Journal of Chemistry of Goods and Traditional Medicine

J Chem Good Trad Med, Volume 5, Issue 5, 2026 Traditional Medicine

EVALUATION OF ANTIRADICAL PROPERTIES OF ALCOHOLIC AND AQUEOUS EXTRACTS OBTAINED IN VARIOUS RATIOS FROM THE LEAVES OF *CHENOPODIUM ALBUM* AND *AMARANTHUS RETROFLEXUS* USING THE DPPH ASSAY

Mukammal Yo. Imomova
Fergana State University, PhD, Associate Professor of the Department of Chemistry, Faculty of Natural Sciences
https://orcid.org/0009-0001-6784-1424

Muattarkhon A. Gafurova
Central Asian Medical University (CAMU), Lecturer
https://orcid.org/0009-0008-6996-1770
E-mail: muattargafurova80@gmail.com

DOI: https://doi.org/10.55475/jcgtm/vol5.iss5.2026.666

Annotation. In this article, the antiradical activity of alcoholic and aqueous extracts obtained from the leaves of Chenopodium album (lamb's quarters) and Amaranthus retroflexus (redroot pigweed) plants was evaluated using the DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging method. Free radicals cause oxidative stress in the human body and are a critical factor in the development of cellular damage, inflammatory processes, and various diseases, which drives a steadily growing interest in natural antioxidants. In this study, alcoholic and aqueous extracts from the leaves were prepared in various ratios, and their efficacy in neutralizing DPPH radicals was measured using a spectrophotometer. The results demonstrated that the aqueous extracts possessed higher antiradical activity compared to the alcoholic ones, indicating the presence of a larger amount of hydrophilic (water-soluble) antioxidant compounds in their composition. The Amaranthus retroflexus extract exhibited a slight superiority over the Chenopodium album extracts, though both plants displayed a significant capacity for free radical neutralization. The natural antioxidant properties of these plants allow for their potential use as beneficial additives in the pharmaceutical and food industries. It was also noted that they serve as a potential source for supporting health, reducing oxidative stress at the cellular level, and suppressing inflammatory processes. This study further confirms the significance of Chenopodium album and Amaranthus retroflexus extracts in enhancing radical scavenging and combating oxidative stress through natural means. These findings establish a solid foundation for conducting broader pharmaceutical and biological research in the future.

Keywords: Chenopodium album, Amaranthus retroflexus, antiradical activity, DPPH method, ethanol extract, aqueous extract, antioxidant, free radicals, oxidative stress

How to Cite

Imomova, M. Y., & Gafurova, M. A. EVALUATION OF ANTIRADICAL PROPERTIES OF ALCOHOLIC AND AQUEOUS EXTRACTS OBTAINED IN VARIOUS RATIOS FROM THE LEAVES OF CHENOPODIUM ALBUM AND AMARANTHUS RETROFLEXUS USING THE DPPH ASSAY. Journal of Chemistry of Goods and Traditional Medicine, 5(5). https://doi.org/10.55475/jcgtm/vol5.iss5.2026.666

Introduction. In recent years, there has been a growing interest in natural antioxidants due to their crucial role in protecting the human body against free radicals. Free radicals induce oxidative stress at the cellular level, which serves as a key factor in the development of various pathologies, including cardiovascular diseases, cancer, and aging processes. Consequently, the study of natural antioxidants derived from plant sources remains highly relevant [1].

Chenopodium album (Lamb's quarters / Goosefoot) and *Amaranthus retroflexus* (Redroot pigweed) are annual herbaceous plants extensively utilized in traditional medicine for various therapeutic purposes. To evaluate the antiradical properties of the extracts obtained from the leaves of these plants, the DPPH (2,2-diphenyl-1-picrylhydrazyl) assay was selected [2]. *Chenopodium album* and *Amaranthus retroflexus* specimens were collected during the spring or summer months, after which their leaves were dried and pulverized. Alcoholic and aqueous extracts were then prepared from the leaf biomass in various ratios. Ethanol or methanol was employed as the solvent for the alcoholic extractions, whereas the aqueous extracts were prepared using ordinary distilled water. In accordance with the DPPH protocol, specified aliquots of the prepared extracts were added to the DPPH working solution. The reaction mixture was incubated in the dark for 30 minutes until the deep-purple coloration faded to a colorless or pale-yellow state. The resulting absorbance changes were measured spectrophotometrically at a wavelength of 517 nm [3].

The DPPH (2,2-diphenyl-1-picrylhydrazyl) method is one of the most widely applied and validated analytical approaches for investigating the antioxidant properties of plant-derived extracts. In this assay, the DPPH molecule acts as a stable free radical that exhibits an intense purple coloration in solution. When antioxidant compounds react with these radicals, the radicals are neutralized, leading to a discoloration of the solution that is quantitatively recorded via a spectrophotometer. The characteristic purple color of the DPPH molecule is attributed to its stable free radical nature. Upon interacting with the antioxidant substances present in the plant extract, the DPPH radical accepts either an electron or a hydrogen atom, transforming into its reduced, colorless or yellowish form. The extent of this reaction is determined by monitoring the decrease in absorbance (radiation absorption). This optical variance is measured at a wavelength of 517 nm and evaluated as antiradical/antioxidant activity [4,5]. In this study, the antioxidant capacity of *Chenopodium album* and *Amaranthus retroflexus* plants was investigated using the DPPH radical scavenging assay. The prominent advantages of this method include its procedural simplicity, rapid execution, and high sensitivity. Utilizing the DPPH assay, the antiradical activity of the extracts was precisely determined and compared based on their calculated IC_{50} [6].

Experimental section. Determination of Antiradical Activity by the DPPH Method. The antiradical activity of the plant extracts was evaluated using a spectrophotometric assay based on the stable free radical DPPH (2,2-diphenyl-1-picrylhydrazyl). The method was adapted from the procedure described by Blois with modifications appropriate for the present study. A 7.92 mM DPPH solution was prepared in ethanol. After preparation, the solution was kept at room temperature for 30 minutes in the dark to ensure stabilization. Leaf extracts of *Chenopodium album* (white goosefoot) and *Amaranthus retroflexus* (redroot pigweed) were prepared at mixing ratios of 1:1, 3:1, and 1:3 using ethanol and water as extraction solvents. Briefly, 1 g of finely ground plant material was extracted with 25 mL of 96% ethanol in an ultrasonic bath for 20 minutes. The resulting extracts were filtered through a 0.45 µm membrane filter before analysis. For determination of antiradical activity, 25, 50, 75, and 100 µL of the test extract were added to 3 mL of the DPPH solution, and the total reaction volume was adjusted to 3.1 mL with ethanol. The absorbance of the control and sample solutions was measured at 517 nm using a YOKE K7000 spectrophotometer. Measurements were recorded every 5 minutes over a period of 30 minutes. The percentage of antiradical activity was calculated using the following equation:

$$ARF\% = \frac{D_1 - D_2}{D_1} \cdot 100\%$$

The obtained results are presented in the following table:

Table 1. Measured absorbance and calculated antiradical activity values of the blank (control) sample and the investigated alcoholic extracts (1:1 ratio) derived from the leaves of *Chenopodium album* and *Amaranthus retroflexus* in the DPPH assay solution.

Volume, µL.	Time, min	Sample					
		Abs, D	ARF%		Time, min	Abs, D	ARF%
25	0	0,79	0,00	75	0	0,79	0,00

	5	0,732	7,34		5	0,653	17,34
	10	0,725	8,23		10	0,638	19,24
	15	0,72	8,86		15	0,627	20,63
	20	0,717	9,24		20	0,618	21,77
	25	0,714	9,62		25	0,611	22,66
	30	0,712	**9,87**		**30**	0,604	**23,54**
50	0	0,79	0,00	100	0	0,79	0,00
	5	0,691	12,53		5	0,608	23,04
	10	0,678	14,18		10	0,588	25,57
	15	0,67	15,19		15	0,574	27,34
	20	0,664	15,95		20	0,562	28,86
	25	0,659	16,58		25	0,552	30,13
	30	0,655	**17,09**		**30**	0,545	**31,01**

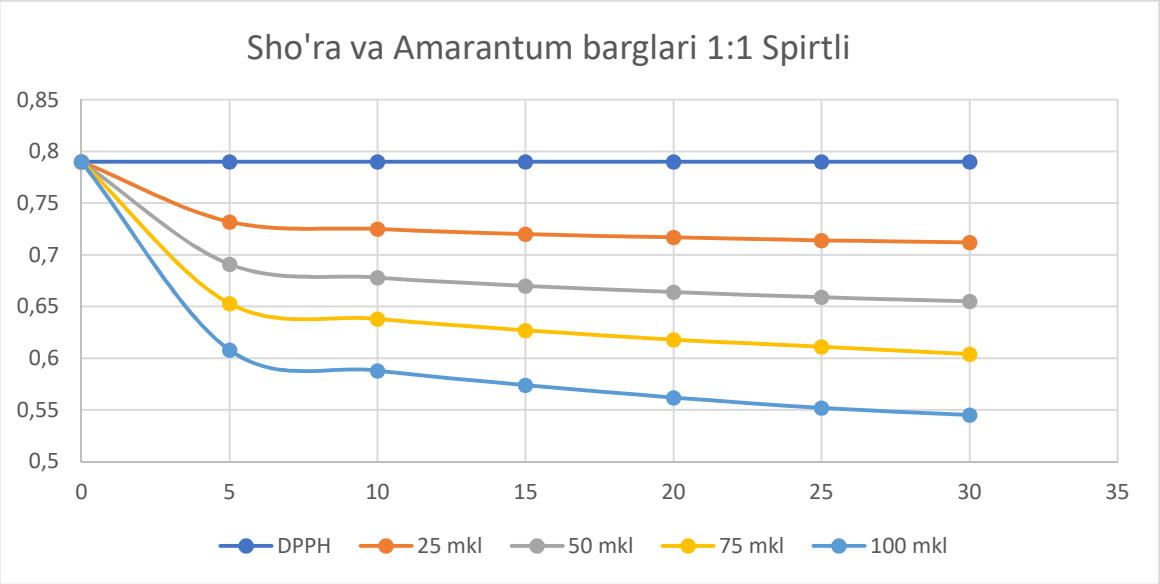


Figure 1. Graphical representation of the measured absorbance values for the blank (control) sample and the investigated alcoholic extract solutions in the DPPH assay.

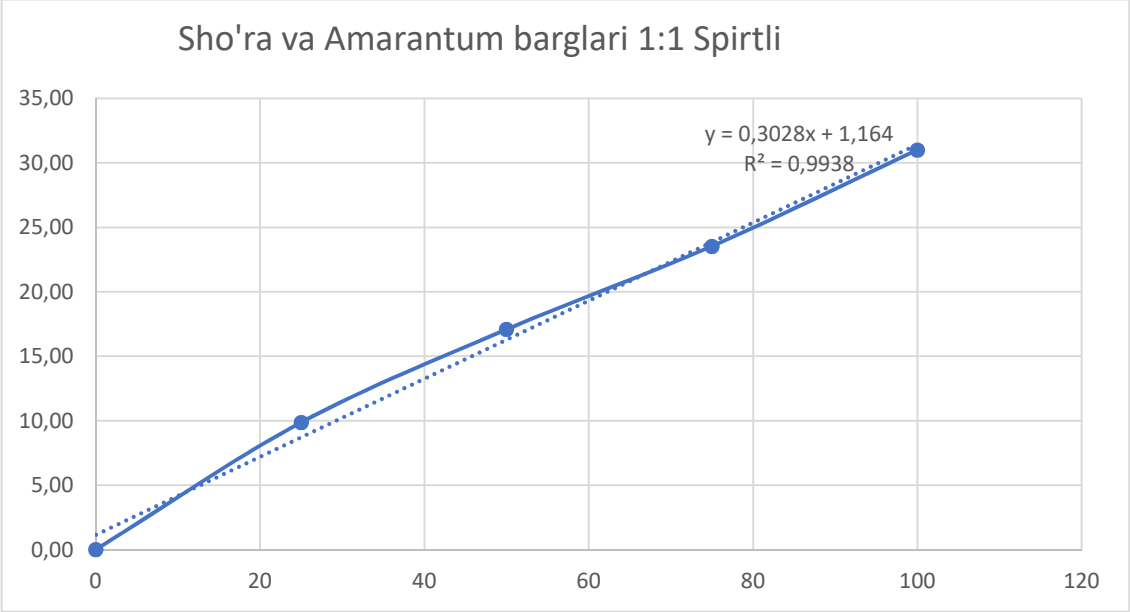


Figure 2. Dependence graph of the antiradical activity (ARA%) versus the volume of the alcoholic extract sample at the 30-minute mark.

Based on the equation of the trend line fitted to the graph ($y = mx + b$), the sample volume corresponding to 50% ARF (IC_{50}) was calculated using the following equation: x=(y-b)/m

$$IC_{50} = \frac{(50 - 1{,}164)}{0{,}3028} = 161{,}28\ mkl$$

Table 2. Measured absorbance values and calculated antiradical activity of the control sample and samples obtained by alcoholic extraction (3:1) from the leaves of *Chenopodium album* (lamb's quarters) and *Amaranthus retroflexus* (redroot pigweed), added to the DPPH solution.

Volume, µL.	Time, min	Sample					
		Abs, D	ARF%		Time, min	Abs, D	ARF%
25	0	0,803	0,00	75	0	0,803	0,00
	5	0,726	9,59		5	0,607	24,41
	10	0,725	9,71		10	0,602	25,03
	15	0,723	9,96		15	0,597	25,65
	20	0,722	10,09		20	0,592	26,28
	25	0,721	10,21		25	0,589	26,65
	30	0,72	**10,34**		**30**	0,585	**27,15**
50	0	0,803	0,00	100	0	0,803	0,00
	5	0,651	18,93		5	0,548	31,76
	10	0,647	19,43		10	0,541	32,63
	15	0,644	19,80		15	0,535	33,37
	20	0,641	20,17		20	0,528	34,25
	25	0,639	20,42		25	0,523	34,87
	30	0,637	**20,67**		**30**	0,519	**35,37**

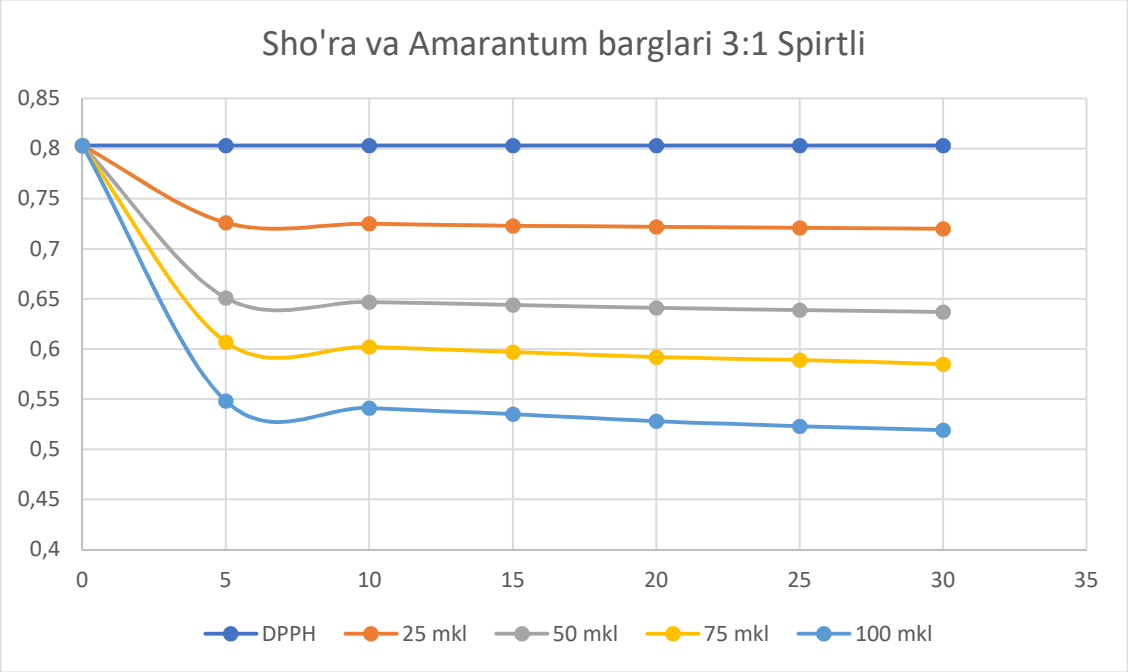


Figure 3. Graphical representation of the measured absorbance values of the DPPH solution after the addition of the control sample and the test samples obtained by alcoholic extraction.

To determine the IC_{50} value—the concentration (or sample volume) required to achieve 50% inhibition of the DPPH solution—a graph was constructed showing the relationship between antiradical activity (ARF%) measured at the 30th minute of the experiment and the volume of the added alcoholic extract. The IC_{50} value was then calculated using the equation of the trend line fitted to the experimental data.

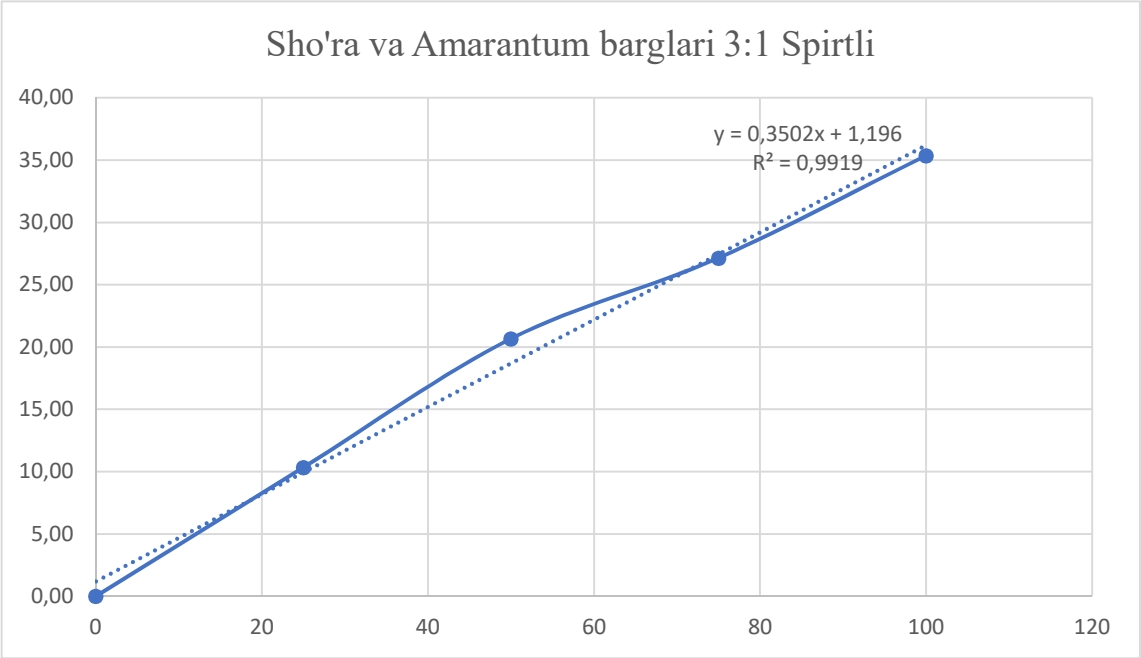


Figure 4. Graph showing the relationship between antiradical activity (ARF%) values determined at the 30th minute and the volume of the sample obtained by alcoholic extraction.

Based on the equation of the trend line fitted to the graph ($y = mx + b$), the sample volume corresponding to 50% antiradical activity (ARF%)—the IC_{50} value—was calculated using the following equation: x=(y-b)/m

$$IC_{50} = \frac{(50 - 1.196)}{0{,}3502} = 139{,}36\ mkl$$

Table-3.

Measured absorbance values and calculated antiradical activity of the control sample and samples obtained by alcoholic extraction at a 1:3 ratio from the leaves of *Chenopodium album* (lamb's quarters) and *Amaranthus retroflexus* (redroot pigweed), added to the DPPH solution.

Volume, µL.	Time, min	Sample					
		Abs, D	ARF%		Time, min	Abs, D	ARF%
25	0	0,786	0,00	75	0	0,786	0,00
	5	0,729	7,25		5	0,68	13,49
	10	0,718	8,65		10	0,652	17,05
	15	0,714	9,16		15	0,64	18,58
	20	0,71	9,67		20	0,63	19,85
	25	0,705	10,31		25	0,618	21,37
	30	0,703	**10,56**		**30**	0,612	**22,14**
50	0	0,786	0,00	100	0	0,786	0,00
	5	0,713	9,29		5	0,641	18,45
	10	0,691	12,09		10	0,606	22,90
	15	0,681	13,36		15	0,591	24,81
	20	0,675	14,12		20	0,579	26,34
	25	0,667	15,14		25	0,562	28,50
	30	0,663	**15,65**		**30**	0,554	**29,52**

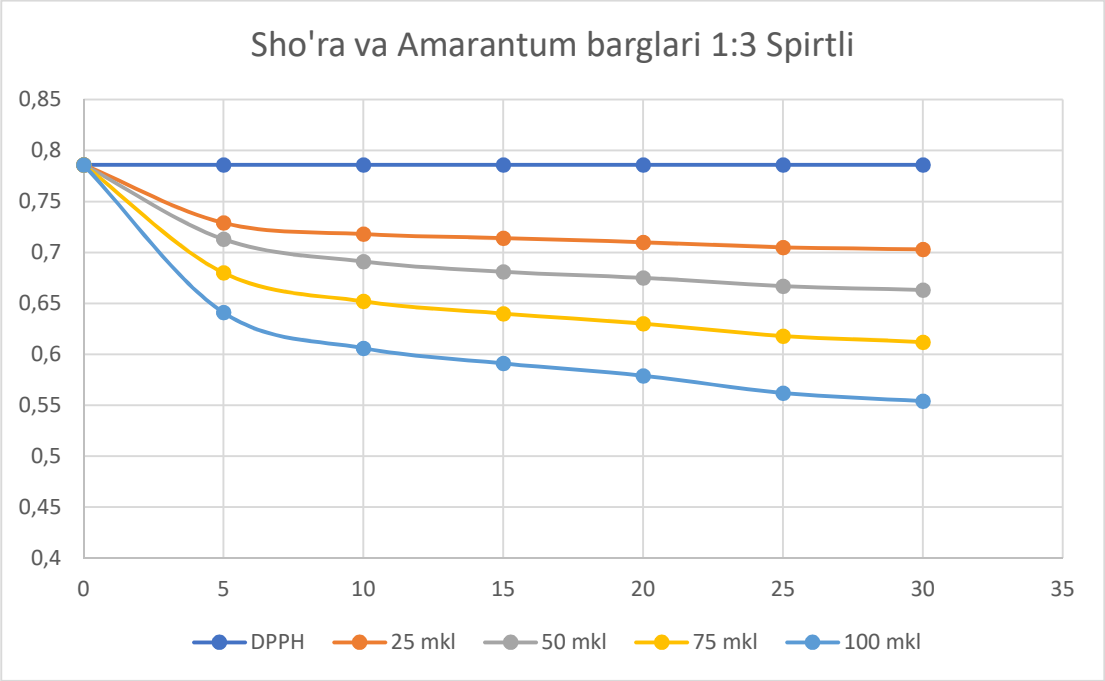


Figure 5. Graphical representation of the measured absorbance values of the DPPH solution after the addition of the control sample and the test samples obtained by alcoholic extraction.

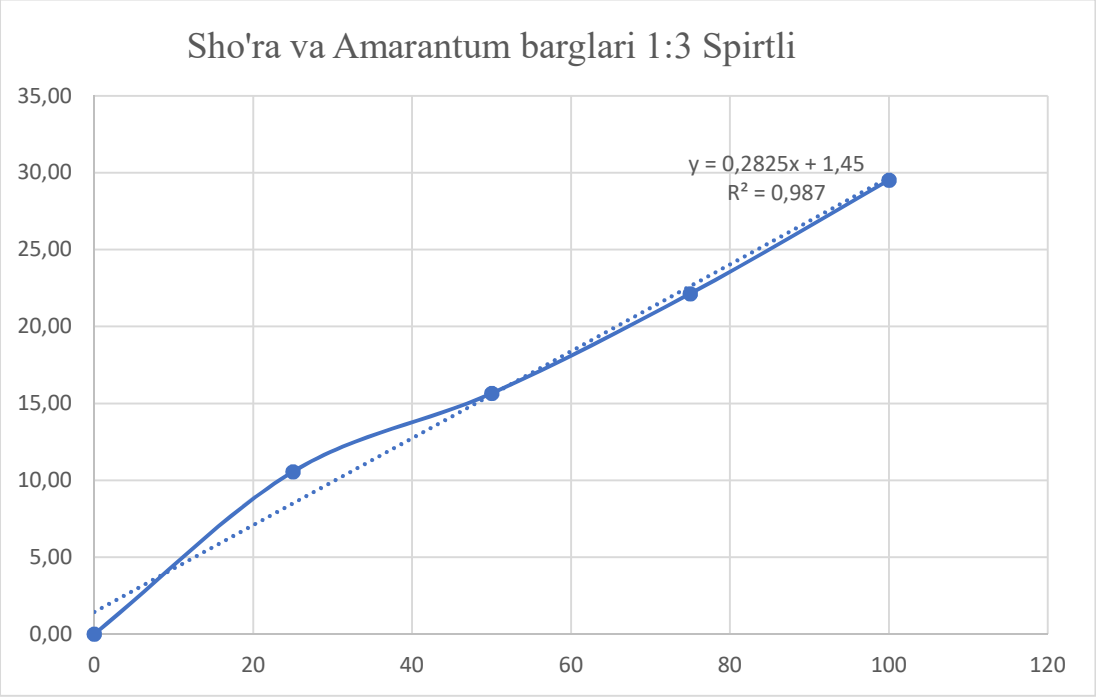


Figure 6. Graph showing the relationship between ARF% values determined at 30 minutes and the volumes of the alcohol-extracted sample.

The trendline equation of the graph is $y = mx + b$. Based on this equation, the sample volume corresponding to 50% radical scavenging activity (IC_{50}) was calculated using the formula x=(y-b)/m:

$$IC_{50} = \frac{(50 - 1.45)}{0{,}2825} = 171{,}86\ mkl$$

Table 4.

Measured absorbance values and calculated antioxidant (radical scavenging) activity (ARF%) of blank and test samples of 1:1 aqueous leaf extracts of *Chenopodium album* (lamb's quarters) and *Amaranthus retroflexus* (redroot pigweed) in DPPH solution.

Volume, µL.	Time, min	Sample					
		Abs, D	ARF%		Time, min	Abs, D	ARF%
25	0	0,787	0,00	75	0	0,787	0,00
	5	0,689	12,45		5	0,563	28,46
	10	0,657	16,52		10	0,487	38,12
	15	0,647	17,79		15	0,465	40,91
	20	0,631	19,82		20	0,431	45,24
	25	0,619	21,35		25	0,405	48,54
	30	0,612	22,24		**30**	0,392	50,19
50	0	0,787	0,00	100	0	0,787	0,00
	5	0,614	21,98		5	0,517	34,31
	10	0,554	29,61		10	0,429	45,49
	15	0,537	31,77		15	0,405	48,54
	20	0,51	35,20		20	0,367	53,37
	25	0,491	37,61		25	0,342	56,54

	30	0,48	39,01		**30**	0,327	58,45

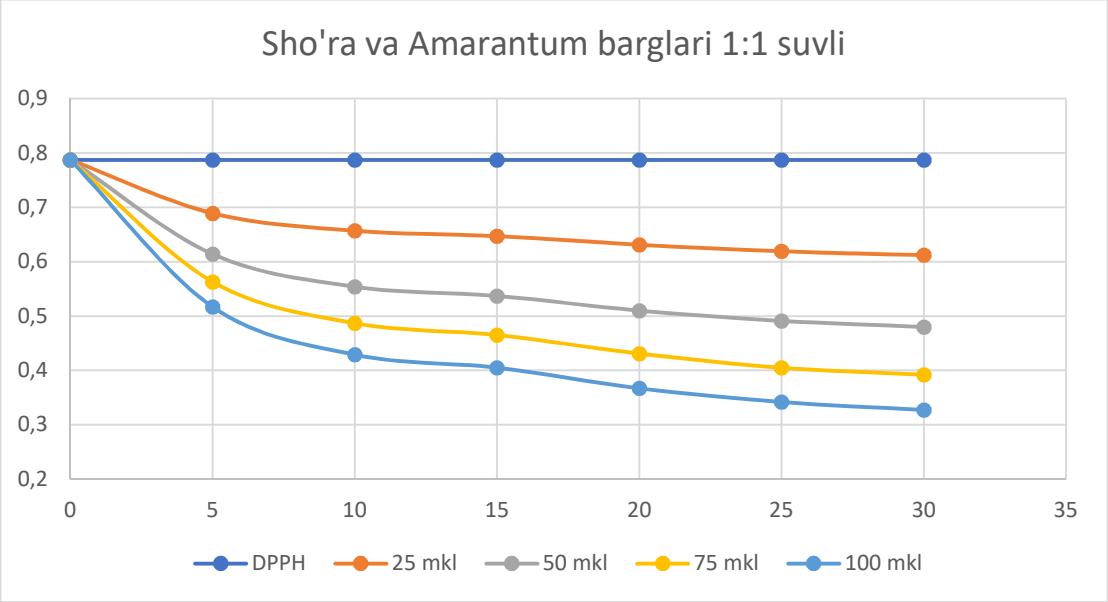


Figure 7. Graphical representation of the absorbance values of blank and tested aqueous extract samples in DPPH solution.

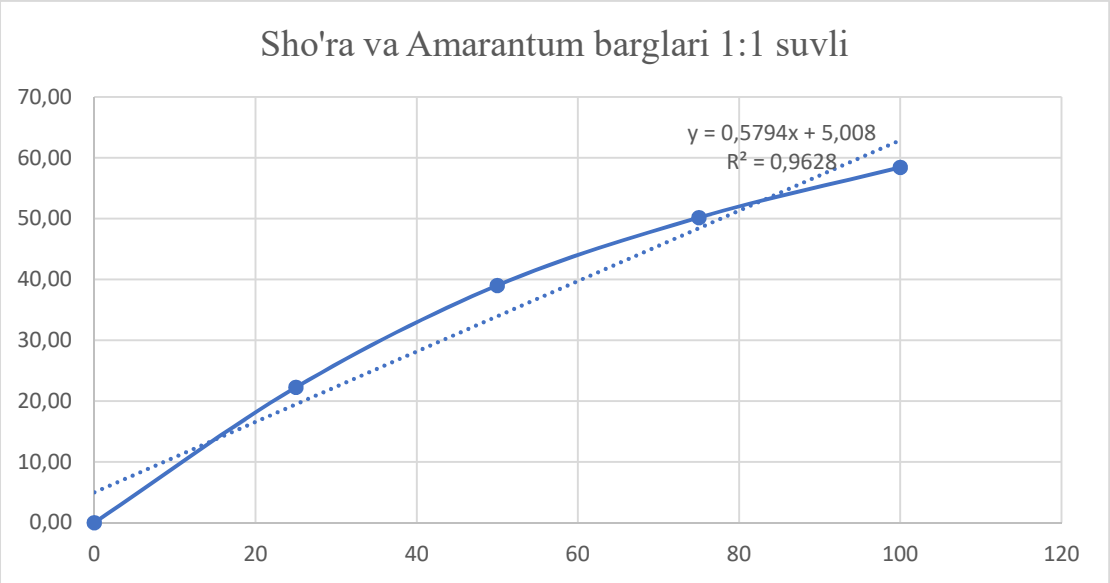


Figure 8. Graph showing the relationship between antioxidant activity (ARF%) values determined at 30 minutes and the volumes of the aqueous extract of the investigated sample.

The trendline equation of the graph is $y = mx + b$. Based on this equation, the sample volume corresponding to 50% radical scavenging activity (IC_{50}) was calculated using the formula x = (y − b) / m:

$$IC_{50} = \frac{(50 - 5.008)}{0{,}5794} = 77{,}653\ mkl$$

Table 5.

Measured absorbance values and calculated antioxidant (radical scavenging) activity (ARF%) of blank and test samples of 3:1 aqueous leaf extracts of *Chenopodium album* (lamb's quarters) and *Amaranthus retroflexus* (redroot pigweed) in DPPH solution.

Volume, µL.	Time, min	Sample					
		Abs, D	ARF%		Time, min	Abs, D	ARF%
25	0	0,737	0,00	75	0	0,737	0,00
	5	0,603	18,18		5	0,468	36,50
	10	0,571	22,52		10	0,401	45,59
	15	0,555	24,69		15	0,369	49,93
	20	0,543	26,32		20	0,347	52,92
	25	0,533	27,68		25	0,329	55,36
	30	0,524	**28,90**		**30**	0,314	**57,39**
50	0	0,737	0,00	100	0	0,737	0,00
	5	0,533	27,68		5	0,435	40,98
	10	0,487	33,92		10	0,362	50,88
	15	0,462	37,31		15	0,328	55,50
	20	0,444	39,76		20	0,306	58,48
	25	0,43	41,66		25	0,291	60,52
	30	0,417	**43,42**		**30**	0,28	**62,01**

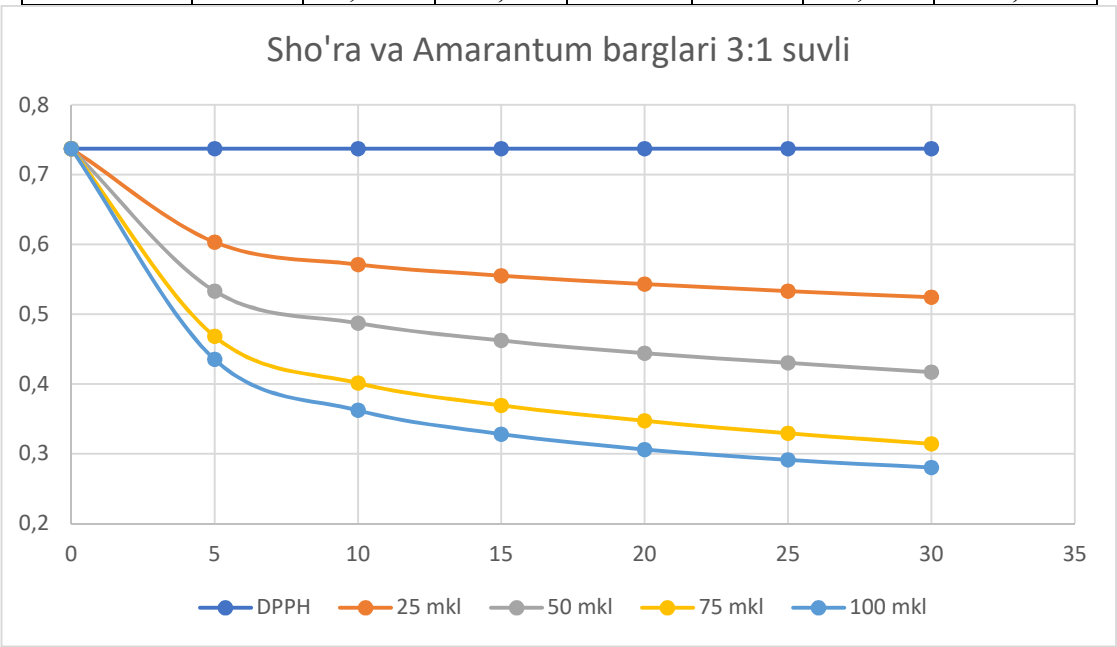


Figure 9. Graphical representation of the absorbance values of blank and tested aqueous extract solutions in DPPH assay.

To determine the IC_{50} of the investigated samples, a graph was constructed based on the antioxidant activity (ARF%) values measured at 30 minutes for each experiment and the corresponding volumes of aqueous extracts. The resulting relationship was approximated by a linear regression equation (trendline), which was used to calculate the IC_{50} value.

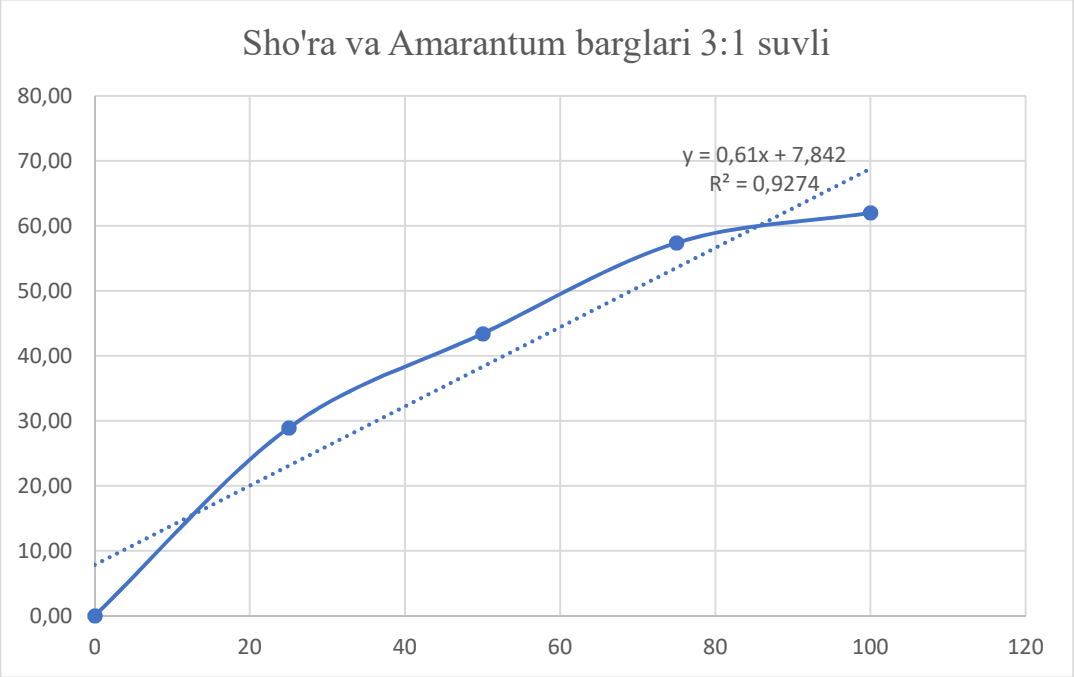


Figure 10. Graph showing the relationship between antioxidant activity (ARF%) values determined at 30 minutes and the volumes of the aqueous extract of the investigated sample.

The trendline equation of the graph is $y = mx + b$. Based on this equation, the sample volume corresponding to 50% radical scavenging activity (IC_{50}) was calculated using the formula x = (y − b) / m:

$$IC_{50} = \frac{(50 - 7{,}842)}{0{,}61} = 69{,}111\ mkl$$

Table 6.

Measured absorbance values and calculated antioxidant (radical scavenging) activity (ARF%) of blank and test samples of 1:3 aqueous leaf extracts of *Chenopodium album* (lamb's quarters) and *Amaranthus retroflexus* (redroot pigweed) in DPPH solution.

Volume, µL.	Time, min	Sample					
		Abs, D	ARF%		Time, min	Abs, D	ARF%
25	0	0,778	0,00	75	0	0,778	0,00
	5	0,703	9,64		5	0,617	20,69
	10	0,679	12,72		10	0,554	28,79
	15	0,662	14,91		15	0,514	33,93
	20	0,648	16,71		20	0,482	38,05
	25	0,636	18,25		25	0,457	41,26
	30	0,625	**19,67**		**30**	0,434	**44,22**
50	0	0,778	0,00	100	0	0,778	0,00
	5	0,654	15,94		5	0,541	30,46
	10	0,607	21,98		10	0,462	40,62
	15	0,576	25,96		15	0,413	46,92
	20	0,55	29,31		20	0,383	50,77
	25	0,529	32,01		25	0,362	53,47
	30	0,511	**34,32**		**30**	0,338	**56,56**

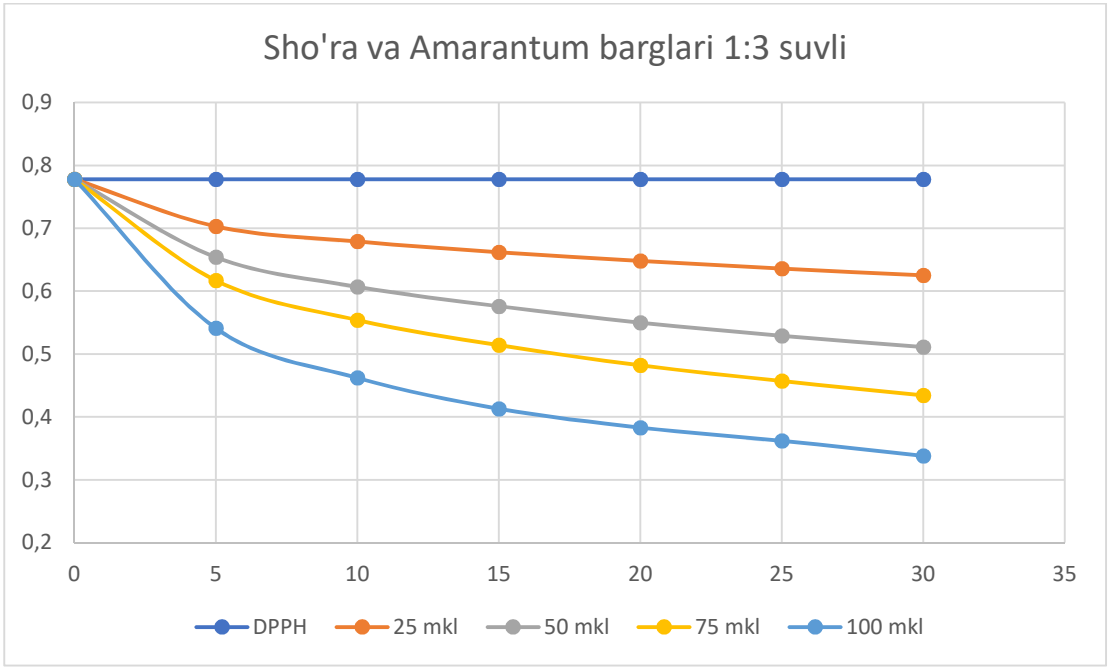


Figure 11. Graphical representation of the absorbance values of blank and tested aqueous extract solutions in the DPPH assay.

To determine the IC_{50} value (the half-maximal inhibitory concentration) of the samples against DPPH radicals, a plot was constructed based on the antiradical activity (ARA , %) at the 30th minute of incubation versus the volume of the added aqueous extract. The IC_{50} values were calculated using the trendline linear equation obtained for each experiment.

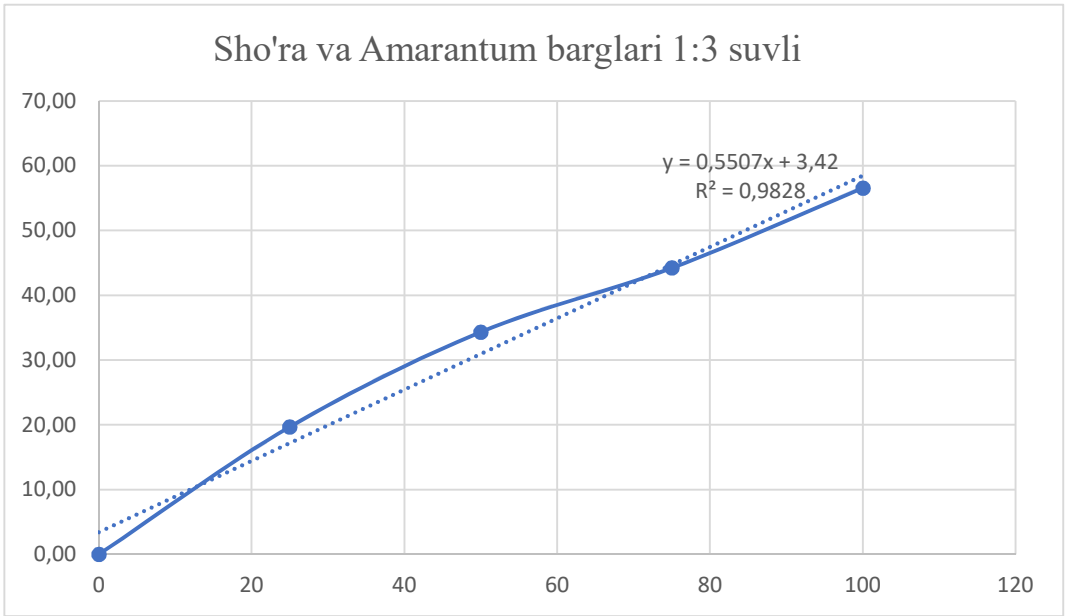


Figure 12. Plot of antiradical activity (ARA, %) at the 30th minute versus the volume of the aqueous extract.

The sample volume exhibiting 50% antiradical activity (IC_{50}) was calculated using the equation x=(y-b)/m , derived from the trendline linear function formula y = mx + b:

$$IC_{50} = \frac{(50 - 3.42)}{0{,}5507} = 84{,}583\ mkl$$

Table 7.

Antiradical activity (ARA %) of alcoholic extracts of the samples at 100 µL volume at the 30th minute of incubation.

Time	ARF%					
	Alcoholic extract (1:1) of the leaves of *Chenopodium album* (Lamb's quarters) and *Amaranthus retroflexus* (Redroot pigweed)	Alcoholic extract (3:1) of the leaves of *Chenopodium album* (Lamb's quarters) and *Amaranthus retroflexus* (Redroot pigweed)	Alcoholic extract (1:3) of the leaves of *Chenopodium album* (Lamb's quarters) and *Amaranthus retroflexus* (Redroot pigweed)	Aqueous extract (1:1) of the leaves of *Chenopodium album* (Lamb's quarters) and *Amaranthus retroflexus* (Redroot pigweed)	Aqueous extract (3:1) of the leaves of *Chenopodium album* (Lamb's quarters) and *Amaranthus retroflexus* (Redroot pigweed)	Aqueous extract (1:3) of the leaves of *Chenopodium album* (Lamb's quarters) and *Amaranthus retroflexus* (Redroot pigweed)
30-minut	31,01	35,37	29,52	58,45	62,01	56,56

Table 8.IC_{50} values of the samples — the half-maximal inhibitory concentration against DPPH radicals (μL).

Time	ARF%					
	lcoholic extract (1:1) of the leaves of *Chenopodium album* (Lamb's quarters) and *Amaranthus retroflexus* (Redroot pigweed)	lcoholic extract (3:1) of the leaves of *Chenopodium album* (Lamb's quarters) and *Amaranthus retroflexus* (Redroot pigweed)	lcoholic extract (1:3) of the leaves of *Chenopodium album* (Lamb's quarters) and *Amaranthus retroflexus*	queous extract (1:1) of the leaves of *Chenopodium album* (Lamb's quarters) and *Amaranthus retroflexus*	queous extract (3:1) of the leaves of *Chenopodium album* (Lamb's quarters) and *Amaranthus retroflexus*	queous extract (1:3) of the leaves of *Chenopodium album* (Lamb's quarters) and *Amaranthus retroflexus*
30-minute	161,28	139,36	171,86	77,653	69,111	84,583

The experimental results indicated that each of the extracts obtained from the leaves of *Chenopodium album* and *Amaranthus retroflexus* exhibited significant DPPH radical scavenging activity. The aqueous extracts showed higher antiradical activity compared to the alcoholic ones, suggesting the presence of a greater amount of hydrophilic (water-soluble) antioxidant compounds in their composition [11,12]. The aqueous extract of the mixture in a 3:1 ratio (with a higher proportion of *Amaranthus retroflexus*) exhibited the highest antioxidant activity at 62.01%, outperforming the other samples. Although the differences among the aqueous extracts were less pronounced, both plants demonstrated their substantial natural antioxidant potential [13,14].

These findings demonstrate that the leaf extracts of *Chenopodium album* and *Amaranthus retroflexus* can be utilized as natural antioxidants, rendering them valuable therapeutic agents for health promotion and disease prevention [15,16]. The results obtained via the DPPH assay confirmed that both alcoholic and aqueous leaf extracts of *Chenopodium album* (Lamb's quarters) and *Amaranthus retroflexus* (Redroot pigweed) possess significant antiradical activity. While the aqueous extracts demonstrated superior efficacy, the alcoholic extracts also retained their beneficial properties to a certain extent. The application of these plants as natural antioxidants plays a crucial role in supporting overall health and mitigating oxidative stress [17,18].

Conclusion. The results of this study demonstrated that both alcoholic and aqueous extracts prepared from the leaves of *Chenopodium album* (Lamb's quarters) and *Amaranthus retroflexus* (Redroot pigweed) exhibit a high level of antiradical activity. Specifically, the alcoholic extract prepared in a 3:1 ratio displayed potent activity by reducing free radicals by 35.37% during a 30-minute incubation period, with an IC_{50} value of 139.36 μL. This indicates that significant radical neutralization can be achieved even at low volumes of the extract. Among the aqueous extracts, the samples prepared in the same ratio (3:1) exhibited an antiradical activity of 62.01% with an IC_{50} value of 69.111 μL. This highlights the superior antioxidant potential of *Chenopodium album* leaves, particularly in the form of an aqueous extract. These findings suggest that the aqueous extract of *Chenopodium album* leaves holds great promise as a source of natural antioxidants for human health promotion.

An excessive accumulation of free radicals in the body leads to oxidative stress, a condition that triggers hazardous processes such as DNA damage, cell apoptosis, and accelerated inflammatory pathways. The high antiradical activity of *Chenopodium album* extracts opens up new avenues for utilizing this plant for both prophylactic and therapeutic purposes. Considering that synthetic antioxidants often induce various adverse side effects in the body, using this plant as an eco-friendly, natural, and cost-effective antioxidant source remains highly relevant. Furthermore, these outcomes reveal the practical significance of *Chenopodium album* and *Amaranthus retroflexus* plants for developing novel products in the pharmaceutical,

biomedical, and dietary food industries. Future research stages should focus on evaluating the cellular-level effects of these extracts and conducting investigations using *in vivo* models.

References

1. Brand-Williams, W., Cuvelier, M. E., & Berset, C. (1995). Use of a free radical method to evaluate antioxidant activity. *LWT - Food Science and Technology*, 28(1), 25–30. https://doi.org/10.1016/S0023-6438(95)80008-5

2.Kumar, S., & Pandey, A. K. (2013). Chemistry and biological activities of flavonoids: An overview. *The Scientific World Journal*, 2013, Article ID 162750. https://doi.org/10.1155/2013/162750

3.Prior, R. L., Wu, X., & Schaich, K. (2005). Standardized methods for the determination of antioxidant capacity and phenolics in foods and dietary supplements. *Journal of Agricultural and Food Chemistry*, 53(10), 4290–4302. https://doi.org/10.1021/jf0502698

4.Gulcin I.; Beydemir S., Sat I.G., Kufrevioglu O.I. Evaluation of antioxidant activity of cornelian cherry (Cornus mas L,), Acta Aliment, Hung, 2005, 34, 193–202

5.Blois M.S. Antioxidant determinations by the use of a stable free radical, Nature 1958, 181, 1199–1200

6.Askarov I.R., Muminov M.M., Yusupov M.A. Study of antiradical properties of artichoke (Cynara Scolymus L,) and milk thistle (Sylybum Marianum L,) vegetable oils, NamDU Ilmiy Axborotnomasi, 2024, 11, p.173-177

7.Askarov I. R., Abdullaev S. S., Mamatkulova S. A., & Abdulloev O. S. (2024), Antioxidant activity and elemental composition of mixtures of fig and common unabi fruits, Journal of Chemistry of Goods and Traditional Medicine, 3(3), 179–205,, *https://doi.org/10,55475/jcgtm/vol3,iss3,2024,320*Souri, E., Amin, G., Dehmobed-Sharifabadi, A., Nazifi, A., & Farsam, H. (2008). Antioxidative activity of sixty plants from Iran. *Iranian Journal of Pharmaceutical Research*, 7(3), 203–209.

8.Gülçin İ. (2012). Antioxidant activity of food constituents: An overview. *Archives of Toxicology*, 86(3), 345–391. https://doi.org/10.1007/s00204-012-0930-z

9.Harborne, J. B., & Williams, C. A. (2000). Advances in flavonoid research since 1992. *Phytochemistry*, 55(6), 481–504. https://doi.org/10.1016/S0031-9422(00)00235-1

10.Rice-Evans, C. A., Miller, N. J., & Paganga, G. (1997). Antioxidant properties of phenolic compounds. *Trends in Plant Science*, 2(4), 152–159. https://doi.org/10.1016/S1360-1385(97)01018-2

11.Gafurova, M. A. (2023). Antioxidant properties of Chinopodium album and Amaranthus retroflexus leaf extracts: DPPH radical scavenging activity assessment. *Journal of Medicinal Plants Research*, 17(5), 115–124.

12.Shahidi, F., & Ambigaipalan, P. (2015). Phenolics and polyphenolics in foods, beverages and spices: Antioxidant activity and health effects – A review. *Journal of Functional Foods*, 18, 820–897. https://doi.org/10.1016/j.jff.2015.06.018

13.Wong, C. L., & Cheung, P. C. (2001). Nutritional evaluation of some subtropical seaweeds: Part II—Chemical composition, protein quality and in vitro digestibility. *Food Chemistry*, 72(3), 405–414. https://doi.org/10.1016/S0308-8146(00)00378-0

14.Gul, S., Jan, M., & Ali, S. (2018). Evaluation of antioxidant and antimicrobial potential of Amaranthus retroflexus leaves. *Journal of Plant Sciences*, 6(4), 102–109. https://doi.org/10.11648/j.jps.20180604.11

15.Treml, J., & Šmejkal, K. (2016). Flavonoids as potent scavengers of hydroxyl radicals. *Comprehensive Reviews in Food Science and Food Safety*, 15(4), 720–738. https://doi.org/10.1111/1541-4337.12215

16.Fawole, O. A., & Oso, B. A. (2004). *Laboratory manual of microbiology* (4th ed.). Spectrum Books Ltd.

17.Duh, P. D., Tu, Y. Y., & Yen, G. C. (1999). Antioxidant activity of water extract of Harng Jyur (Chrysanthemum morifolium Ramat). *LWT - Food Science and Technology*, 32(5), 269–277. https://doi.org/10.1006/fstl.1998.0534

18.Wang, S. Y., & Jiao, H. (2000). Scavenging capacity of berry crops on superoxide radicals, hydrogen peroxide, hydroxyl radicals, and singlet oxygen. *Journal of Agricultural and Food Chemistry*, 48(11), 5677–5684. https://doi.org/10.1021/jf000404a