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Amino Acid Determination in Kernels of Selected Apricot and Almond Cultivars

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Abstract. **Apricot fruit are a popular and highly sought-after type of fruit. However, few people are aware that in cultivars with sweet kernels, these kernels are suitable for consumption. Although they are a rich source of nutritionally valuable compounds, the kernels often remain underutilized during fruit processing. In our study, 15 apricot cultivars of different origins were analyzed. In addition, three almond cultivars were included in the experiment for comparison. Kernel weight and taste were evaluated, and these data are summarized in a quality assessment of the studied apricot kernels. The results show that the total amino acid content in the kernels ranged from 125.70 to 305.32 mg·g^{-1} dried kernels and was not dependent on kernel origin, weight, or taste. The main amino acids identified in apricot kernels, as well as in almond kernels, with significant content levels were glutamic acid (29.92–74.47 mg·g^{-1}), aspartic acid (13.20–39.29 mg·g^{-1}), arginine (10.17–69.51 mg·g^{-1}), glycine (7.39–16.25 mg·g^{-1}), and alanine (6.46–16.59 mg·g^{-1}). Specifically, the Canadian cultivar Harlayne showed the highest amino acid content; however, due to the sweet-bitter taste of its kernel, it may be more suitable for medicinal use rather than for the direct consumption of kernels.**

Introduction

Apricots (*Prunus armeniaca* L.) are a widespread, popular, and attractive fruit species with a broad range of uses. The fruit has a distinct flavor, a heavy fragrance, and an appealing yellow to orange base color with a reddish overcolor (Bartolini et al. 2015). Not only the attractive fruit and even the flowers (Göttingerová et al. 2020; Gundogdu et al. 2017; Khanyile and Gürcan 2024) consumed, but also the kernels or oil are extracted from them. In recent years, the demand for alternative plant sources of proteins and lipids has been increasing. At the same time, there has been emphasis on sustainability of the production of these nutritional resources, suggesting that sweet apricot kernels could be a delicacy in the same way as sweet almonds (Pawar and Nema 2023; Sharma et al. 2010; Zezulová et al. 2026).

Apricot kernels, a by-product of apricot fruit, are a rich source of protein, fats, fiber, carbohydrates, phenolic compounds, vitamins, and minerals (Akhone et al. 2022; Al Juhaimi et al. 2018; Alpaslan and Hayta 2006; Özcan 2000; Rampáčková et al. 2021). Apricot seeds also contain, among other compounds, steroid substances and oils with a predominance of oleic acid (73.4%) (Semwal et al. 2023). Turan et al. (2007) reported that the total oil content in apricot kernels ranges from 40.23% to 53.19%. Among amino acids, aspartic acid and glutamic acid, tyrosine, serine, proline, arginine, and others are mainly represented (Alajil et al. 2022; Kamel and Kakuda 1992; Mustafa et al. 2023; Haciseferogullari et al. 2007). Their risk component is the cyanogenic glycoside amygdalin, which causes the bitterness of the seeds. Hence, the bitterness level of kernels is determined by the amount of amygdalin (Al-Soufi et al. 2022). Apricot kernels are used in various industrial sectors, such as the food industry, cosmetics, or medicine. The folk tradition relates apricot to antipyretic, antiseptic, antispasmodic, antiasthmatic, analgesic, laxative, demulcent, emetic, expectorant, ophthalmic, sedative, vulnerary, tonic, and more effects (Viorica-Mirela et al. 2013). As a result, apricot kernels help boost skin health, improve metabolism, enhance vision, reduce the risk of diabetes, and maintain digestive functioning (Yıldızlı et al. 2021).

The nutritional and functional composition of apricot kernels is a critical factor in deciding their suitability for utilization and processing into various value-added products. The aim of our study was to determine the amino acid content in apricot kernels from genotypes grown in the Czech Republic and to obtain data that will be useful for further research, apricot growers, and entrepreneurs in this field.

Material and Methods

Site of planting and plant material. Fifteen apricot cultivars and three almond cultivars of different origins were analyzed in our study (Table 1): nine apricot cultivars from the Czech Republic, two from Canada, two from the United States, one from Slovakia, and one each from countries of the former Soviet Union (Fig. 1). Almond varieties originated in France and Italy (Fig. 2). Trees of these cultivars were grown in the experimental orchard at the Faculty of Horticulture in Lednice, Mendel University in Brno (lat. 48.80°N, long. 16.80°E; elevation, 172 m).

Ten fruit from each variety were harvested at their biological harvest and transported to the laboratory for pomological analysis. The weight of the stone and the kernel was measured, and the taste of each kernel was qualified (sweet, bittersweet, bitter).

Preparation of the plant samples for analyzing the amino acids. Before the determination of amino acid content, the seeds were dried and pulverized in a mill. Sample processing involved weighing 5 mg of the sample, to which 1 mL of 6 M hydrochloric acid was added. The sample was subsequently mineralized using an MW Anton Paar system (hydrolysis parameters: power, 80 W; mineralization time, 90 min; maximum temperature, 120 °C; maximum pressure, 25 bar). After mineralization, the sample was diluted at a ratio of 1:9 with a sodium-cycle dilution buffer (100 µL of sample + 900 µL of sodium dilution buffer). The sample was then centrifuged for 20 min at 25,000 *g* and 4 °C. After centrifugation, 500 µL of the sample was collected and mixed with 500 µL of 0.6 M sodium hydroxide in sodium-cycle dilution buffer. This diluted sample was then further diluted once more at a ratio of 1:1 with 0.6 M sodium hydroxide in a sodium-cycle dilution buffer.

Amino acid analysis. The analysis was performed using an Ingos AAA-400 liquid chromatograph equipped with a visible light detector. Separation was carried out on a glass chromatographic column (inner diameter,

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

Cultivar	Species	Origin	Cultivar	Species	Origin
Bobcot	*Prunus armeniaca*	Canada	LE-13	*P. armeniaca*	Czech Republic
Goldrich	*P. armeniaca*	United States	LE-108	*P. armeniaca*	Czech Republic
Gvardějskij	*P. armeniaca*	Countries of the former Soviet Union	LE-5500	*P. armeniaca*	Czech Republic
Harlayne	*P. armeniaca*	Canada	LE-5711	*P. armeniaca*	Czech Republic
Stark Early Orange	*P. armeniaca*	United States	LE-9828	*P. armeniaca*	Czech Republic
Velkopavlovická	*P. armeniaca*	Czech Republic	LE-9900	*P. armeniaca*	Czech Republic
Vestar	*P. armeniaca*	Slovakia	Ferragnes	*Prunus amygdalus*	France
H-848	*P. armeniaca*	Czech Republic	Genco	*P. amygdalus*	Italy
H-877	*P. armeniaca*	Czech Republic	Supernova	*P. amygdalus*	Italy

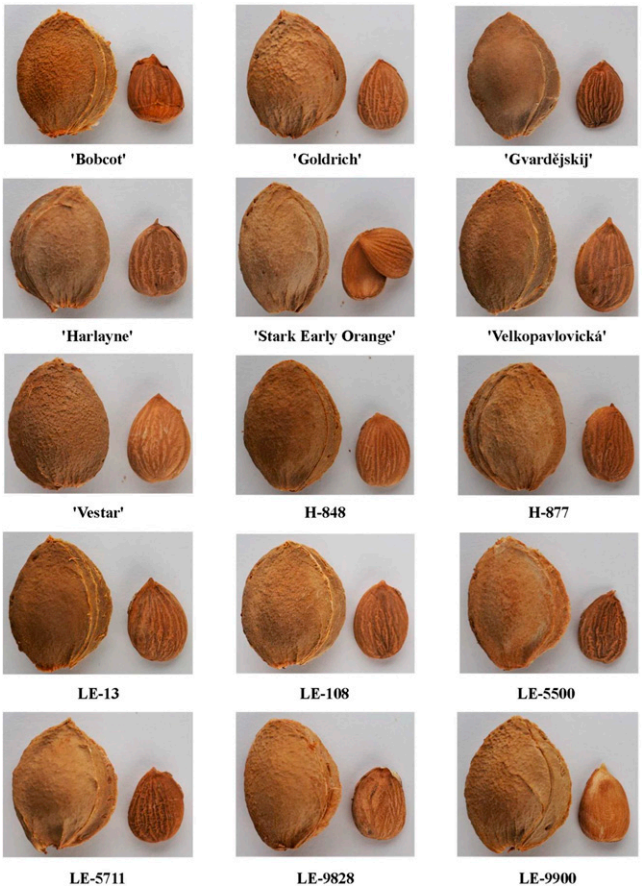

Fig. 1. The overall appearance of the apricot kernels for the cultivars used in this study.

3.7 mm; length, 32 cm) packed with a strong cation-exchange resin in the sodium cycle LG ANB (particle size, 12 µm; crosslinking, 8%). The column was set at a temperature of 60 to 80 °C and the reactor was maintained at 120 °C.

The sample (100 µL) was injected automatically using an autosampler. The mobile phase flow rate was 0.3 mL·min^{-1}. The mobile phase consisted of A: ninhydrin reagent; B (1): buffer 1, pH 2.7 (citric acid, sodium citrate, sodium chloride, sodium azide, thiodiglycol); C (2): buffer 2, pH 3.0 (citric acid, sodium citrate, sodium chloride, sodium azide, thiodiglycol); D (3): buffer 3, pH 4.25 (citric acid, sodium citrate, sodium chloride, sodium azide, thiodiglycol); E (4): buffer 4, pH 9.7 (sodium citrate, sodium chloride, boric acid, sodium azide); and F (6): 0.2 M sodium hydroxide.

The compounds were eluted using a linearly increasing gradient, as shown in Table 2. Detection of the separated compounds was performed at wavelengths of 440 and 570 nm. The duration of a single analysis was 120 min.

Fig. 2. The overall appearance of the almond kernels for the cultivars used in this study.

An amino acid standard dissolved in sodium dilution buffer was used for quantification. For amino acid calibration, six calibration solutions were prepared within a concentration range of 0.125 to 0.004 µmol·mL^{-1}. The concentration of amino acids is expressed in milligrams per gram of dried kernels.

Statistical analysis. The established data were processed using Microsoft's Excel (Redmond, WA, USA) and Statistica 12 software (TIBCO, Palo Alto, CA, USA). A single-factor analysis of variance (level of significance, $P \leq 0.05$) was used for statistical processing, and Tukey's honestly significant difference test was used subsequently to assess the statistical significance of differences between individual apricot and almond cultivars.

Results

The average weight of a fresh apricot kernel was 1.01 g, whereas the average weight of almond kernels was 0.92 g. The greatest kernel weight was measured in the apricot genotype H-848 (1.29 g), whereas the lowest weight was recorded in three genotypes: 'Gvardějskij', LE-5500, and LE-9828 (0.66 g). Among almond cultivars, the greatest kernel weight was observed in the cultivar Supernova (1.24 g), and the lowest was seen in the cultivar Ferragnes (0.61 g) (Fig. 3).

A sweet taste was noted in the kernels of six apricot cultivars, kernels of five cultivars were bitter, and four cultivars had bittersweet kernels. Almond cultivars had sweet kernels. All data are presented in Table 3.

The main detected amino acid components with the highest contents were glutamic acid, arginine, and aspartic acid. Specifically, glutamic acid was the most abundant amino acid in the studied set. Its content ranged from 29.92 to 74.47 mg·g^{-1}. Significantly high values were recorded in the cultivars Harlayne (74.47 mg·g^{-1}), Velkopavlovická (69.65 mg·g^{-1}), and Bobcot (69.04 mg·g^{-1}). In contrast, the lowest values were detected in the apricot hybrid LE-13 (41.03 mg·g^{-1}) and in the almond cultivar Genco (29.92 mg·g^{-1}).

The average content of the semiessential amino acid arginine reached a concentration of 47.63 mg·g^{-1}. Remarkably high values were observed in two American cultivars, Stark Early Orange and Goldrich, with contents of 69.51 and 64.66 mg·g^{-1}, respectively. In contrast, a markedly low arginine content was detected in the hybrid LE-13 (10.17 mg·g^{-1}). Almond kernels again exhibited low arginine contents.

Table 2. Parameters of the linearly increasing gradient.

Time (min)	Column temperature (°C)	Buffer no.
0.00	60	1
5.00	60	2
33.00	60	3
50.00	60	4
66.00	75	4
83.00	80	4
88.00	80	6
94.00	80	6
100.00	80	6
101.00	60	1
114.00	60	1
115.00	60	1
120.00	60	1

The aspartic acid content in the 15 apricot cultivars ranged from 20.61 to 39.29 mg·g^{-1}. The highest values were recorded in the hybrid LE-5500 (39.29 mg·g^{-1}) together with the cultivar Bobcot (38.25 mg·g^{-1}), followed by the cultivars Harlayne and Goldrich, and the hybrid LE-5711 (34.24, 33.58, and 32.25 mg·g^{-1}, respectively). In contrast, the lowest value was measured in the hybrid LE-13 (20.61 mg·g^{-1}). The average aspartic acid content in almond kernels was 15.32 mg·g^{-1}.

Glycine and alanine were also the most abundant compounds among the nonessential amino acids. Among these, glycine was the most prevalent, with an average content of 14.68 mg·g^{-1} in apricot kernels and 10.24 mg·g^{-1} in almond kernels. Significant values were observed in the cultivars Harlayne, Velkopavlovická, and Bobcot, with contents of 16.25, 15.48, and 14.84 mg·g^{-1}, respectively. A low glycine content was traditionally detected in the hybrid LE-13 (10.44 mg·g^{-1}). Low values were also recorded in the almond cultivars, with the lowest content measured in 'Supernova' (7.39 mg·g^{-1}).

The alanine content in apricot kernels ranged from 9.44 to 16.59 mg·g^{-1}, and in almond kernels ranged from 6.46 to 10.23 mg·g^{-1}. The highest value was observed in the cultivar Harlayne (16.59 mg·g^{-1}), whereas the apricot hybrid LE-13 had the lowest content (9.44 mg·g^{-1}). Among almonds, the highest alanine content was recorded in the cultivar Genco (10.23 mg·g^{-1}) and the lowest in the cultivar Supernova (6.46 mg·g^{-1}).

The analyzed essential and nonessential amino acids, together with the measured values, are presented in Tables 4 through and 6. Comparison of the total content of essential amino acids depending on the cultivar and flavor is shown in Fig. 4. The distribution of total essential amino acid content depending solely on kernel flavor is presented in Fig. 5. Differences among cultivars in all individual determinations were evaluated as statistically highly significant.

Discussion

In the apricot breeding program at the Faculty of Horticulture in Mendel University in Brno, emphasis is placed, among other goals, on obtaining hybrids with high-quality pomological traits. Unfortunately, apricot kernels have not yet received comparable attention (Nečas et al. 2020). Given that apricot kernels represent a significant source of protein and essential amino acids, the breeding and selection of new cultivars should integrate this nutritional aspect to address the global search for alternative food sources.

Our analysis revealed an overall average amino acid content of 82.49 mg·g^{-1} in apricot kernels and 50.06 mg·g^{-1} in almond kernels. El-Safy et al. (2012) reported a total amino acid content in fresh apricot kernels of 31.44 g·100 g^{-1} protein, whereas Mustafa et al. (2023) reported an average value of 49.69 g·100 g^{-1} protein. In almond kernels, an average content of 17.30 g·100 g^{-1} was determined (Calixto et al. 1981).

Our results show that glutamic acid, arginine, and aspartic acid were the most abundant amino acids in the kernels of the tested apricot and almond genotypes. This finding is consistent with studies by Alpaslan and Hayta (2006), Ahrens et al. (2005), House et al. (2019), Joia et al. (2025), Mustafa et al. (2023), Özcan (2023), Zhu et al. (2025), and Yin et al. (2020). However, our results do not fully agree with some previously published research. For example, Alajil et al. (2022) reported aspartic acid and tyrosine as the major amino acids. Mesarović et al. (2018) considered leucine and arginine to be the dominant amino acids in Serbian apricot cultivars, whereas glutamic acid was found to be the most common in apricot kernels grown in China (Liu et al. 2021).

In our study, the total glutamic acid content ranged from 29.92 to 74.47 mg·g^{-1}. The minimum amount was recorded in the kernels of the almond cultivar Supernova, whereas the maximum was found in the kernels of the apricot cultivar Harlayne. The arginine content in the tested genotypes ranged from 10.17 mg·g^{-1} (apricot hybrid LE-13) to 69.51 mg·g^{-1} (apricot cultivar Stark Early Orange). The values of aspartic acid, the third main amino acid, varied from 13.29 mg·g^{-1} (almond cultivar Supernova) to 39.29 mg·g^{-1} (apricot hybrid LE-5500).

Yin et al. (2020) monitored the amino acid content in kernels of selected Serbian apricot cultivars, and found the average values were 26.50 × 10^{-2} g·g^{-1} protein for glutamic acid, 10.11 × 10^{-2} g·g^{-1} protein for arginine, and 11.25 × 10^{-2} g·g^{-1} protein for aspartic acid. In another study, Mustafa et al. (2023) analyzed amino acids in apricot, peach, and mango kernels. The average glutamic acid content was 23.52 g·100 g^{-1} protein for apricot, 23.25 g·100 g^{-1} protein for peach,

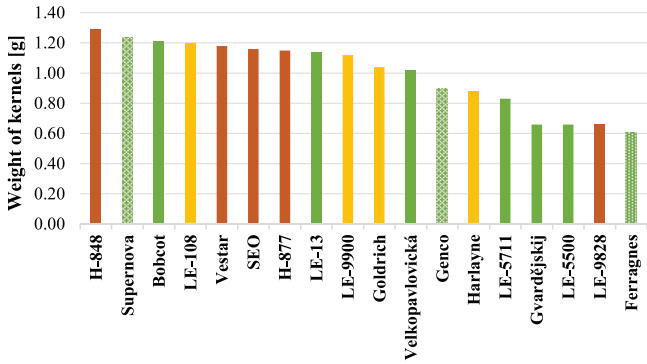

Fig. 3. The average weight of fresh apricot and almond kernels. Green columns = sweet kernels; brown columns = bitter kernels; yellow columns = bittersweet kernels.

Table 3. The physical properties and taste of apricot and almond kernels.[i]

Cultivar/hybrid	Kernel wt (g)	Taste	Cultivar	Weight of kernel (g)	Taste
Bobcot	1.21 ± 0.03 c–e[ii]	Sweet	LE-13	1.14 ± 0.08 b–e	Sweet
Goldrich	1.04 ± 0.04 de	Bittersweet	LE-108	1.20 ± 0.05 c–e	Bittersweet
Gvardějskij	0.66 ± 0.03 a	Sweet	LE-5500	0.66 ± 0.11 a	Sweet
Harlayne	0.88 ± 0.03 a–c	Bittersweet	LE-5711	0.83 ± 0.04 ab	Sweet
Stark Early Orange	1.16 ± 0.07 b–e	Bitter	LE-9828	0.66 ± 0.06 b–e	Bitter
Velkopavlovická	1.02 ± 0.05 b–e	Sweet	LE-9900	1.12 ± 0.15 b–e	Bittersweet
Vestar	1.18 ± 0.03 c–e	Bitter	Ferragnes	0.61 ± 0.05 a	Sweet
H-848	1.29 ± 0.02 e	Bitter	Genco	0.90 ± 0.04 a–d	Sweet
H-877	1.15 ± 0.14 b–e	Bitter	Supernova	1.24 ± 0.07 de	Sweet

[i] Data are the mean ± standard deviation of 10 replications.
[ii] Different lowercase letters indicate statistically significant differences between groups.

Table 4. Nonessential amino acids (non-EAAs): aspartic acid, glutamic acid, arginine, glycine, and alanine.[i]

Cultivar	Non-EAAs (mg·g^{-1})					
	Aspartic acid	Glutamic acid	Arginine	Glycine	Alanine	Total non-EAAs
Apricot						
Bobcot	38.25 ± 0.38 j[ii]	69.04 ± 0.95 jk	59.02 ± 1.80 g–j	14.84 ± 0.24 h–j	15.12 ± 0.13 h–j	196.27 ± 3.45 ij
Goldrich	33.58 ± 0.10 hi	57.19 ± 0.50 g–i	64.66 ± 1.13 ij	12.59 ± 0.10 c–f	13.04 ± 0.15 fg	181.06 ± 1.81f–i
Gvardějskij	31.19 ± 0.45 fg	54.41 ± 0.13 d–h	40.21 ± 0.43 cd	12.62 ± 0.10 c–f	13.40 ± 0.12 fg	151.83 ± 0.68 c–e
Harlayne	34.24 ± 0.06 i	74.47 ± 0.13 k	62.85 ± 1.13 h–j	16.25 ± 0.03 j	16.59 ± 0.13 j	204.40 ± 1.07 j
H-848	24.50 ± 1.07 c	57.86 ± 3.01 hi	56.60 ± 2.07 f–j	12.30 ± 0.47 c–f	12.67 ± 0.90 ef	163.93 ± 3.35 d–f
H-877	26.32 ± 0.13 d	56.66 ± 0.75 f–i	60.14 ± 0.48 g–j	12.96 ± 0.12 e–g	12.47 ± 0.18 ef	168.55 ± 1.01 e–g
LE-13	20.61 ± 0.20 b	41.03 ± 0.65 bc	10.17 ± 1.38 a	10.44 ± 0.10 b	9.44 ± 0.08 bc	91.69 ± 1.35 a
LE-108	30.97 ± 0.15 fg	48.14 ± 0.40 de	42.79 ± 0.65 c–e	11.59 ± 0.03 b–e	11.25 ± 0.04 de	144.74 ± 0.85 c
LE-5500	39.29 ± 1.05 j	63.53 ± 2.01 ij	50.69 ± 0.93 d–h	14.10 ± 0.24 g–i	15.73 ± 0.26 ij	183.34 ± 4.38 g–i
LE-5711	32.25 ± 1.28 gh	50.76 ± 0.93 d–g	43.46 ± 8.21 c–f	11.67 ± 0.32 b–e	11.20 ± 0.16 de	149.34 ± 5.83 cd
LE-9828	24.09 ± 0.21 c	50.09 ± 0.22 d–f	54.74 ± 3.65 e–i	11.24 ± 0.04 bc	12.31 ± 0.18 ef	152.47 ± 3.75 c–e
LE-9900	28.55 ± 0.12 e	54.99 ± 0.43 e–h	60.41 ± 0.40 h–j	12.91 ± 0.09 d–g	12.24 ± 0.10 ef	169.10 ± 0.13 e–g
Stark Early Orange	29.46 ± 0.30 ef	67.63 ± 0.53 jk	69.51 ± 2.47 j	13.67 ± 0.50 f–h	13.54 ± 0.23 f–h	193.81 ± 3.26 h–j
Velkopavlovická	29.97 ± 0.85 ef	69.65 ± 2.48 jk	46.86 ± 2.38 d–g	15.48 ± 0.51 ij	15.12 ± 0.67 h–j	177.08 ± 6.83 f–h
Vestar	28.20 ± 0.55 e	67.60 ± 2.02 jk	55.99 ± 1.76 e–i	14.68 ± 0.47 hi	14.59 ± 0.35 g–i	181.06 ± 4.73f–i
Almond						
Ferragnes	13.79 ± 0.16 a	34.42 ± 0.39 ab	24.87 ± 1.55 b	11.49 ± 0.06 b–d	8.37 ± 0.13 b	92.94 ± 1.17 a
Genco	18.97 ± 0.16 b	47.85 ± 0.14 cd	31.33 ± 1.04 bc	11.83 ± 0.10 b–e	10.23 ± 0.05 cd	120.21 ± 1.32 b
Supernova	13.20 ± 1.25 a	29.92 ± 2.07 a	23.05 ± 0.75 ab	7.39 ± 0.37 a	6.46 ± 0.28 a	80.02 ± 4.46 a

[i] Data are the mean ± standard deviation of 3 replications.
[ii] Lowercase letters refer to the grouping based on Tukey's honestly significant difference test.

and 20.33 g·100 g^{-1} protein for mango. The average values for arginine and aspartic acid were 9.43 and 11.30 g·100 g^{-1} protein for apricot, 8.91 and 16.27 g·100 g^{-1} protein for peach, and 7.14 and 10.50 g·100 g^{-1} protein for mango.

Furthermore, Chen et al. (2024) analyzed kernels of 'Xiaobai' apricot (*Prunus armeniaca* L. cv. Xiaobai), a unique apricot cultivar typical of the Xinjiang Province. These apricots are characterized by sweet kernels, extremely sweet flesh, and high juiciness. Aspartic acid was identified as the most significant amino acid, with a value of 1200 ± 30 mg·100 g^{-1}.

Ahrens et al. (2005) analyzed three commercial almond cultivars, in which glutamic acid (35.18 g·100 g^{-1} protein), aspartic acid (12.32 g·100 g^{-1} protein), and arginine (9.47 g·100 g^{-1} protein) were dominant. In the study by Shi et al. (2023), glutamic acid was dominant (19.2%–32.5%), followed by arginine (9.3%–13.2%), aspartic acid (9.9%–11.32%), and leucine (6.2%–10.3%).

The most abundant nonessential amino acid in apricot and almond kernels was tyrosine. Moreover, our data showed that leucine had the highest value among essential amino acids in all kernels, followed by isoleucine and valine. In contrast, threonine had the lowest values. In the study by Abd El-Rahman et al. (2015), phenylalanine and leucine predominated in apricot kernels. Similarly, Sarabandi et al. (2023) reported higher contents of leucine and phenylalanine in apricot kernels, whereas methionine was present in the lowest amount. These findings are also valid for almond kernels (Ahrens et al. 2005; Calixto et al. 1981; Seron et al. 1998).

Conclusion

At a time when the world is facing numerous changes, such as global climate change, the need for rational and sustainable agricultural production, the depletion of natural resources, and overpopulation, it is important to seek solutions to mitigate these critical impacts on humanity. One approach is to explore food sources with added value for human health that are currently underutilized in the food industry. Apricot kernels are a nutritionally valuable source of protein, and it can be stated that some cultivars are very

Table 5. Nonessential amino acids (non-EAAs): histidine, proline, serine, and tyrosine.[i]

Cultivar	Non-EAAs (mg·g^{-1})				
	Histidine	Proline	Serine	Tyrosine	Total Non-EAAs
Apricot					
Bobcot	7.66 ± 0.18 d–f[ii]	7.85 ± 0.79 fg	7.15 ± 0.28 fg	4.54 ± 0.22 de	27.20 ± 1.15 h
Goldrich	6.47 ± 0.06 b–d	6.04 ± 0.23 d–f	5.98 ± 0.37 c–f	2.24 ± 0.14 a–d	20.73 ± 0.73 d–g
Gvardějskij	6.92 ± 0.05 b–e	5.55 ± 0.11 de	6.27 ± 0.22 d–f	4.15 ± 0.30 cd	22.89 ± 0.05 e–h
Harlayne	8.04 ± 0.01 d–f	8.71 ± 0.13 g	6.89 ± 0.21 f	2.17 ± 0.22 a–d	25.81 ± 0.13 gh
H-848	6.51 ± 0.28 b–d	4.29 ± 0.31 cd	5.41 ± 0.25 c–f	2.59 ± 0.66 a–d	18.80 ± 0.39 c–e
H-877	6.64 ± 0.03 b–d	5.73 ± 0.12 de	2.47 ± 0.37 ab	3.91 ± 0.37 b–d	18.75 ± 0.61 c–e
LE-13	10.08 ± 0.17 f	1.19 ± 0.40 ab	4.91 ± 0.14 c–e	7.27 ± 0.12 f	23.45 ± 0.58 e–h
LE-108	5.66 ± 0.22 a–d	4.12 ± 0.26 cd	6.27 ± 0.30 d–f	3.45 ± 0.20 a–d	19.50 ± 0.41 c–f
LE-5500	7.56 ± 0.26 c–f	6.97 ± 0.99 e–g	6.71 ± 0.41 ef	4.25 ± 0.12 cd	25.49 ± 1.68 gh
LE-5711	9.41 ± 1.88 ef	2.30 ± 0.24 bc	5.79 ± 0.59 c–f	6.74 ± 1.63 ef	24.24 ± 3.82 e–h
LE-9828	5.70 ± 0.10 a–d	6.44 ± 0.38 ef	4.51 ± 0.35 cd	2.13 ± 0.18 a–c	18.78 ± 0.28 c–e
LE-9900	6.39 ± 0.06 b–d	3.26 ± 0.41 bc	2.20 ± 0.81 a	2.73 ± 0.30 a–d	14.58 ± 0.36 a–c
Stark Early Orange	6.90 ± 0.51 b–e	4.34 ± 0.18 cd	4.43 ± 0.20 cd	2.89 ± 0.24 a–d	18.56 ± 0.63 c–e
Velkopavlovická	7.58 ± 0.44 c–f	5.43 ± 0.43 de	7.17 ± 0.31 fg	2.44 ± 0.08 a–d	22.62 ± 0.94 e–h
Vestar	7.19 ± 0.21 c–e	6.74 ± 0.19 e–g	8.81 ± 0.18 g	2.27 ± 0.06 a–d	25.01 ± 0.36 f–h
Almond					
Ferragnes	4.41 ± 0.04 ab	1.77 ± 0.09 ab	2.22 ± 0.16 a	1.09 ± 0.03 a	9.49 ± 0.03 a
Genco	5.04 ± 0.06 a–c	4.20 ± 0.35 cd	5.54 ± 0.13 c–f	1.64 ± 0.07 ab	16.42 ± 0.49 b–d
Supernova	3.70 ± 0.10 a	0.16 ± 0.07 a	4.22 ± 0.38 bc	3.25 ± 0.14 a–d	11.33 ± 0.34 ab

[i] Data are the mean ± standard deviation of 3 replications.
[ii] Lowercase letters refer to the grouping based on Tukey's honestly significant difference test.

Table 6. Essential amino acids (EAAs): isoleucine, leucine, lysine, phenylalanine, threonine, and valine.[i]

Cultivar	EAAs (mg·g^{-1})						
	Isoleucine	Leucine	Lysine	Phenylalanine	Threonine	Valine	Total EAAs
Apricot							
Bobcot	10.65 ± 0.20 c–f[ii]	21.72 ± 0.42 fg	9.29 ± 0.57 cd	10.94 ± 0.42 f–h	3.39 ± 0.04 d–f	14.39 ± 0.25 h	70.38 ± 1.48 jk
Goldrich	8.65 ± 0.09 a–e	17.1 ± 0.14 d–g	9.04 ± 0.08 cd	9.28 ± 0.23 d–f	4.11 ± 0.14 ef	8.74 ± 0.64 b–f	56.92 ± 1.13 f–h
Gvardějskij	9.33 ± 0.26 a–e	19.18 ± 0.11 d–g	11.24 ± 0.10 de	8.96 ± 0.13 de	3.16 ± 0.27 c–f	12.70 ± 0.25 e–h	64.57 ± 0.30 h–j
Harlayne	11.37 ± 0.09 c–f	23.29 ± 0.17 g	11.35 ± 0.03 de	12.45 ± 0.09 h	3.74 ± 0.02 d–f	12.92 ± 0.22 f–h	75.12 ± 0.02 k
H-848	8.58 ± 0.31 a–e	17.82 ± 0.86 d–g	9.08 ± 0.45 cd	9.41 ± 0.62 d–f	1.86 ± 0.35 a–c	9.32 ± 1.04 c–h	56.07 ± 1.70 e–h
H-877	8.52 ± 0.08 a–e	18.27 ± 0.24 d–g	9.39 ± 0.30 c–e	8.85 ± 0.03 de	2.89 ± 0.37 b–e	12.24 ± 0.06 e–h	60.16 ± 0.89 g–i
LE-13	11.60 ± 0.11 d–f	1.87 ± 0.65 a	0.30 ± 0.01 a	4.90 ± 0.05 a	3.37 ± 0.40 d–f	3.99 ± 3.67 ab	26.03 ± 3.55 a
LE-108	8.02 ± 0.04 a–d	16.04 ± 0.18 c–g	8.33 ± 0.19 cd	7.82 ± 0.03 b–d	4.05 ± 0.15 ef	11.11 ± 0.10 c–h	55.37 ± 0.02 e–h
LE-5500	10.56 ± 0.30 c–e	21.24 ± 0.66 fg	13.06 ± 0.20 e	10.52 ± 0.65 e–g	3.99 ± 0.06 ef	12.05 ± 0.09 d–h	71.42 ± 1.89 jk
LE-5711	11.95 ± 2.35 ef	7.38 ± 4.41 a–c	3.37 ± 2.75 ab	6.66 ± 0.76 a–c	3.76 ± 0.17 d–f	11.88 ± 0.92 d–h	45.00 ± 4.69 cd
LE-9828	11.93 ± 1.94 d–f	5.56 ± 5.24 ab	9.93 ± 0.18 de	8.41 ± 0.06 cd	2.84 ± 0.12 b–e	9.09 ± 0.38 b–g	47.76 ± 3.61 c–f
LE-9900	14.52 ± 0.19 f	16.96 ± 0.26 d–g	9.20 ± 0.17 cd	9.08 ± 0.01 d–f	1.28 ± 0.11 a	0.30 ± 0.10 a	51.34 ± 0.36 d–g
Stark Early Orange	8.12 ± 0.23 a–e	19.56 ± 0.55 e–g	7.83 ± 0.21 cd	10.67 ± 0.30 e–g	3.35 ± 0.10 d–f	14.32 ± 0.12 gh	63.85 ± 0.43 h–j
Velkopavlovická	10.49 ± 0.09 c–e	21.27 ± 0.21 fg	10.76 ± 0.54 de	11.88 ± 0.37 gh	3.44 ± 0.09 d–f	11.63 ± 0.77 c–h	69.47 ± 1.69 i–k
Vestar	9.79 ± 0.26 b–e	20.48 ± 0.59 e–g	8.49 ± 0.29 cd	10.59 ± 0.36 e–g	4.46 ± 0.38 f	9.88 ± 0.52 c–h	63.69 ± 0.78 h–j
Almond							
Ferragnes	6.00 ± 0.03 ab	10.71 ± 0.15 b–d	7.67 ± 0.31 cd	6.03 ± 0.11 ab	2.92 ± 0.43 b–e	6.44 ± 0.13 bc	39.77 ± 0.63 bc
Genco	7.48 ± 0.07 a–c	14.42 ± 0.05 c–f	6.17 ± 0.02 bc	7.94 ± 0.06 cd	2.52 ± 0.09 a–d	7.56 ± 0.42 b–e	46.09 ± 0.46 c–e
Supernova	5.46 ± 0.20 a	11.70 ± 0.45 b–e	3.06 ± 0.15 ab	5.38 ± 0.40 a	1.65 ± 0.44 ab	6.99 ± 0.49 b–d	34.24 ± 1.77 ab

[i] Data are the mean ± standard deviation of 3 replications.
[ii] Lowercase letters refer to the grouping based on Tukey's honestly significant difference test.

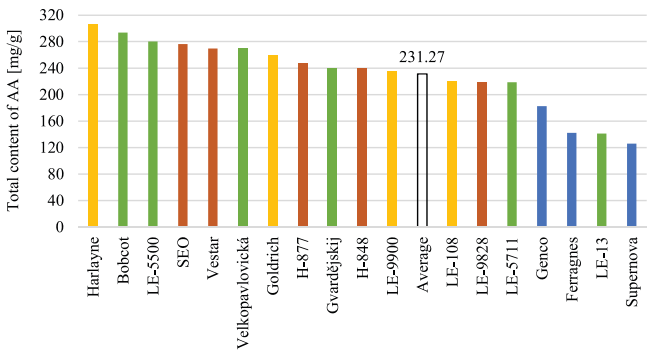

Fig. 4. Comparison of total essential amino acid (AA) content depending on kernel cultivar and taste. Green columns = sweet kernels; brown columns = bitter kernels; yellow columns = bittersweet kernels; blue columns = sweet almond kernels. SEO = 'Stark Early Orange'.

interesting biochemically and offer potential that could be harnessed in breeding programs as well as in further research.

In our experiment, the Canadian cultivar Harlayne achieved the best results, showing high amino acid values; however, because of its sweet–bitter kernels, it might be suitable only for industrial or medicinal use. The Canadian cultivar Bobcot, together with the hybrid LE-5500, were identified as genotypes with promising potential because of their sweet kernels and high amino acid content. In contrast, almond kernels, which are commonly consumed, exhibited significantly low values for all detected amino acids.

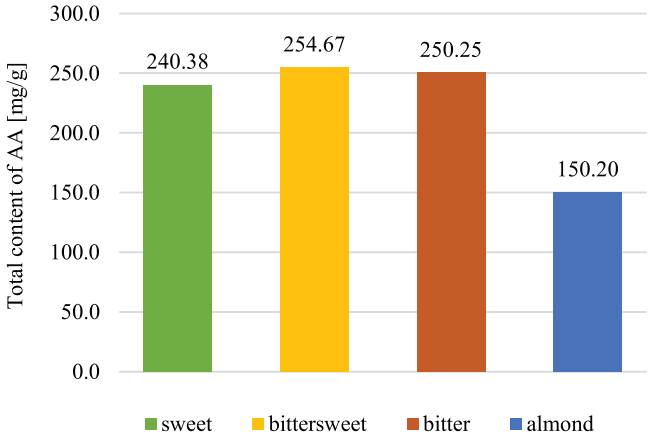

Fig. 5. Comparison of total essential amino acid (AA) content depending on kernel taste.

The results obtained may contribute to the promotion of apricot kernels as a new and promising resource for the food industry, gastronomy, and human nutrition. However, they still need to find their proper place in the market, which is expected to continue evolving in society for some time.

References Cited

Abd El-Rahman AA, El Hadary AE, Abd El Aleem MI. 2015. Detoxification and nutritional evaluation of peach and apricot meal proteins. J Biol Chem Environ Sci. 10(3):597–622. https://doi.org/10.21608/bces.2015.474397.

Ahrens S, Venkatachalam M, Mistry AM, Lapsley K, Sathe SK. 2005. Almond (*Prunus dulcis* L.) protein quality. Plant Foods Hum Nutr. 60(3):123–128. https://doi.org/10.1007/s11130-005-6840-2.

Akhone MA, Bains A, Tosif MM, Chawla P, Fogarasi M, Fogarasi S. 2022. Apricot kernel: Bioactivity, characterization, applications, and health attributes. Foods. 11(15):2184. https://doi.org/10.3390/foods11152184.

Alajil O, Sagar VR, Kaur C, Rudra SG, Vasudev S, Chandran D, Sharma K, Kumar M, Lorenzo JM. 2022. Chemical characterization of apricot kernel: Nutraceutical composition, amino acid, and fatty acid profile. Food Anal Methods. 15(9):2594–2604. https://doi.org/10.1007/s12161-022-02317-z.

Ali S, Masud T, Abbasi KS, Mahmood T, Hussai A. 2015. Apricot: Nutritional potentials and health benefits-a review. Ann Food Sci Technol. 16:175–189.

Al Juhaimi F, Özcan MM, Ghafoor K, Babiker EE. 2018. The effect of microwave roasting on bioactive compounds, antioxidant activity and fatty acid composition of apricot kernel and oils. Food Chem. 243:414–419. https://doi.org/10.1016/j.foodchem.2017.09.100.

Alpaslan M, Hayta M. 2006. Apricot kernel: Physical and chemical properties. J Am Oil Chem

Soc. 83(5):469–471. https://doi.org/10.1007/s11746-006-1228-5.
Al-Soufi MH, Alshwyeh HA, Alqahtani H, Al-Zuwaid SK, Al-Ahmed FO, Al-Abdulaziz FT, Raed D, Hellal K, Mohd Nani NH, Zubaidi SN, Mio Asni NS, Hamezah HS, Kamal N, Al-Muzafar H, Mediani A. 2022. A review with updated perspectives on nutritional and therapeutic benefits of apricot and the industrial application of its underutilized parts. Molecules. 27(15):5016. https://doi.org/10.3390/molecules27155016.
Bartolini S, Leccese A, Viti R. 2015. Quality and antioxidant properties of apricot fruits at ready-to-eat: Influence of the weather conditions under Mediterranean coastal area. J Food Process Technol. 7:1–6. https://doi.org/10.4172/2157-7110.1000538.
Calixto FS, Bauza M, de Toda FM, Argamenteria A. 1981. Amino acids, sugars, and inorganic elements in the sweet almond (*Prunus amygdalus*). J Agric Food Chem. 29(3):509–511. https://doi.org/10.1021/jf00105a018.
Chen L, Tang R, Zhang J, Li Q, Fang D, Jiang L, Abudureheman B, Ye X. 2024. Evaluation of the Xinjiang indigenous fruits Xiaobai apricots: Chemical and nutritional studies. J Agric Food Res. 18:101536. https://doi.org/10.1016/j.jafr.2024.101536.
El-Safy FS, Salem RH, Abd El-Ghany ME. 2012. Chemical and nutritional evaluation of different seed flours as novel sources of protein. World J Dairy Food Sci. 7(1):59–65. https://doi.org/10.5829/idosi.wjdfs.2012.7.1.61215.
Göttingerová M, Kumšta M, Nečas T. 2020. Health-benefitting biologically active substances in edible apricot flowers. HortScience. 55(8):1372–1377. https://doi.org/10.21273/HORTSCI15038-20.
Gundogdu M, Ercisli S, Berk S, Kan T, Canan I, Gecer MK. 2017. Diversity on color and phenolic compounds in apricot fruits. Food Measure. 11(4):2087–2093. https://doi.org/10.1007/s11694-017-9592-4.
Haciseferogullari H, Gezer I, Ozcan MM, Asma BM. 2007. Postharvest chemical and physical-mechanical properties of some apricot varieties cultivated in Turkey. J Food Eng. 79:364–373. https://doi.org/10.1016/j.jfoodeng.2006.02.003.
House JD, Hill K, Neufeld J, Franczyk A, Nosworthy MG. 2019. Determination of the protein quality of almonds (*Prunus dulcis* L.) as assessed by in vitro and in vivo methodologies. Food Sci Nutr. 7(9):2932–2938. https://doi.org/10.1002/fsn3.1146.
Joia S, Siddiqi RA, Singh TP. 2025. Study of physicochemical properties, amino acid composition and fatty acid profile of bitter Himalayan wild apricot kernel: A step towards its valorization. Waste Biomass Valor. 16(8):4309–4320. https://doi.org/10.1007/s12649-025-02889-x.
Kamel BS, Kakuda Y. 1992. Characterization of the seed, oil and meal from apricot, cherry, nectarine, peach and plum. J Am Oil Chem Soc. 69:493–494. https://doi.org/10.1007/BF02540957.
Khanyile L, Gürcan K. 2024. Plastome analysis of cultivated apricots: Genome structure, nucleotide diversity, and phylogeny. Turkish J Agric For. 48(5):692–702. https://doi.org/10.55730/1300-011X.3212.
Liu MJ, Shi FF, Zhang QA. 2021. Evaluation of the ultrasonically-accelerated debitterizing with citric acid solutions of different pH: On the basis of amino acids changes in apricot kernels during debitterizing. J Food Process Preserv. 45(5):e15403. https://doi.org/10.1111/jfpp.15403.
Mesarović J, Trifković J, Tosti T, Akšić MF, Milatović D, Ličina V, Milojković-Opsenica D. 2018. Relationship between ripening time and sugar content of apricot (*Prunus armeniaca* L.) kernels. Acta Physiol Plant. 40(8):157. https://doi.org/10.1007/s11738-018-2731-7.
Mustafa MAM, Sorour MAH, Mehanni AHES, Hussien SM. 2023. Amino acid profile, physicochemical properties and fatty acids composition of some fruit seed kernels after detoxification. Chem Biol Technol Agric. 10(1):37. https://doi.org/10.1186/s40538-023-00412-9.
Nečas T, Göttingerová M, Wolf J, Kiss T, Rampáčková E, Ondrášek I. 2020. New promising apricot hybrids from Faculty of Horticulture in Lednice. Acta Hortic. 1290:169–178. https://doi.org/10.17660/ActaHortic.2020.1290.30.
Özcan M. 2000. Composition of some apricot *Prunus armeniaca* kernels grown in Turkey. Acta Aliment. 29(3):289–294. https://doi.org/10.1556/AAlim.29.2000.3.7.
Özcan MM. 2023. A review on some properties of almond: Impact of processing, fatty acids, polyphenols, nutrients, bioactive properties, and health aspects. J Food Sci Technol. 60(5):1493–1504. https://doi.org/10.1007/s13197-022-05398-0.
Pawar KR, Nema PK. 2023. Apricot kernel characterization, oil extraction, and its utilization: A review. Food Sci Biotechnol. 32(3):249–263. https://doi.org/10.1007/s10068-022-01228-3.
Rampáčková E, Göttingerová M, Gála P, Kiss T, Ercişli S, Nečas T. 2021. Evaluation of protein and antioxidant content in apricot kernels as a sustainable additional source of nutrition. Sustainability. 13(9):4742. https://doi.org/10.3390/su13094742.
Sarabandi K, Mohammadi M, Akbarbaglu Z, Ghorbani M, Najafi S, Safaeian Laein S, Jafari SM. 2023. Technological, nutritional, and biological properties of apricot kernel protein hydrolysates affected by various commercial proteases. Food Sci Nutr. 11(9):5078–5090. https://doi.org/10.1002/fsn3.3467.
Semwal P, Semwal C, Bhatt A, S, Parashar T, Ankur A, Jakhmola V, Kumar S. 2023. Apricot- A new source of chemically active constituents: A medicinal overview. Biomed Pharmacol J. 16(2). https://doi.org/10.13005/bpj/2693.
Seron LH, Poveda EG, Moya MP, Carratalá MM, Berenguer-Navarro V, Grané-Teruel N. 1998. Characterisation of 19 almond cultivars on the basis of their free amino acids composition. Food Chem. 61(4):455–459. https://doi.org/10.1016/S0308-8146(97)00083-6.
Sharma PC, Tilakratne BMKS, Gupta A. 2010. Utilization of wild apricot kernel press cake for extraction of protein isolate. J Food Sci Technol. 47(6):682–685. https://doi.org/10.1007/s13197-010-0096-z.
Shi T, Cao J, Cao J, Zhu F, Cao F, Su E. 2023. Almond (*Amygdalus communis* L.) kernel protein: A review on the extraction, functional properties and nutritional value. Food Res Int. 167:112721. https://doi.org/10.1016/j.foodres.2023.112721.
Turan S, Topçu A, Karabulut I, Vural H, Hayaloglu AA. 2007. Fatty acid, triacylglycerol, phytosterol, and tocopherol variations in kernel oil of Malatya apricots from Turkey. J Agric Food Chem. 55(26):10787–10794. https://doi.org/10.1021/jf071801p.
Viorica-Mirela P, Nicoleta RD, Camelia M, Gabriela DD, Constantin M, Alexandra G. 2013. The possibilities of obtaining, characterizing and valorification of almond oil (*Prunus amygdalus*). J Agroaliment Process Technol. 19:455–458.
Yıldızlı G, Coral G, Ayaz F. 2021. Biochar as a biocompatible mild anti-inflammatory supplement for animal feed and agricultural fields. Chem Biodivers. 18(6):e2001002. https://doi.org/10.1002/cbdv.202001002.
Yin M, Wuyun T, Jiang Z, Zeng J. 2020. Amino acid profiles and protein quality of Siberian apricot (*Prunus sibirica* L.) kernels from Inner Mongolia. J For Res. 31(4):1391–1397. https://doi.org/10.1007/s11676-019-00882-4.
Zezulová E, Nečas T, Mrázová M, Kiss T. 2026. Apricot kernels as a new source of protein and antioxidants. Acta Hortic. 1449:449–456. https://doi.org/10.17660/ActaHortic.2026.1449.61.
Zhu X, Meng T, Ren F, An N, Chen B, Liu X, Liu H. 2025. A review on apricot kernel seed proteins and peptides: Biological functions and food applications. Int J Biol Macromol. 292:139053. https://doi.org/10.1016/j.ijbiomac.2024.139053.