UDC 616.08+615.03+612.3
DOI https://doi.org/10.32782/2522-9680-2026-1-101

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To cite this article: Levitsky A., Burdo O., Malinovskii V., Yuzkiv Ya., Pavlenko K., Selivanska I., Lapinska A. (2026). Aktynidija jak dzherelo harchovyh antyoksydantiv dlja profilaktyky ta likuvannja post-stresovyh reakcij [Actinidia as a source of dietary antioxidants for the prevention and treatment of post-stress reactions]. *Fitoterapiia. Chasopys – Phytotherapy. Journal*. 1, 101–108, doi: https://doi.org/10.32782/2522-9680-2026-1-101

ACTINIDIA AS A SOURCE OF DIETARY ANTIOXIDANTS FOR THE PREVENTION AND TREATMENT OF POST-STRESS REACTIONS

Relevance. *Oxidative stress plays a significant role in the pathogenesis of many diseases. This necessitates the use of antioxidants. One of the largest sources of natural antioxidants is actinidia.*

The aim of the study is *to investigate the content of flavonoids, as the most active antioxidants, in the juice concentrate from actinidia fruits.*

Material and methods. *Actinidia juice concentrate was obtained using the microwave dehydration method (Burdo et al., 2020). The content of vitamins C and P was determined by spectrophotometric methods, comparing their content in actinidia juice concentrate with the content in apple and grape juices. The content of flavonoids was determined using the HPLC method.*

Research results. *It has been established that actinidia contains significantly more vitamins P and C than apples and grapes. The total amount of polyphenolic compounds in actinidia concentrate is 1783.3 mg%, which is almost 10 times higher than the content of polyphenols in apples and grapes. It has been found that almost 64% of actinidia polyphenols are flavonoids (vitamin P). Of this number, the most is flavonols – 24%. Flavanones make up 13.6% and catechins − 10.6%. A significant proportion of flavonoids is catechin-like substances, namely 51.6%. Anthocyanidins and isoflavones are absent in actinidia juice concentrate.*

Conclusion. *Puree from actinidia fruits contains a significant amount of water-soluble antioxidants (vitamins C and P), exceeding most other plants in this indicator. Actinidia concentrate (dried fruit) contains an extremely high concentration of flavonols (269 mg%), which makes it easy to meet a person's daily requirement for this vitamin (50 mg). The HPLC method allows the identification of all other polyphenolic substances that have antioxidant properties.*

Key words: *actinidia, flavonoids, vitamin P, microwave dehydration, HPLC of polyphenols.*

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Бібліографічний опис статті: Левицький А., Бурдо О., Малиновський О., Юзьків Я., Павленко К., Селіванська І., Лапінська А. (2026). Актинідія як джерело харчових антиоксидантів для профілактики та лікування постстресових реакцій. *Фітотерапія. Часопис*, 1, 101–108, doi: https://doi.org/10.32782/2522-9680-2026-1-101

АКТИНІДІЯ ЯК ДЖЕРЕЛО ХАРЧОВИХ АНТИОКСИДАНТІВ ДЛЯ ПРОФІЛАКТИКИ ТА ЛІКУВАННЯ ПОСТСТРЕСОВИХ РЕАКЦІЙ

Актуальність. *У патогенезі багатьох хвороб значну роль відіграє оксидативний стрес. Це зумовлює необхідність застосування антиоксидантів. Одним із найбільших джерел природних антиоксидантів є актинідія.*

Мета дослідження *– дослідити вміст флавоноїдів як найактивніших антиоксидантів у концентраті соку з плодів актинідії.*

Матеріали та методи. *Концентрат соку актинідії отримували за допомогою мікрохвильового методу дегідратації (Бурдо та ін., 2020). Вміст вітамінів С і Р визначали спектрофотометричними методами, порівнюючи їх вміст у концентраті соку актинідії із вмістом у соках з яблук та винограду. Визначення вмісту флавоноїдів здійснювали за допомогою методу ВЕРХ.*

Результати дослідження. *Встановлено, що актинідія містить значно більше вітамінів Р і С, ніж яблука і виноград. Загальна кількість поліфенольних сполук у концентраті актинідії становить 1783,3 мг%, що майже в 10 разів перевищує вміст поліфенолів у яблуках та винограді. Виявлено, що майже 64% поліфенолів актинідії становлять флавоноїди (вітаміни Р). З цього числа більше всього флавонолів – 24%. Флаванони становлять 13,6%, а катехіни – 10,6%. Значну частку флаваноїдів становлять катехіноподібні субстанції, а саме 51,6%. У концентраті соку актинідії відсутні антоціанідини та ізофлавони.*

Висновки. *Пюре з плодів актинідії містить значну кількість водорозчинних антиоксидантів (вітамінів С і Р), перевищуючи за цим показником більшість інших рослин. Концентрат актинідії (сухофрукти) містить надзвичайно високу концентрацію флавонолів (269 мг%), що дозволяє легко задовольнити добову потребу людини в цьому вітаміні (50 мг). Метод ВЕРХ дозволяє визначити всі інші поліфенольні субстанції, які володіють антиоксидантними властивостями.*

Ключові слова: *актинідія, флавоноїди, вітамін Р, мікрохвильова дегідратація, ВЕРХ поліфенолів.*

Introduction. Actuality.

In the pathogenesis of post-stress reactions, the processes of lipid and protein peroxidation play a crucial role (Reddy, 2023). Therefore, the state of the body's antioxidant systems plays a significant role in the prevention and treatment of post-stress reactions (Reddy, 2023; Ray et al., 2012; Gorbenko et al., 2016).

As is known, in addition to endogenous antioxidant systems represented by glutathione peroxidase, catalase, hemeoxygenase, cysteine, ubiquinone, squalene; an exogenous antioxidant system, provided by dietary antioxidants, also plays a significant role (Mishhenko et al., 2020; Stote et al., 2023; Bacchetti et al., 2019).

Dietary antioxidants include fat-soluble (tocopherol, carotene, lycopene) and water-soluble (ascorbic acid, polyphenols) compounds. The main source of dietary antioxidants is fruits and vegetables.

Kiwifruit (synonymous name for actinidia), a fruit from the *Actinidiaceae* family, has been found to be the richest source of ascorbic acid (vitamin C) (Barna, Sokolova, 2005). However, there is virtually no data on the content of other antioxidants in actinidia, in particular polyphenols, which have extremely high antioxidant activity (Makarenko, Levitsky, 2016; Middleton, 2000; Levitsky, Malinovskii, 2025).

In traditional technologies, dry concentrates are obtained by successive dehydration of raw materials in evaporators and spray dryers or in chamber dryers. The greater the drying fraction, the higher the total energy consumption. The authors use microwave dehydration technology, the advantage of which is that it eliminates energy-wasting drying. World experience shows that scientific interest in microwave technologies is growing dynamically. Numerous facts and confirmations of the technological and energy feasibility of using microwave devices in food and pharmaceutical (Ibis et al., 2024; Carvalho et al., 2021; Dumpler, Moraru, 2024; Kalinke, Kulozik, 2024; Kalinke et al., 2025).

The aim of the study

The aim of our work was to determine the content of polyphenol antioxidants in actinidia juice concentrate obtained using the dehydration method we developed (Burdo et al., 2020; Burdo et al., 2025).

Material and methods. The object of the study was chosen to be actinidia fruits (acktinos), *Actinidia deliciosa* (A.Chev.) C.F.Liang & A.R.Ferguson, without varietal affiliation, country of origin − Ukraine. Juices, dehydrated berries (dried fruits) and pre-mashed (puree) were analyzed.

The samples were dehydrated in a dehydrator, the main components of which are a resonator shaft, a reaction volume, a refrigeration system, pressure control devices, and magnetron control systems. The resonator shaft with a cross section of 20x20 mm is made of stainless steel, 1.5 mm thick, and 1 m high. The working volume of the reactor is divided into vaporization and separation zones. The kinetic dependences of the influence of the microwave field power, the type of extractant, the type of product on the values of steam productivity and specific energy consumption have been determined. At the same time, in the entire concentration range up to 80 °brix, the steam productivity does not depend on the type of raw material and has constant values. The proposed dehydration technology requires energy consumption 3.5 times less than traditional ones, with almost complete preservation of taste and aromatic components.

The experimental stand for studying the dehydration process under the action of an electromagnetic field consists of an evaporation chamber, which is connected to a condensate collector and a vacuum pump through a condenser. The vapor volumes of the evaporation chamber and the condenser are interconnected, and the current vacuum value in the entire system is monitored using a sample vacuum gauge. The microwave energy is supplied by the power electronics unit according to the commands of the control unit, which contains a timer and a power regulator. The water cooling system includes a steam compressor refrigeration machine, a tank with cooling water, a water temperature regulator and a circulation pump, which provides cold water to the condenser. Data collection and processing were carried out by a measuring and computing complex. Thanks to the automation of the data collection process, current information from electronic scales, the outlet steam temperature meter and the product in the evaporation chamber is received via the interface, recorded and processed by the processor.

The stand used electronic scales of the brand TVE-0.21-0.01 and temperature sensors of the Dallas DS18b20 series. Data collection and processing was implemented on the basis of the CHUWI CW1506 tablet. The developed program provided for the display of thermograms, kinetics of moisture reduction in the chamber and instantaneous values of the moisture removal rate (grams per minute) on the display screen. The condensate weight was recorded using scales, which resulted in accurate steam output values. The effective operating modes were determined: microwave field density 53 kW/m^3, chamber pressure 10 kPa. Specific energy consumption during dehydration 3.6 MJ/kg.

The ascorbic acid content was determined by spectrophotometric method (Moharram, Youssef, 2014). For this purpose, solutions of actinidia juice and concentrate in 0.001M HCl were prepared. To 1 ml of juice solution or concentrate, 1 ml of 1 mM $FeCl_3$ solution and 1 ml of 3 mM $K_3[Fe(CN)_6]$ solution were added and after 5 minutes the extinction was measured at 693 nm on a Shimadzu UV-1240mini spectrophotometer.

The ascorbic acid content was determined using a calibration curve using ascorbic acid solution.

The content of flavonoids (vitamin P) was determined by spectrophotometric method (Nadaroğlu et al., 2007). For this purpose, a solution of actinidia juice or concentrate in ethanol was prepared. 1 ml of juice solution (concentrate) was mixed with 0.5 ml of 5% $AlCl_3$ solution in ethanol, 2.5 ml of ethanol was added and the extinction was measured at 410.5 nm on a Shimadzu UV-1240mini or Spekol 11 spectrophotometer.

To calculate the vitamin P content, a similar reaction was performed with a quercetin solution.

Analysis of extracts for composition and polyphenol content by high-performance liquid chromatography (HPLC) (Levitsky et al., 2012; Khodakov, 2013; Khodakov et al., 2015).

The analysis was carried out on a Prominence LC-20 liquid chromatography system from Shimadzu (Japan), which consists of the following functional modules: a DGU-20A3R degasser, a solvent supply system, an LC-20AD pump module, a SIL-20AC autodispenser refrigerator, an SPD-20AV spectrophotometric detector, a CTO-20A column thermostat, a Thermo Scientific Syncronis column, and aQ reversed-phase filler with a $C_{18}[(CH_2)_{17}CH_3]$, grafted group, length 250 mm, internal diameter 4.6.

HPLC conditions:

1. The composition of the mobile phase: component A is methanol, component B is a 1% solution of phosphoric acid in deionized water.
2. Chromatography mode is gradient.
3. The mobile phase speed is constant at 0.5 ml/min.
4. The column temperature is constant, 40°C.
5. Injection volume – 5 μl.

Identification of substances in the extracts was carried out by comparing the retention time and spectral characteristics of the studied substances with similar characteristics of polyphenol standards. Commercial preparations produced in China, Germany, and Switzerland, as well as some samples obtained from scientists at the Kharkiv Chemical and Pharmaceutical Institute, were used as polyphenol standards.

The spectral characteristics of the studied compounds were determined by the height of the peaks of these substances on chromatograms at wavelengths of 255, 286, and 350 nm compared to the height of the peak at a wavelength of 225 nm (Khodakov, 2013).

Research results and their discussion. The results of determining the content of vitamin C (ascorbic acid) and vitamin P (bioflavonoids) in products from actinidia, red grapes and apples using spectrophotometric methods are presented in table 1.

Table 1

The content of vitamins C and P in the juices of actinidia, red grapes and apples (spectrophotometric method)*

№№	Products	Vitamin C, мг%	Vitamin P, мг%
1	A. Juices and purees:		
2	Actinidia puree	364	6.25
3	Grape juice	50	0.84
4	Apple juice	1.2	0.64
5	B. Concentrates		
6	Actinidia (dried fruits)	375	18.5
7	Grape	325	2.23
8	Apple	243	0.84

*Mean value of three replicates

From these data it can be seen that actinidia puree contains 7 times more vitamin C than grape juice and 300 times more than apple juice.

According to scientific literature (Stote et al., 2023; Bacchetti et al., 2019), the richest source of vitamin C is considered to be rose hips, which contain 100–120 mg% of vitamin C.

In terms of vitamin P content, actinidia puree exceeds the similar indicator of grape juice by 7.5 times, and the indicator of apple juice by almost 10 times.

It is known (Makarenko, Levitsky, 2016) that the richest in vitamin P is grapefruit, the juice of which contains 4.9 mg% of bioflavonoids.

In juice concentrates obtained using our method, the vitamin C content increases significantly: for grapes by 6.5 times, and for apples by 200 times.

The concentration of vitamin P in concentrates also increases significantly: for actinidia by 3 times and for grapes by 2.7 times.

Using the HPLC method allowed us to determine the content of vitamin P (flavonoids) and a number of other polyphenolic compounds that have antioxidant properties (fig. 1.)

Table 2 presents the results of determining the composition and content of polyphenols of different groups in actinidia concentrate.

The total amount of polyphenols in dried actinidia fruits is almost 10 times higher than the polyphenol content in grape and apple juice concentrates.

A total of 7 groups of polyphenolic compounds were identified, with no anthocyanins, isoflavones, or resveratrol.

It is important to emphasize that the HPLC method allows us to determine the content of all representatives

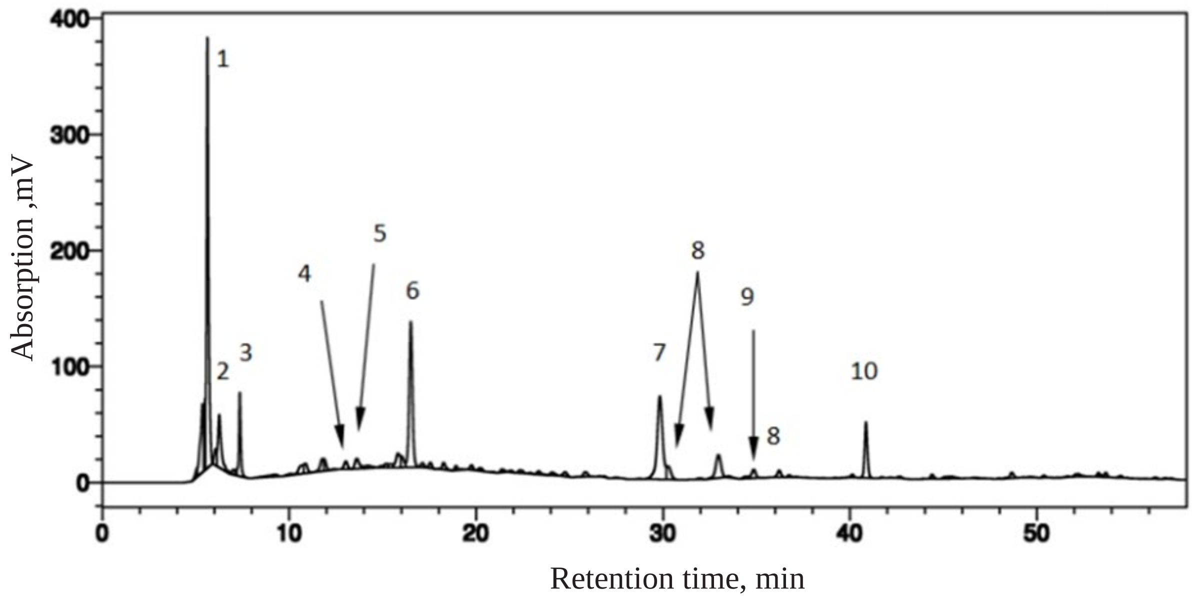

Fig 1. Chromatogram of ethanol extract of actinidia (ratio: 1 g of sample to 20 ml of 70% ethanol) at λ = 255 nm. 1, 2, 3 – catechin-like, 4, 5 – catechins, 6 – chlorogenic acid, 7 – rutin, 8 – flavonol glycosides, 9 – luteolin glycosides, 10 – quercetin

of vitamin P (flavonoids) and thanks to this we obtained a very high indicator, namely 269 mg%, which is ten times higher than the content of vitamin P in grape and apple juice concentrates (Fig. 2).

Table 2

Polyphenol content in actinidia concentrate (metod of HPLC)

Polyphenol group	Content		Main representatives
	mg%	% of total polyphenols	
Total number	1783.29		
1. Phenolic acids	405.27	22.7	Chlorogenic acid = 75.6 %
2. Catechins	120.82	6.8	
3. Catechin-like substances	585.77	32.8	
4. Flavonols	268.95	15.1	Rutin = 57.7% Quercetin
5. Flavones	4.89	0.27	Luteolin glycosides
6. Flavanones	13.84	0.78	Hesperidin, naringenin
7. Flavanone-like substances	141.07	7.91	
8. Anthocyanins	0	0	
9. Resveratrol	0	0	
10. Isoflavones	0	0	
11. Unidentified polyphenols	242.70	13.6	

*Mean value of three replicates

The results of our research indicate a unique feature of actinidia fruits to biosynthesize and accumulate a large number of polyphenols, including flavonoids, which are vitamin P (Levitsky, Malinovskii, 2025).

Analysis of published data on the content of polyphenols in other plant products confirms our confidence in the uniqueness of this plant as a source of exogenous (alimentary) antioxidants.

Based on the fact that in the pathogenesis of a significant number of diseases (atherosclerosis, hepatitis, heart disease, cancer, stress) free radical processes with the formation of toxic peroxidation products play a crucial role (Levitsky, Malinovskii, 2025), the consumption of dietary antioxidants can be considered mandatory for the prevention and treatment of these diseases.

The method we used to obtain actinidia concentrates allows us to solve this problem and thereby significantly improve people's health, which is extremely important due to the significant increase in morbidity and mortality.

Conclusions.

1. Puree from actinidia fruits contains a significant amount of water-soluble antioxidants (vitamins C and P), exceeding most other plants in this indicator.

2. Actinidia concentrate (dried fruit) contains an extremely high concentration of flavonols (269 mg%), which makes it easy to meet a person's daily requirement for this vitamin (50 mg).

3.The HPLC method allows the identification of all other polyphenolic substances that have antioxidant properties.

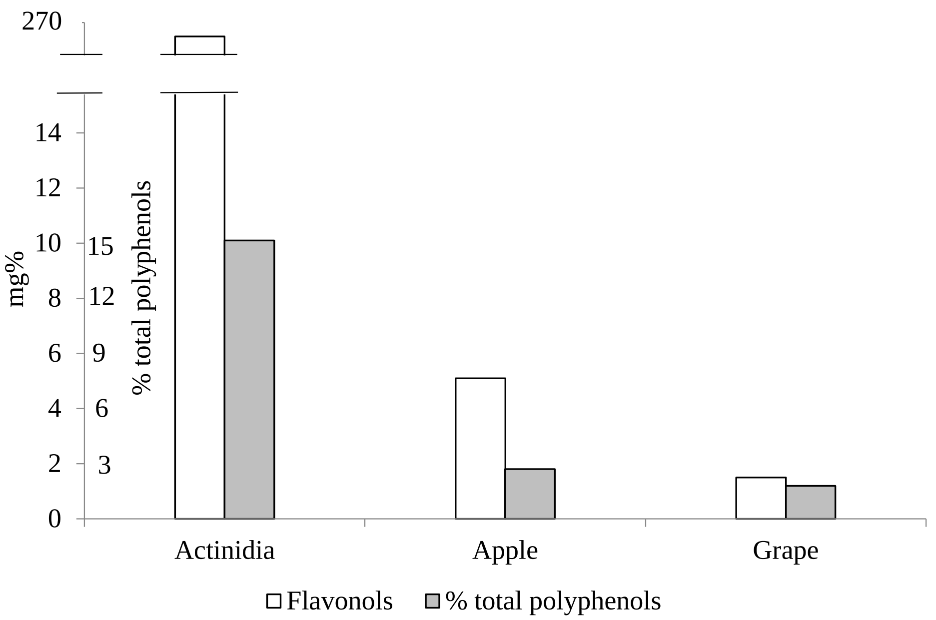

Fig. 2. Vitamins P (flavonoids) content in fruit juice concentrates (HPLC method)

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Дата першого надходження статті до видання: 18.09.2025
Дата прийняття статті до друку після рецензування: 20.02.2026
Дата публікації (оприлюднення) статті: 30.04.2026

Conflict of interest: none.

Authors' contributions:
Levitsky A.P. – idea, writing the text, proofreading of the article;
Burdo O.I. – reseach design, editing;
Malinovskii V.O. – collection and analysis of literature;
Yuzkiv Ya.C. – responsibility for statistical analysis;
Pavlenko K.V. – participation in writing the article;
Selivanska I.O. – collection of material, writing the article;
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