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Amino Acid Profile of *Rhus coriaria* L. (Sumac) Grown in Different Regions

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ABSTRACT
In this study, the amounts of amino acids in Rhus coriaria L. (Sumac) samples grown in different regions were analyzed by High Performance Liquid Chromatography (HPLC). A comparison of the amino acid content of analyzed samples showed that Maraş sumac was the richest in glutamic acid, on the other hand, Kadana and Sheladize were rich in non-essential amino acids. It was observed that the sumacs of Shelaza and Maraş regions were the poorest for non-essential amino acids. In terms of essential amino acids, it was determined that the sumacs of the Kadana and Sheladize regions were richer, while the sumacs of the Suleymania and Maraş regions were poorer. It can be said that all of the examined sumac samples are rich in glutamic acid, histidine and alanine, but poor in glycine. It was seen that the richest in terms of total essential and non-essential amino acids was the Kadana sumac, while the poorest was the Shelaza sumac. It can be said that the amount of essential and non-essential amino acids varies between regions, resulting from geographical and ecological differences.

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ÖZET
Bu çalışmada, farklı bölgelerde yetişen *Rhus coriaria* L. (Sumak) örneklerinde aminoasit miktarları Yüksek Performanslı Sıvı Kromatografisi (HPLC) ile analiz edildi. Analiz edilen örneklerdeki aminoasit miktarları karşılaştırıldığında, glutamik asit bakımından en zengin Maraş bölgesi sumağı iken, esansiyel olmayan diğer amino asitler bakımından ise Kadana ve Sheladize bölgeleri olduğu tespit edilmiştir. Esansiyel olmayan amino asitler açısından en fakir Shelaza ve Maraş bölgesi sumaklarının olduğu gözlenmiştir. Esansiyel amino asitler açısından Kadana ve Sheladize bölgesi sumaklarının daha zengin, Süleymaniye ve Maraş bölgesi sumaklarının ise daha fakir olduğu tespit edilmiştir. İncelenen sumak örneklerinin hepsinin, glutamik asit, histidin ve alanin bakımından zengin ve glisin bakımından fakir oldukları söylenebilir. Toplam esansiyel ve non-esansiyel amino asit bakımından en zengin Kadana sumağı iken, en fakir Shelaza sumağının olduğu görülmüştür. Esansiyel ve non-esansiyel amino asit miktarlarının bölgeler arasında değişiklik göstermesi, coğrafi ve ekolojik farklılıklardan kaynaklandığı söylenebilir.

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INTRODUCTION
Sumac (*Rhus coriaria* L.) is a medicinal and perennial wild plant belonging to the Anacardiaceae family. Sumac fruit is used in the food industry as a spice and used in many dishes to add sourness and colour, as well as aroma and flavor. In economic terms, the fruits and leaves of sumac are also used in the food, medicine, leather and dye industries (Shabbir, 2012; Abu Reidah et al., 2014). Sumac has protective and beneficial effects against various diseases such as diabetes, some types of cancer, inflammation, dysentery and digestive system disorders. It has also been reported to have

antiviral, antibacterial, anti-ischemic, DNA protective, non-mutagenic, analgesic, antifungal, antioxidant and hypolipidemic activities (Ünder and Saltan, 2019). Sumac is a natural source of bioactive compounds which contains components such as organic acids, fatty acids, essential and non-essential amino acids, vitamins, carbohydrates, minerals, tannins, anthocyanins, flavonoids, terpenoids and phenolic acids (Demchik et al., 2015; Abu-Reidah et al., 2015; Kossah et al., 2009). The amino acid content of foodstuffs is a measure of their nutritional value; therefore, it is important to determine their amino acid content (Hayes, 2020). It has been reported that amino acids are important in the metabolism of nutrients, cellular growth and development, reproduction and health, and abnormal physiological functions and diseases occur when the intake rate is unbalanced or deficient (Song et al., 2018). Also, liver dysfunction is caused by a change in the ratio of aromatic amino acids to branched-chain amino acids (Tajiri and Shimizu, 2013). Different amino acids are employed to detoxify ammonia in the blood, as well as in the treatment of heart failure, peptic ulcers (Stoimenova et al., 2013). One of the main sources of amino acid is vegetables and fruits. Essential amino acids used in the metabolism for the protein synthesis must be taken with diet. Determination of amino acid levels in samples is important because the type and content of amino acids may differ in different samples. It is reported that the chemical composition and biological properties of sumac samples are largely dependent on their country of origin (Wang and Zhu 2017). Essential amino acids used in protein synthesis and in metabolism must be taken with diet. Amount of amino acids determined in plants, vegetables, and fruits become important subject because one of the main source of amino acids in developing countries.

The goal of this work is to determine the amount of essential and non-essential amino acids and compare the results in sumac samples (*Rhus coriaria* L.) grown in different regions.

MATERIAL and METHODS

Materials

All sumac samples in both Turkey and Iraq were obtained from free market stores and analyzes were carried out after drying 10 hours in an oven at 60°C. 10.0 grams of each sample were taken and grinded in blender and separated from seeds and used in the analysis.

Determination of Amino Acid

Hydrolysis: Approximately 1.0 grams of ground samples were taken into a glass tube and 5.0 mL 6.0 N HCl was added and vortexed thoroughly then, samples were kept at 110 °C for 24 hours to break peptide bonds (Elkin and Wasynczuk, 1987). After that, the samples cooled to room temperature, filtered and the filtrate volume was completed to 10 mL with distilled water.

Derivatization: Standard amino acid solutions were prepared using 0.10 N HCl at different concentrations between 1.0 to 5.0 µg/mL. Fifty µL standard amino acid solutions or hydrolyzed samples were transferred to 5.0 mL glass tubes and dried under vacuum at 65 °C. Then 50 µL of "**reagent 1**" solution [(2: 2: 1 mixture of ethanol: water: Triethylamine (TEA) (v/v)] was added and vortexed and dried again under vacuum at 65 °C. The dried samples were vortexed by adding 50 µL of "**reagent 2**" solution [7:1:1:1 mixture of ethanol: water: TEA: phenyl isothiocyanate (v/v)] and left at room temperature in the dark for 30 minutes for complex formation. Afterwards, the samples were dried again under vacuum at 35 °C (Kwanyuen and Burton, 2010). 1.0 mL mobile phase A and Acetonitrile (ACN) mixture (8:2 v/v) was added to each dried sample, vortexed and the samples were taken into HPLC vials for analysis.

Chromatographic procedure for amino acid analysis: Amino acid analysis was performed by HPLC by modifying Elkin and Wasynczuk (1987) with Kwanyuen and Burton (2010) methods. Nucleodur 100-5 C18 column (250x4.6 mm, 5 µm) was used. The analyses were carried out by applying the gradient program at 40 °C. The injected sample volume is 20 µL. The mobile phase consists of eluent A and eluent B mixture with a flow rate of 0.8 mL/min and measured at 254 nm (Table 1). Eluent A is 0.07 M $CH_3COONa \cdot 3H_2O$ (pH=6.4 with CH_3COOH) and eluent B is a mixture of ACN and water (60:40 v/v).

Equipment and chemicals

Experiments were carried out by SHIMADZU HPLC, Prominence-I LC- 2030C 3D Model equipped with PDA detector, Blender (Fakir Hausgrate 220 W), Double distilled (H_2O) water was used throughout the work. All the chemicals used are reagent or analytical grade and obtained from Merck or Sigma-Aldrich.

Table 1. Gradient program used for the separation of Phenylthiocarbamyl-amino acids

Time (minute)	Flow rate (mL/min)	% Eluent A	% Eluent B
0.01	0.8	90	10
12.00	0.8	70	30
16.00	0.8	65	35
16.01	0.8	50	50
25.00	0.8	100	0
30.00	0.8	50	50
30.01	0.8	10	90
35.00	0.8	10	902

Statistical Analysis

All measurements were triplicated and Mean ± Standard Error was determined. The results were subjected to one-way ANOVA by SPSS 10.0 for

Windows. Differences between the group's means were analysed for significance using Tukey HSD test the level of statistical significance was expressed as $p<0.05$. Statistical difference indicated in table horizontal column with the different letter while the same letter indicates no statistical difference.

RESULT and DISCUSSION

Both primary and secondary metabolites are synthesized in the leaves and fruits of plants. Amino acids are primary metabolites and form the building blocks of proteins. In biological systems, essential amino acids are included in neurotransmitter and biosynthesis processes, and are required for protein synthesis (Davidson, 2019). The non-essential and essential amino acid amounts in sumac samples grown in different regions of Turkey and Iraq are given in Table 2, and 3 respectively.

Glutamic and aspartic acid have an important effect on the flavour of foods (Duan et al., 2020). Aspartic acid, which is involved in the tricarboxylic acid cycle, activates defence systems and catalysis the production of signal amino acids (Han et al., 2021). The highest amount of aspartic acid was found in the Kadana region, while the lowest was found in the sumac samples grown in the Sheladize region (Table 2).

Glutamic acid, which is effective in the carbon and nitrogen cycle in metabolism, is also important for proline biosynthesis (Forde and Lea., 2007). The highest and lowest amounts of glutamic acid were observed in sumacs in Maraş and Shelaza regions, respectively.

Asparagine, which provides nitrogen accumulation, is important in regulating the sugar balance in the cell (Haroun et al., 2010). The highest asparagine was observed in Kadana and the lowest in Shelaza regions.

While serine has a fundamental role in signaling in living organisms (Ros et al., 2014), Glycine protects plasma membranes by reducing the effect of oxygen-dependent free radicals. It has been reported that glycine and serine together are metabolic regulators promoting tumor cell growth (Gorska-Ponikowska et al., 2017). Glycine and serine were found highest in Sumacs of the Sheladize region.

While glutamine regulates nitrogen metabolism in the cell (DeBerardinis et al., 2007), alanine plays a role in the regulation of the defence system and intracellular pH (Kalefetoğlu and Ekmekçi, 2005). The highest amount of glutamine and alanine was observed in sumac grown in the Kadana region.

Bakar et al. (2020) reported that the least amount of amino acid in black and white myrtle fruit is glutamine. It is reported that serine amino acid is highest in white myrtle fruit at 2.75 (mg ·(g ·dw)$^{-1}$), and glutamic acid is found in black myrtle fruit at 1.8 (mg ·(g ·dw)$^{-1}$).

Duan et al. (2020) found the amounts of aspartic acid, glutamic acid, proline, serine and glycine in licorice 0.56, 0.37, 6.38, 4.86 and 0.14 g kg^{-1}, respectively. On the other hand in pursley, alanine, proline, leucine, isoleucine, valine and threonine were found to be 2.79, 0.80, 0.35, 0.22, 0.79 and 0.79 g kg^{-1} respectively.

Mukhtar et al. (2022) found the amounts of glycine, asparagine, glutamine, histidine and arginine in bitter tomato eggplant grown in Nigeria 4.58, 5.36, 1.22, 8.40 and 0.09 (mg ·(g ·dw)$^{-1}$), respectively.

Proteins rich in proline, glycine, leucine and methionine play an important role in cell wall growth, while leucine, isoleucine and valine have been reported to protect the cell against osmotic stress (Zemanova et al., 2017). Proline and valine were highest in Sheladize, while leucine, isoleucine and methionine were found in sumac samples grown in the Kadana region.

It is stated that threonine, which is in the structure of proteins such as collagen and elastin, is important in fat metabolism and immune system (Olgun et al., 2016). The lowest amount of threonine was observed in the Suleymania region sumac.

It has been reported that histidine is necessary for the formation of red blood cells and myelin sheath, while arginine is important in growth hormone synthesis and strengthening the immune system (Lee and Kim, 2019). Both histidine and arginine were observed to be the highest in the sumac of the Kadana region.

It is stated that tryptophan, which is important in cell development, is the precursor of neurotransmitter biomolecules (Zemanova et al., 2017). Lysine has a role in metabolism, such as producing glutamic acid and increasing resistance to stress (Kishor et al., 2020). The sumac sample grown in the Sheladize region is quite rich in tryptophan and lysine compared to other regions.

Cysteine is very important in supporting protein folding and stability by forming disulfide bonds with other cysteine molecules. Cysteine is a precursor molecule for the synthesis of glutathione, which plays an important role in the response of plants to stress (Mendoza-Cozatl et al., 2010). Tyrosine is required for the synthesis of a variety of natural compounds in plants, such as tocopherols, ubiquinone, betalains, and benzylisoquinoline alkaloids. Tyrosine-derived metabolites, tocopherols and ubiquinone are important for plant survival (Xu et al., 2020). These amino acids were found highest in sumac samples grown in the Kadana region.

Mukhtar et al. (2022) found the amounts of methionine, tryptophan, lysine, cysteine and tyrosine in the dark eggplant sample grown in Turkey 3.71, 1.0, 6.80, 1.88 and 1.02 (mg (g ·dw)$^{-1}$), respectively.

Table 2. Non-essential Amino acid amounts in sumac samples grown in different regions of Turkey and Iraq (μg ·(g ·dw)$^{-1}$).

	Maraş	Elazığ	Sheladize	Shahi	Charput	Shelaza	Ranya	Kadana	Trwanish	Derishke	Suleymania
Aspartic A	23.5±1.2^{a}	48.5±2.5^{b}	10.3±0.5^{a}	80.5±1.6^{c}	65.8±3.2^{c}	20.4±0.9^{a}	71.9±1.7^{c}	170.5±5.5^{e}	126.2±5.2^{d}	71.6±3.2^{c}	74.7±2.3^{c}
Glutamic A	566.3±48.8^{f}	701.9±19.4^{d}	857.6±29.4^{e}	630.1±9.0^{bcd}	579.5±17.3^{bc}	308.6±9.7^{a}	723.9±7.0^{d}	908.3±17.1^{e}	650.7±5.5^{cd}	534.1±12.0^{b}	640±24.3^{bcd}
Asparagine	106.7±2.9^{a}	176.5±7.1^{b}	229.5±6.9^{c}	301.5±5.6^{d}	236.3±6.0^{c}	85.9±3.2^{a}	116.6±4.5^{a}	586.4±8.6^{f}	453.0±13.9^{e}	238.9±10.2^{c}	247.6±7.9^{c}
Serine	207.5±9.3^{a}	223.9±7.0^{ab}	461.2±23.5^{d}	410.8±9.9^{cd}	419.5±10.1^{cd}	222.8±5.2^{ab}	264.8±7.0^{b}	394.9±8.1^{c}	403.7±7.3^{c}	259.8±8.4^{b}	202.1±4.7^{a}
Glycine	1.6±0.1^{abc}	1.8±0.1	5.0 ±0.4^{d}	2.2±0.1^{c}	4.3±0.2^{d}	1.4±0.05^{ab}	1.6±0.03^{abc}	1.8±0.1^{abc}	1.2±0.05^{a}	1.7±0.1^{abc}	2.0±0.04^{bc}
Glutamine	41.1±1.4^{a}	101.3±2.8^{ef}	116.6 ±5.6^{fg}	104.0±3.2^{ef}	90.6±3.7^{de}	47.9±1.3^{ab}	104.5±3.1^{ef}	190.9±5.1^{f}	159.0±6.4^{h}	81.0±3.7^{cd}	66.2±2.9^{bc}
Alanine	348.9±4.5^{ab}	385.0±10.0^{bc}	514.5±12.5^{d}	616.7±12.8^{f}	542.8±11.6^{de}	316.2±5.7^{a}	568.9±9.4^{ef}	889.7±8.2^{h}	752.4±11.2^{g}	507.0±16.7^{d}	426.8±9.3^{c}
Proline	12.7±0.7^{a}	49.8±2.5^{b}	291.8±12.5^{c}	60.6±2.9^{b}	69.0±2.7^{bc}	90.7±3.8^{cd}	72.3 ±3.5^{bcd}	159.7±4.9^{e}	95.5±3.4^{d}	67.7±3.7^{bc}	71.8±3.2^{bc}
Tyrosine	12.5±0.8^{ab}	1.0.0±0.9^{a}	23.5±0.9^{d}	9.1±0.4^{a}	25.1±1.3^{d}	10.2±0.7^{a}	16.3±1.0^{d}	40.1±1.9^{f}	20.8±0.8^{cd}	32.5±1.5^{e}	17.3±0.9^{bc}
Cysteine	11.8±0.7^{a}	23.8±1.5^{b}	38.4±1.4^{d}	33.4±0.9^{cd}	21.0±1.0^{b}	12.8±0.5^{a}	30.6±0.9^{c}	51.9±1.7^{e}	34.9±1.5^{cd}	20.3±0.6^{b}	30.6±1.3^{c}

Table 3. Essential Amino acid amounts in sumac samples grown in different regions of Turkey and Iraq (μg ·(g ·dw)$^{-1}$).

	Maraş	Elazığ	Sheladize	Shahi	Charput	Shelaza	Ranya	Kadana	Trwanish	Derishke	Suleymania
Histidine	635.3±25.6^{b}	496.0±12.7^{a}	1079.3±20.0^{f}	837.9±8.8^{d}	981.7±9.0^{e}	469.8±8.3^{a}	693.9±22.8^{bc}	1303.4±16.3^{g}	1084.3±29.4^{f}	718.7±13.6^{bc}	772.9±22.8^{cd}
Arginine	96.8±1.8^{a}	246.2±11.2^{c}	314.7±15.0^{d}	255.1±6.9^{c}	220.4±7.2^{bc}	117.2±3.9^{a}	302.7±7.6^{b}	500.3±7.5^{f}	371.4±10.0^{e}	219.8±8.0^{bc}	202.3±6.3^{b}
Threonine	283.4±6.6^{b}	211.2±5.4^{a}	612.1±20.2^{f}	613.2±9.5^{f}	588.3±8.4^{f}	295.3±5.2^{b}	277.6 ±4.9^{a}	515.5±4.9^{e}	449.2±4.6^{d}	368.3±7.4^{c}	187.9±4.6^{a}
Valine	14.9±0.7^{e}	9.7±0.5^{d}	17.4±0.6^{f}	9.4±0.6^{cd}	8.7±0.4^{cd}	8.7±0.5^{cd}	9.6 ±0.4^{d}	3.2±0.2^{a}	6.0±0.5^{cd}	9.5±0.6^{b}	7.0±0.4^{bc}
Methionine	71.9±3.4^{bc}	81.7±2.5^{b}	204.8±7.4^{g}	163.8±7.8^{f}	223.0±8.2^{g}	103.5±3.9^{d}	69.3 ±1.3^{b}	92.3±2.5^{b}	130.2±3.2^{e}	94.9±2.4^{b}	29.5±1.9^{a}
Leucine	162.2±4.3^{a}	266.7±6.9^{b}	495.6±17.3^{d}	565.1±17.1^{e}	383.4±11.7^{c}	181.9±4.8^{a}	531.7 ±7.0^{de}	1040.6±9.0^{g}	730.5±19.2^{f}	413.2±5.6^{c}	485.1±15.0^{d}
Isoleucine	149.1±6.3^{b}	175.7±5.7^{b}	347.8±6.9^{e}	335.3±5.2^{a}	351.2±6.3^{e}	151.6±5.0^{b}	266.4 ±3.4^{d}	421.2±8.2^{g}	388.1±6.3^{f}	217.2±5.3^{c}	42.9±1.4^{a}
Phenylalanine	8.7±0.4^{a}	16.8±1.0^{ab}	18.8±1.0^{ab}	57.1±2.1^{c}	62.5±3.4^{cd}	12.4±0.5^{a}	69.8 ±3.2^{cd}	167.6±4.4^{f}	66.9±3.1^{cd}	29.0±1.5^{b}	72.8±3.6^{e}
Tryptophan	46.8±2.3^{ab}	51.1±2.5^{ab}	194.6 ±4.1^{g}	110.1±5.4^{f}	90.6±1.9^{e}	66.9±2.6^{cd}	60.2 ±2.8^{bc}	91.1±2.2^{e}	99.3±2.9^{ef}	75.4±2.4^{d}	42.6±1.7^{a}
Lysine	28.5±1.2^{b}	38.6±1.1^{c}	110.5 ±1.8^{g}	68.1±2.4^{f}	64.4±2.7^{ef}	49.0±2.6^{d}	30.4 ±1.4^{bc}	32.2±1.7^{bc}	57.9±2.4^{de}	37.5±1.7^{bc}	16.6±0.9^{a}

Table 4. Total Essential, Total Non-essential, Total Amino acid (µg ·(g ·dw)$^{-1}$) with ratio of TE/TNE and TE/TA

	TE*	TNE*	TA*	TE/TNE%	TE/TA%
Maraş	1497.5±48.3 ^{a}	2332.4±51.8 ^{f}	3830.0±84.8 ^{cd}	64	39
Elazığ	1593.7±26.4 ^{a}	1722.3±42.7 ^{b}	3316.0±68.6 ^{b}	93	48
Sheladize	3395.7±17.9 ^{e}	2548.5±75.9 ^{g}	5944.2±93.7 ^{g}	133	57
Shahi	3015.0±33.0 ^{d}	2249.0±3.2 ^{ef}	5264.0±29.9 ^{f}	134	57
Charput	2974.2±9.5 ^{d}	2053.9±37.8 ^{de}	5028.1±38.0 ^{f}	145	59
Shelaza	1456.3±16.6 ^{a}	1117.0±16.8 ^{a}	2573.3±32.2 ^{a}	130	57
Ranya	2311.6±30.9 ^{c}	1971.5±17.9 ^{cd}	4283.0±29.5 ^{e}	117	54
Kadana	4167.3±28.7 ^{f}	3394.4±31.2 ^{h}	7561.7±59.6 ^{h}	123	55
Trwanish	3383.7±51.1 ^{e}	2697.4± 47.4 ^{g}	6081.0±93.2 ^{g}	125	56
Derishke	2183.5±26.1 ^{c}	1814.6±34.7 ^{bc}	3998.1±45.1 ^{de}	120	55
Suleymania	1859.6±46.6 ^{b}	1779.0±30.2 ^{bc}	3638.6±69.9 ^{c}	105	51

* : TE : Total Essential Amino acid, TNE : Total Non-essential Amino acid, TA : Total Amino acid

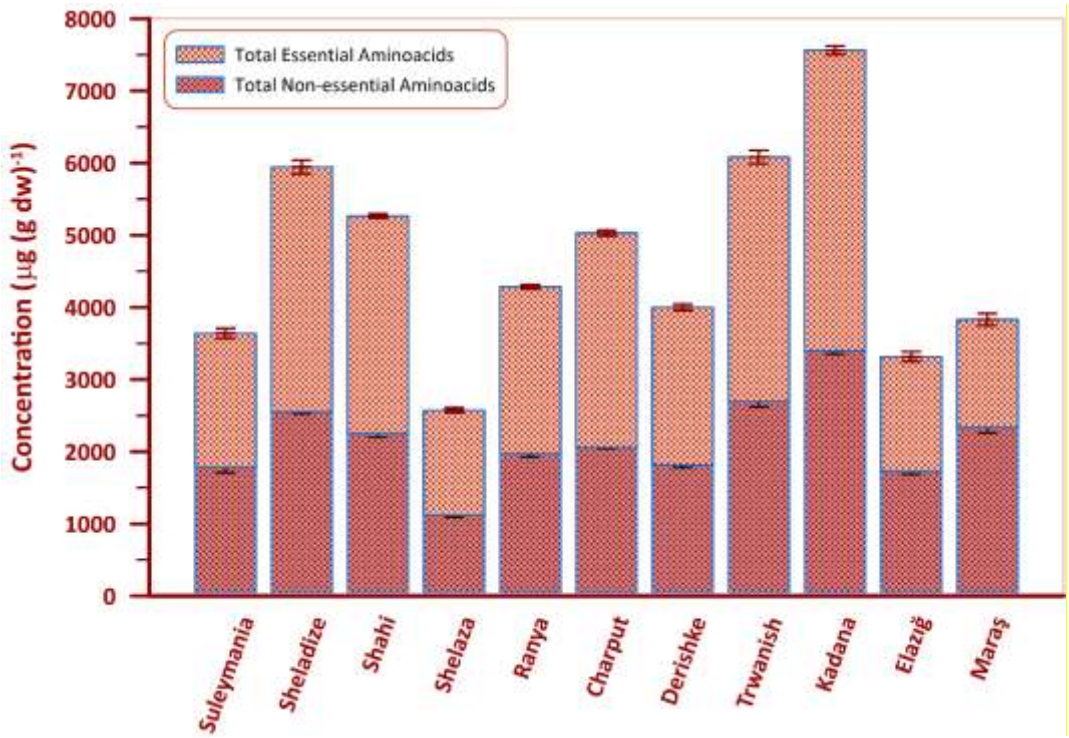

Figure 1. Total essential and non-essential amino acid amounts in sumac samples from different regions

The ratio of amino acids is important for the metabolism to work in a proper way. While the highest total essential and total amino acids were in the Kadana region, the total non-essential amino acid Sheladize region were found in sumac samples (Table 4 and Figure 1).

It was observed that the total amount of essential amino acids in the sumac samples grown in different regions varied between 1456.3±16.6 - 4167.3±28.7 (µg ·(g ·dw)$^{-1}$), and the total amino acid amounts 2573.3±32.2 - 7561.7±59.6 (µg ·(g ·dw)$^{-1}$) were observed (Table 4 and Figure 1).

Wang and Zhu (2017) reported in their study that the essential amino acid content of *Rhus typhina* in the range of 0.05 to 3.16 mg/(g protein) from two different sumac samples, and the non-essential amino acid content varies between 0.10 to 7.46 mg/(g protein).

Sadiq et al. (2013) found the amount of essential amino acids in the pulp and seed of the date palm (*Phoenix dactylifera*), respectively 12.78 and 7.11 g/100 g dw, while the total amino acid amount 28.22 and 15.28 g/100 g dw were reported..

The study carried out by Zhou et al. (2019) using Nitraria tangutorum Bobr pulp and peel, reported that the total essential and non-essential amino acids amount ranged between 44.39-53.51 and 65.65-71.41 (mg ·(g ·dw)$^{-1}$) respectively. Mukhtar et al. (2022) reported that the total amount of essential amino acids in five different eggplant samples ranged from 19.31 to 27.21 (mg ·(g ·dw)$^{-1}$). Bouba et al. (2016) showed that the total non-essential amino acid (TNE) amounts of P. brazzeana, A. Daniellii, and S. Melongena, which are wild plants used as a spice in Cameroon, are 35.8, 52.04, 59.78 g/(100 g protein), respectively. They reported that the TE/TA ratio was 1.62, 0.72 and 0.45, respectively. It has been reported that the daily total essential amino acid requirement of the individual (70 kg) is about 12.88 g (Joint WHO/FAO/UNU, 2007). A person consuming 10 grams of sumac grown in Kadana

region get daily need of 0.32% of essential amino acid. It has been reported that a good protein source should have a TE/TA ratio of over 40% and TE/ TNE ratio of over 60% (Zhou et al., 2019). While the ratios of TE/TNE in sumac samples vary between 64%-145%, the ratios of TE/TA vary between 39% - 59%. From these results, it can be said that the essential amino acid ratios are high in all sumac samples studied (Table 4).

CONCLUSION

It has been determined that the sumacs of Kadana and Sheladize regions are rich in non-essential amino acids, while the sumacs of Shelaza and Maraş regions are poor. In terms of essential amino acids, the sumac obtained from Kadana and Sheladize regions was richer, while the sumac from Suleymania and Maraş regions were found to be poor. It can be said that all of the examined sumac samples are rich in glutamic acid, histidine and alanine, but poor in glycine. While the total amount of essential amino acids varies between 1456.3 and 4167.3 ($\mu g \cdot (g \cdot dw)^{-1}$) the highest was observed in the sumac of the Kadana region. TE/TNE ratio in the examined sumac samples ranged from 64% to 145%, and TE/TA between 39% and 59%. From these results, it can be said that sumac samples are a good source of essential amino acids. The differences in the amounts of essential and non-essential amino acids between different samples may be due to geographical and ecological differences.

Author's Contributions

The contribution of the authors is equal.

Statement of Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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