	24.7 ± 0.4 jkl	Veselka	16.3 ± 0.1 bc

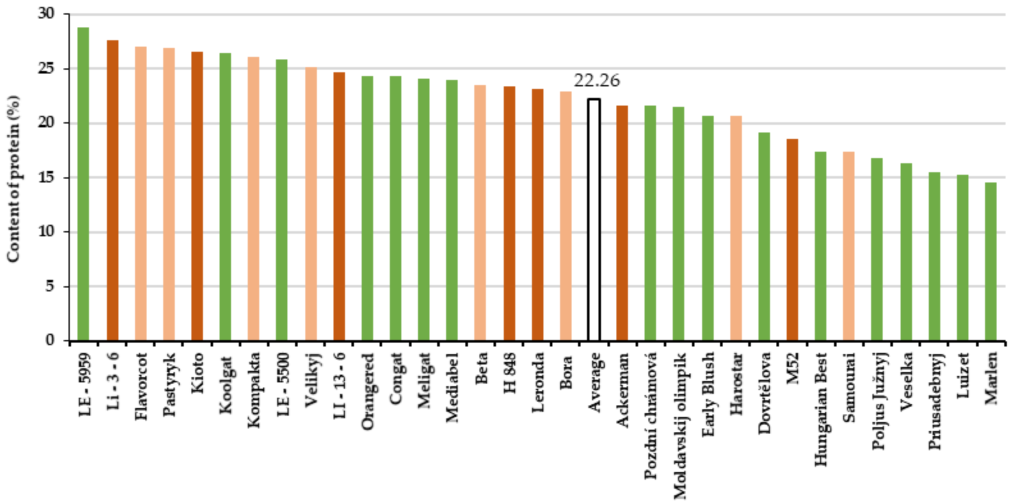

Figure 1. Total protein content in kernels of apricot cultivars. The green columns represent sweet kernels, brown columns are for bitter kernels and orange columns are for bittersweet kernels.

The values of total phenolic content (TPHC) ranged from 1277.3 to 63.5 mg GAE/100 g DW (Table 4). The average value of TPHC was 267 ± 156 mg GAE/100 g DW. The highest value was measured in the Italian cultivar Bora, which was as an outlier not included in statistical analysis. The lowest values were measured in the Canadian Harostar and French Congat cultivars. After Bora, the next highest values were measured in LE-5959, Pozdní chrámová and Moldavskij Olimpik.

Table 4. Total phenolic content in kernels of apricot cultivars. The data are displayed as the mean ± standard deviation of three replications; a . . . u refer to the grouping based on Tukey HSD test.

Cultivar	Total Phenolic Content (mg GAE/100 g DW)	Cultivar	Total Phenolic Content (mg GAE/100 g DW)
Ackerman	343.4 ± 0.9 o	LI-3-6	113.7 ± 0.6 b
Beta	318 ± 2 m	Luizet	426.7 ± 0.9 q
Bora	1277 ± 5 u	M52	160 ± 1 ef
Congat	68.0 ± 0.7 a	Hungarian Best	196 ± 3 gh
Dovrtělova	321.0 ± 0.7 mn	Marlen	239.7 ± 0.2 j
Early Blush	330 ± 1 n	Mediabel	139.8 ± 0.7 c
Flavorcot	161 ± 5 ef	Meligat	289.2 ± 0.9 l
H-848	144 ± 5 cd	Moldavskij Olimpik	626 ± 2 r
Harostar	64 ± 1 a	Orangered	236.0 ± 0.4 ij
Kioto	111.9 ± 0.5 b	Pastyryk	346.4 ± 0.1 o
Kompakta	189.6 ± 0.3 g	Poljus Južnyj	278.7 ± 0.5 k
Koolgat	226 ± 2 i	Pozdní chrámová	648 ± 3 s
LE-5500	349.3 ± 0.9 o	Priusadebnyj	201.0 ± 0.4 h
LE-5959	663 ± 1 t	Samourai	233 ± 0.2 ij
Leronda	190.8 ± 0.4 g	Velikyj	164 ± 3 f
LI-13-6	139 ± 2 c	Veselka	385 ± 1 p

The values of total flavonoid content (TFC) (Table 5) ranged from 153.1 to 0 mg CE/100 g DW with the mean value reaching 22 ± 19 mg CE/100 g DW. The cultivar Bora had the highest value and was assessed as an outlier. The next highest values were measured in cultivars LE-5959, Pozdní chrámová and Moldavskij Olimpik. Unmeasurable low values of TFC were found in the Harostar, Congat and Velikyj cultivars.

Table 5. Total flavonoid content in kernels of apricot cultivars. The data are displayed as the mean ± standard deviation of three replications; a . . . m refer to the grouping based on Tukey HSD test.

Cultivar	Total Flavonoid Content (mg CE/100 g DW)	Cultivar	Total Flavonoid Content (mg CE/100 g DW)
Ackerman	38.0 ± 0.1 hi	LI-3-6	8.5 ± 0.3 abcd
Beta	5.9 ± 0.4 ab	Luizet	52.3 ± 0.6 jk
Bora	153 ± 3 m	M52	13 ± 1 bcd
Congat	— a	Hungarian Best	13 ± 1 bcde
Dovrtělova	37.4 ± 0.4 hi	Marlen	15.0 ± 0.1 bcdef
Early Blush	30.2 ± 0.3 gh	Mediabel	9.3 ± 0.5 abcd
Flavorcot	10.3 ± 0.3 abcd	Meligat	18.4 ± 0.3 def
H-848	14.1 ± 0.4 bcdef	Moldavskij Olimpik	61.5 ± 0.5 kl
Harostar	— a	Orangered	29.3 ± 0.2 gh
Kioto	6.4 ± 0.1 ab	Pastyryk	9.1 ± 0.5 abcd
Kompakta	13.8 ± 0.5 bcde	Poljus Južnyj	45 ± 9 ij
Koolgat	14 ± 0 bcde	Pozdní chrámová	63.1 ± 0.8 l
LE-5500	23.5 ± 0.4 efg	Priusadebnyj	17.5 ± 0.4 cdef
LE-5959	69 ± 1 l	Samourai	24.2 ± 0.4 fg
Leronda	13.52 ± 0.06 bcde	Velikyj	— a
LI-13-6	7.9 ± 0.2 abc	Veselka	31 ± 3 gh

The values of antioxidant activity ranged from 2348.4 to 483.4 mg TE/100 g DW with the mean value reaching 732 ± 257 mg TE/100 g DW. The cultivar Bora was assessed as an outlier with the highest value (Table 6). Surprisingly, the next highest value was reached by the cultivars Velikyj, Koolgat and LE-5959. The lowest value was measured for Harostar.

Table 6. Antioxidant activity of kernels of apricot cultivars. The data are displayed as the mean ± standard deviation of three replications; a . . . g refer to the grouping based on Tukey HSD test. The groups with similar values are denoted by same letters.

Cultivar	Antioxidant Activity (mg TE/100 g DW)	Cultivar	Antioxidant Activity (mg TE/100 g DW)
Ackerman	983.12 ± 0.04	LI-3-6	598.55 ± 0.05 d
Beta	757.54 ± 0.06	Luizet	837.5 ± 0.3
Bora	2348.4 ± 0.6	M52	597 ± 1 d
Congat	524.53 ± 0.03	Hungarian Best	591.06 ± 0.07 c
Dovrtělova	674.1 ± 0.2	Marlen	856 ± 2
Early Blush	609.1 ± 0.2 e	Mediabel	585.84 ± 0.05 b
Flavorcot	587.9 ± 0.1 bc	Meligat	682.9 ± 0.1 g
H-848	580 ± 1 a	Moldavskij Olimpik	803.0 ± 0.3
Harostar	483.41 ± 0.07	Orangered	620.4 ± 0.1 f
Kioto	608.0 ± 0.2 e	Pastyryk	543.05 ± 0.02
Kompakta	579.2 ± 0.1 a	Poljus Južnyj	654.7 ± 0.13
Koolgat	1427.6 ± 0.2	Pozdní chrámová	879.9 ± 0.4
LE-5500	615.5 ± 0.4	Priusadebnyj	553.13 ± 0.09
LE-5959	1205.0 ± 0.3	Samourai	649.1 ± 0.1
Leronda	622.1 ± 0.1 f	Velikyj	1600 ± 3
LI-13-6	719.5 ± 0.2	Veselka	685.5 ± 0.1 g

For final comparison, all results of nutritive substances of sweet, bitter and bittersweet kernels are shown in Figure 2. In our study, the mean value of TPC in sweet kernels was 21 ± 1%, in bitter kernels 24 ± 1% and in bittersweet kernels 24 ± 1%. Interestingly, high values of TPHC were measured in cultivars with sweet kernels (330 ± 174 mg GAE/100 g DW on average). THPC of cultivars with bitter kernels was considerably lower (172 ± 80 mg GAE/100 g DW on average). TPHC of cultivars with bittersweet kernels was between the sweet and the bitter kernel cultivars, resulting in 210 ± 98 mg GAE/100 g DW on average. The antioxidant activity of sweet kernels, bittersweet kernels and bitter kernels was 753 ± 240, 742 ± 387 and 672 ± 144 mg TE/100 g DW, respectively.

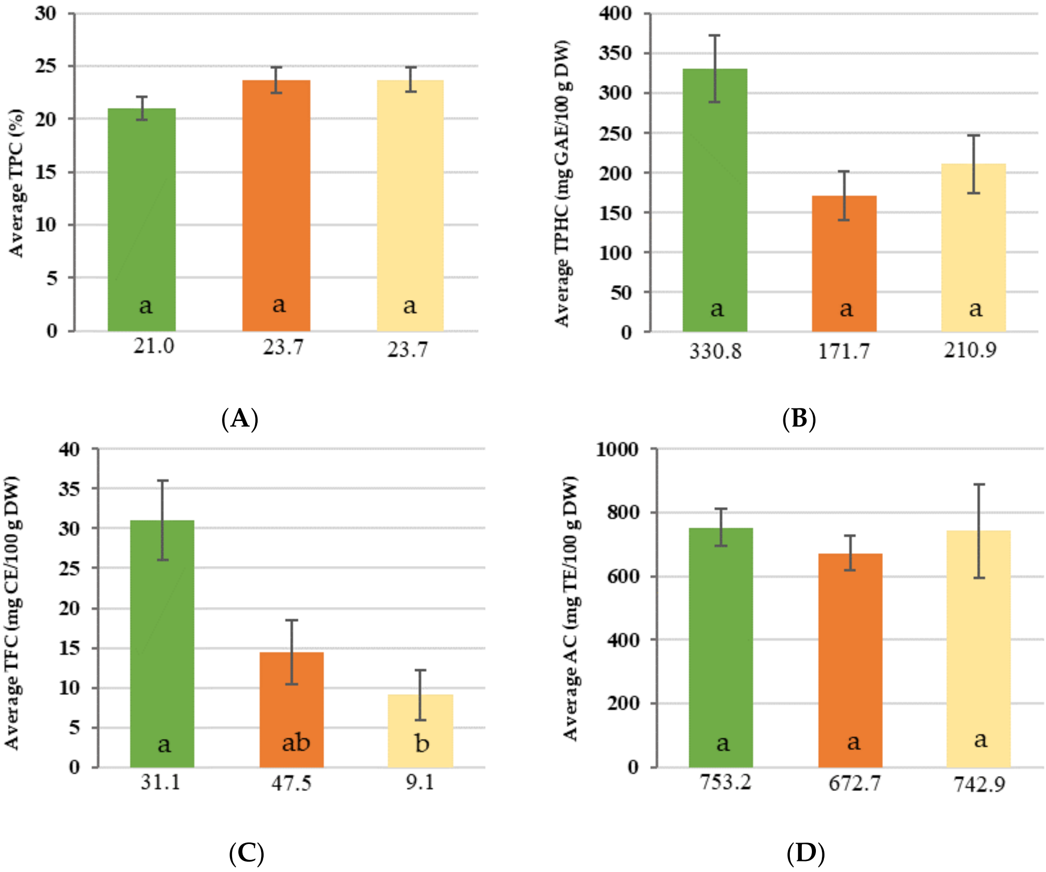

Figure 2. Comparison of average values of nutritive substances with their deviation in sweet (green column), bitter (orange column) and bittersweet (yellow column) apricot kernels; (**A**) total protein content (TPC); (**B**) total phenolic content (TPHC); (**C**) total flavonoid content (TFC), (**D**) antioxidant capacity (AC). Letters a . . . b indicate statistical significance of differences between sweet, bitter and bittersweet groups of cultivars.

Correlation was established between TPHC and TFC, which had the correlation coefficient R = 0.9572 (Figure 3). Cultivars Pastyryk, Beta and Velikyj deviated from this correlation as they had high values of TPHC but low TFC. All of them belong to the bittersweet kernel group. Conversely, cultivars Poljus Južnyj, Orangered and Luizet had higher values of TFC compared to TPHC.

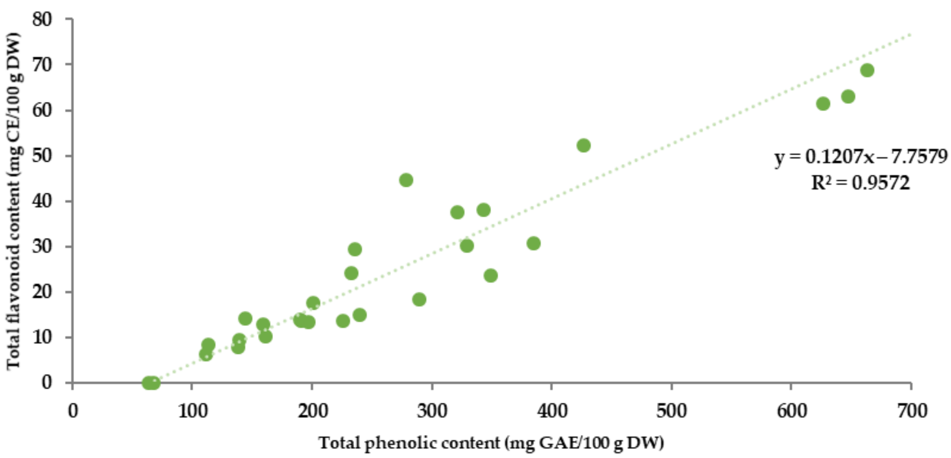

Figure 3. Correlation between total flavonoid content and total phenolic content of apricot kernels.

4. Discussion

High protein and phenolic content in apricot kernels are a positive parameter in terms of their consumption or processing. In our study, the mean value of TPC was 22.26% and it corresponded to results from other studies (14.1% to 45.3%) [20–23,32–34].

Lazos et al. (1991) measured 21.2% of TPC in apricot kernels, 26.7% in peach kernels and 25.3% in sweet cherry kernels [35]. Sweet apricot kernels could be used in the food industry similarly to almonds (*Prunus amygdalus* L.). Barbera et al. (1994) found that almond kernels grown in Spain contained 23.03% to 23.98% TPC, while Calixto et al. (1981) measured 20.51% TPC and Özcan (2000) found only 12.7% to 16.3% TPC in almonds [13,36,37]. With regard to the high amygdalin content in bitter kernels (26 ± 14 $mg \cdot g^{-1}$), only sweet apricot kernels are suitable for consumption as they contain considerably less amygdalin (0.16 ± 0.09 $mg \cdot g^{-1}$) [19]. In our study, the average value of TPC in sweet apricot kernels ranged from 14.56% to 28.77% with a mean value of 21 ± 4%. The highest TPC was in the Czech hybrid LE-5959, which contained the most protein (28.8 ± 0.2%) and its weight was approximately average (1.0 ± 0.1 g). The second highest TPC content was in the French cultivar Koolgat (26.5 ± 0.4%), with weight slightly under the average value (0.79 ± 0.07 g). A similar result was found in the Czech hybrid LE-5500 (0.85 ± 0.06 g) with the third highest TPC (25.9 ± 0.3%). Cultivars with sweet kernels, such as Orangered, Congat and Meligat, had slightly higher weight than average. An interesting cultivar is the Moldavskij Olimpik, which had average TPC values (21.52 ± 0.08%) but the heaviest kernels (1.7 ± 0.1 g). The cultivar Luizet had the second heaviest kernels, but its TPC was much less than average (15.3 ± 0.1%). Processing of bitter apricot kernels is also in the long-term interest. Aside from the use of amygdalin in traditional Chinese medicine [38], the protein concentrate extracted from apricot kernels has been used for preparation of transglutaminase-induced gels, which are used for delivering sensitive compounds into functional foods, as well as dietary supplements and pharmaceutical products [39]. In China, approximately 193 thousand tons of bitter kernels are processed every year [40], which have between 23.6% and 26.2% TPC on average [38]. This value corresponds with our results of the average TPC in bitter kernels (23.7%), but the range was higher (18.6% to 27.7%). Famiani et al. (2020) expressed the hypothesis that proteins in the kernels of stone fruits are accumulated in kernels from the endocarp during the hardening of the stone [2]. The process of translocation of proteins is still unknown and could be an interesting topic in future research.

Korekar et al. (2011) analyzed kernels of 14 apricot cultivars for their TPHC which ranged from 92.2 to 162.1 mg GAE/100 g with a mean value of 128.5 mg GAE/100 g DW [41]. Juhaimi et al. (2018) studied phenolic and flavonoid compounds in kernels of four Turkish apricots and their results ranged from 54.41 to 59.61 mg GAE/100 g DW for TPHC and 18.17 to 23.56 mg CE/100 g DW for TFC [14]. In our study, the results for TPHC were much higher (267 ± 156 mg GAE/100 g DW on average). The result for TFC was similar to Juhaimi et al.'s (2018) (22 ± 19 mg CE/100 g DW) [14]. Yıldırım et al. (2010) measured ten times higher values of TPHC in bitter apricot kernels than in sweet ones [29]. In our study, sweet kernels contained more phenolics than bitter kernels (sweet—331 mg GAE/100 g DW; bitter—172 mg GAE/100 g DW). Just for comparison, 425, 589 and 461 mg GAE/100 g was measured in dry hazelnuts, walnuts and pistachios with seed coats, respectively [42]. In our study, much higher TPHC and TFC were measured in cultivars Bora (1277.3 mg GAE/100 g DW), LE-5959 (647.5 mg GAE/100 g DW) and Moldavskij Olimpik (626.3 mg GAE/100 g DW). These cultivars have sweet tasting kernels and the results of antioxidant activity agreed with the phenolic content of mentioned cultivars. Results of antioxidant activity of Turkish apricot kernels in Juhaimi et al. (2018) ranged from 53.98% to 59.61% DPPH [14]. Yigit et al. (2009) mentioned that higher antioxidant activity was found in sweet kernels than in bitter kernels [43]. These results agreed with our study on average, where the antioxidant activity for sweet kernels was 753 mg TE/100 g DW and for bitter kernels 672 mg TE/100 g DW on average. The cultivar Bora, with bittersweet kernels, showed the highest value of antioxidant activity (2348.4 mg TE/100 g

DW) and, surprisingly, a high value of antioxidant activity was measured for Velikyj (1600.1 mg TE/100g DW), which did not correlate to TPHC and TFC. In sweet kernel cultivars, the highest values were measured for LE-5959 (1205.0 mg TE/100g DW) and Koolgat (1427.6 mg TE/100g DW). Thus, these cultivars could be an interesting nutritive source of protein and antioxidants in addition.

5. Conclusions

At a time when the world is driven by many changes, such as global climate change, rational and sustainable agricultural production, depletion of natural resources and overpopulation, it is important to seek solutions to overcome this critical period in the next years. One of the possibilities is to search for food resources with added value for human health which are not yet widely used in the food industry. Apricot kernels are a nutritionally interesting source of proteins, which are the second most abundant component of their weight. The average value of total protein content of 32 cultivars with different origin was 22.26% and the values ranged from 14.56% to 28.77%. No significant correlation between TPC and origin, weight or taste of kernels was found. The average weight of the kernels was 1.02 g and ranged from 0.57 to 1.7 g. The Czech hybrid LE-5959 could be a prospective cultivar for its sweet kernels and high protein content. Interesting results were measured in the cultivar Moldavskij Olimpik, which had average TPC, however a very high value of kernel weight. The data of protein content were supplemented with total phenolic and total flavonoid contents and antioxidant activity in apricot kernels. On average, 267 $\pm$ 156 mg GAE/100 g DW, 22 $\pm$ 19 mg CE/100 g DW and 732 $\pm$ 257 mg TE/100 g DW were measured in kernels of analyzed cultivars. Despite the knowledge about nutritionally interesting substances in apricot kernels, this study is unique in terms of comparing the content values in the kernels of specific apricot cultivars with various origins. However, it was confirmed that the results correspond to the already measured average values.

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