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DYNAMICS OF THE ACCUMULATION OF FLAVONOIDS IN OVERGROUND ORGANS OF CULTIVARS AND FORMS OF *ASIMINA TRILOBA* (L.) DUNAL

Pawpaw three-blade (Asimina triloba (L.) Dunal) is the new plant introduced from North America into different regions of Ukraine. The pawpaw is widely cultivated in many countries of Europe as a valuable food, medicinal and ornamental plant. In the conditions of an introduction in Ukraine adaptation properties of a pawpaw at the biochemical level weren't studied. One of important indicators of adaptation of plants is accumulation of flavonoids, secondary metabolites of the phenolic nature. Flavonoids show multifunctional action in plants, participating in many processes of activity, play an important role in processes of formation of reproductive organs and immunity of plants. Results of researches of dynamics of accumulation of flavonoids at pawpaw cultivars and forms in the South and the North of Ukraine at stages of the major processes of activity — during active growth, blossoming, maturing of fruits and in the course of preparation of plants for organic rest are covered in article. As showed researches, the content of flavonoids as indicator of accumulation of secondary metabolites, though have no crucial importance in the course of complex adaptation, however they are an indicator of biochemical transformations and balance of processes of changes in specific ecological conditions and reflect information about the preadaptation processes of acclimatization of plants in the conditions of an introduction.

Key words: *Asimina triloba*, pawpaw, flavonoids, overground organs, Northern Forest-Steppe of Ukraine, Southern Steppe of Ukraine.

Asimina triloba (L.) Dunal (pawpaw) — a species that is native to the eastern part of United States. It belongs to the big tropical family *Annonaceae* Juss. Of the 130 genera within the *Annonaceae* family, only the genus *Asimina* grows in the temperate climate zone. All other genera grow in the tropical region. *Asimina triloba* — the only species of genera, which spread to 43° north longitude (Ontario, Canada). It is stability to frosts — temperature to minus 25—30 °C, more stability, than apricot, peach and other south plants [10].

The pawpaw is the largest tree fruit native to the United States. This fruit, known commonly as the “poor man’s banana”, may reach up to 1 kg in weight. Pawpaw is the only temperate member of the *Annonaceae* family, which includes several delicious tropical fruits [9].

The North American pawpaw is a deciduous tree with ornamental value and it has qualities as a fruit crop. Pawpaw historically is harvested in the wild and it is being cultivated as an orchard crop in

several states of North America. It may be very commercially important as valuable food and medicinal plant.

Pawpaw has tremendous potential as a new fruit crop because of its:

- 1) adaptation to existing climatic and edaphic conditions;
- 2) nutritional and cosmetic value of the fruit;
- 3) valuable natural compounds;
- 4) nursery wholesale and retail tree production;
- 5) use as a component in manmade “edible” landscapes.

Pawpaw trees may be used for restoration of habitats and biodiversity in parks, wood lots, and forests. Aromas may be used commercially in cosmetics and skin products. Pawpaw plants produce natural compounds (annonaceous acetogenins) in leaf, bark, and shoot tissues that possess both highly antitumor and pesticidal properties. With proper management, organic commercial fruit production may be possible.

In Ukraine it is a new fruit plant, in spite of it was introduced in 1816 year, but it hasn't received

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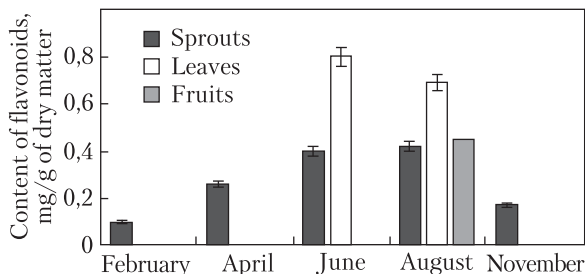


Fig. 1. The total content of flavonoids in sprouts, leaves and fruits of plants of *Asimina triloba* (L.) Dunal, Novokakhovchanka cultivar (Southern Steppe of Ukraine)

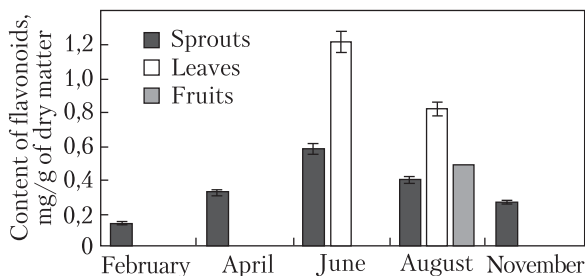


Fig. 2. The total content of flavonoids in sprouts, leaves and fruits of plants of *Asimina triloba* (L.) Dunal, Michurinka cultivar (Southern Steppe of Ukraine)

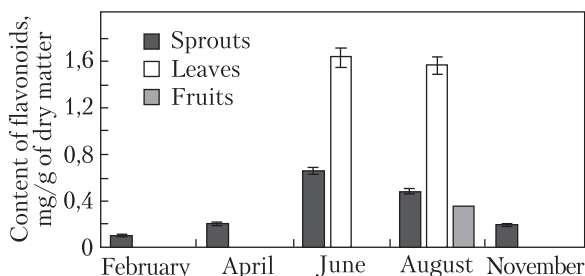


Fig. 3. The total content of flavonoids in sprouts, leaves and fruits of plants of *Asimina triloba* (L.) Dunal, form No. 21 (Southern Steppe of Ukraine)

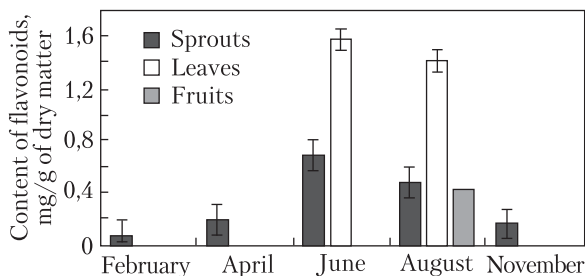


Fig. 4. The total content of flavonoids in sprouts, leaves and fruits of plants of *Asimina triloba* (L.) Dunal, form No. 3 (Southern Steppe of Ukraine)

large spread. In experimental farm “Novokakhovskoe” in Kherson (filiation of Nikitskiy Botanical Garden until 2014 year) collected the biggest collection of *Asimina triloba* in Ukraine, which is based on cultivars of pawpaw of American selection. These cultivars were brought to Ukraine in 1994–1995 years.

To M.M. Gryshko National Botanical Garden (NBG) of the NAS of Ukraine (in Kyiv) pawpaw was introduced in 1993 year from state Oregon. The plants bears fruit every year from 2005 year, they were adapted in Forest Steppe so as in Southern Steppe of Ukraine. Now, thanks our researches the culture of *Asimina* is reborn.

Now *Asimina triloba* occasionally grows in Kherson, Nikolaev, Odessa, Zaporozhye, Dnepropetrovsk, Kharkov, Kyiv region and Kyiv. The pawpaw fruit is oblong in shape, 10–15 cm long, 5–10 cm wide and weights 250–400 g.

The fruit grows singly or in clusters like bananas. The inedible skin turns from green to green-yellow as the fruit ripens. The edible flesh has color from creamy white to yellow. The harvest season of pawpaw fruits in Kyiv is an August to September – mid October [6].

The pawpaw tree contains more than 50 bioactive components, primarily annonaceous acetogenins. Some therapeutic activities have been associated with this material, but the potential to mediate a cancer chemopreventive effect has not been reported.

This plant contains annonaceous acetogenins in the twigs, unripe fruit, seeds, roots and bark tissues, which display antitumor, pesticidal, antimalarial, anthelmintic, antiviral and antimicrobial effects, suggesting many potentially useful applications [12].

Seeds contain alkaloids in the endosperm that are emetic. If chewed, seed poisons may impair mammalian digestion, but if swallowed whole, seeds may pass through the digestive tract intact.

Asimina triloba is a tree fruit in the early stages of commercial production in the United States. It is may be very commercially important as valuable food and medicinal plant, it is perspective for grow in orchards.

Flavonoids are big group of compounds of a secondary metabolism of the phenolic nature.

Flavonoids are rather widespread in flora. They contain both in generative, and in vegetative organs of plants, some of them cause different coloring of flowers, fruits, leaves and sprouts [2, 7]. Variety of flavonoids defines their polyfunctionality — they take part in many vital processes of a vegetable organism [5]. In literature there are data on participation of flavonoids in reproductive processes, in particular they influence pollen germination, process of blossoming [8]. An important role flavonoids, along with other phenolic compounds, play in immunity of plants.

The purpose of our work — to determinate the total content of flavonoids in sprouts, fruits and leaves of different cultivars and forms to a pawpaw during the different periods of vegetation in the conditions of the Northern Forest-Steppe and Southern Steppe of Ukraine.

Objects and methods

Cultivars of *Asimina triloba* Novokakhovchanka, Michurinka; forms No. 21, 2, 7 and No. 3 were objects of researches.

Material for the analysis was selected during the periods of an output of plants from a dormant state, the active growth, blossoming, fructification and preparation for winter.

For a qualitative analysis of flavonoids we used the technique based on them capability to form the colored complex with alcoholic solution of aluminum of chloride which causes bathochromic shift of a long-wave adsorbing band and thus gives the main maximum of absorption at the wavelength of 400 nm [1].

Results and discussion

Laboratory researches were conducted based on department of acclimatization of fruit plants of M.M. Gryshko NBG of the NAS of Ukraine in Kyiv.

In the analysis of histograms of dynamics of accumulation of flavonoids in sprouts of *Asimina triloba* distinction in the content of flavonoids in the forms, growing in the Northern Forest-Steppe of Ukraine and the Southern Steppe of Ukraine is visible (Fig. 1—5). Dynamics of flavonoids content in sprouts to a pawpaw, which grow in the Southern Steppe of Ukraine, has more noticeable

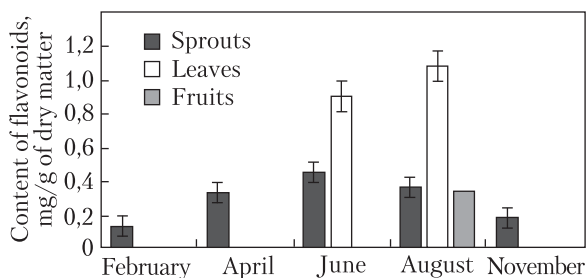


Fig. 5. The total content of flavonoids in sprouts, leaves and fruits of plants of *Asimina triloba* (L.) Dunal, form No. 2 (Northern Forest-Steppe of Ukraine)

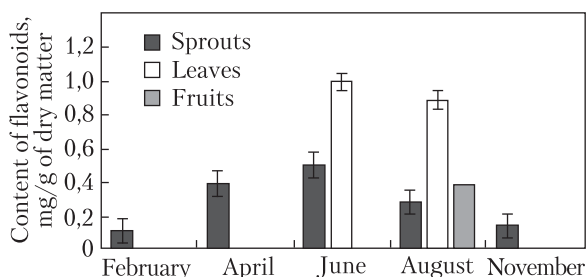


Fig. 6. The total content of flavonoids in sprouts, leaves and fruits of plants of *Asimina triloba* (L.) Dunal, form No. 7 (Northern Forest-Steppe of Ukraine)

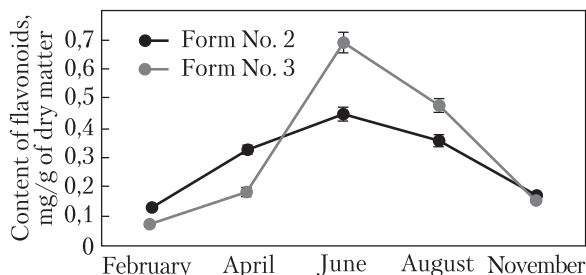


Fig. 7. The comparative content of flavonoids in sprouts of plants of *Asimina triloba* (L.) Dunal, form No. 2 (Northern Forest-Steppe of Ukraine) and form No. 3 (Southern Steppe of Ukraine)

degree of curvature, with a maximum in summer months, than those, which grow in the Northern Forest-Steppe of Ukraine (Fig. 6, 7).

This feature can possibly be considered as adaptive strategy of a type when in a vegetable organism the additional quantity of flavonoids for absorption of surplus of solar radiation which quantity increases with lowering of geographic latitude, that is from the North by the South is synthesized.

From the given drawings it is visible that the total content of flavonoids in sprouts of various cultivars and forms of a pawpaw, during the different periods of vegetation significantly differs. In all cases the pronounced maximum of flavonoids content during flowering time is traced. It can serve confirmations of protective function of flavonoids in a pawpaw.

The highest flavonoids content was observed in plants of Michurinka cultivar. It should be noted that flavonoids content in leaves of a pawpaw significantly exceeds their amount in sprouts — by 2.5—3.0 times.

Conclusion

Though the contents of flavonoids as an indicator of a secondary exchange has no crucial importance in complex process of adaptation, it can be considered as display of biochemical conversions and balance of processes of an exchange in specific ecological conditions, and gives the chance of tentative estimation of prospects of acclimatization of plants at an introduction.

1. Азиміна трилопатева (*Asimina triloba* (L.) Dunal): біохімічний склад і перспективи використання як лікарської рослини / О.А. Грабовецька, С.В. Клименко, В.М. Дерев'янка та ін. // Матеріали міжнар. наук.-практ. конф. «Довкілля і здоров'я людини». — Ужгород, 2008. — С. 370—373.
2. Андреева В.Ю. Разработка методики количественного определения флавоноидов в манжетке обыкновенной (*Alchemilla vulgaris* L. s. l.) / В.Ю. Андреева, Г.И. Калинкина // Химия растительного сырья. — 2000. — № 1. — С. 85—88.
3. Блажей А.С. Фенольные соединения растительного происхождения / А.С. Блажей, Л.П. Шутый. — М.: Мир, 1977. — 239 с.
4. Грабовецька О.А. Азиміна трилопатева (*Asimina triloba* (L.) Dunal) в Степу України: інтродукція, біологія, репродукція : Автореф. дис. ... канд. біол. наук / О.А. Грабовецька. — К., 2011. — 21 с.
5. Запрометов М.Н. Фенольные соединения и их биологические функции / М.Н. Запрометов. — М.: Наука, 1971. — 185 с.
6. Клименко С.В. Азимина во всех ипостасях / С.В. Клименко // Огородник. — 2012. — № 3. — С. 38—40.
7. Клышев Л.К. Флавоноиды растений / Л.К. Клышев, В.А. Бандюкова, Л.С. Алюкина. — Алма-Ата : Наука, 1978. — 220 с.

8. Минаева В.Г. Флавоноиды в онтогенезе растений и их практическое использование / В.Г. Минаева. — Новосибирск : Наука, 1978. — 255 с.
9. Bailey L.H. The standard cyclopedia of horticulture / L.H. Bailey. — New York : MacMillan, 1947. — Vol. 1. — 1200 p.
10. Darrow G.M. Minor temperate fruit / G.M. Darrow // Advances in fruit breeding. [J. Janick and J.N. Moore (eds.)]. — West Lafayette: Purdue Univ. Press, 1975. — P. 276—277.
11. Layne D.R. The pawpaw *Asimina triloba* (L.) Dunal: A new fruit crop for Kentucky and the United States / D.R. Layne // Hort Science. — 1996. — Vol. 31. — P. 777—784.
12. Pomper K. Identification of annonaceous acetogenins in the ripe fruit of the North American pawpaw (*Asimina triloba*) // K. Pomper, J. Lowe, S. Crabtree, W. Keller // Journal of Agricultural and Food Chemistry. — 2009. — Vol. 57. — P. 8339—8343.

REFERENCES

1. Grabovecka, O.A., Klymenko, S.V., Derevjanko, V.M. et al. (2008), *Azymina trylopateva (Asimina triloba* (L.) Dunal): biohimichnyj sklad i perspektyvy vykorystannja jak likarskoi roslyny [Biochemical composition and perspectives of use as a medicinal plant]. Materialy mizhnar. nauk.-prakt. konf. "Dovkillja i zdorovja lju-dynu" [Proceedings of International scientific and practical conference "Environment and health of human"]. Uzhhorod, pp. 370—373.
2. Andreeva, V.Ju. and Kalinkina, G.I. (2000), *Razrabotka metodiki kolichestvennoho opredelenija flavonoidov v manzhetke obyknovnohoj Alchemilla vulgaris* L. s. l. [The developing of methods of quantitative determination of flavonoids of lady's mantle (*Alchemilla vulgaris* L. s. l.)]. Himija rastitelnogo syrja [The chemistry of plant raw materials], N 1, pp. 85—88.
3. Blazhej, A.S. and Shutyj, L.P. (1977), *Fenolnye soedinenija rastitelnogo proishozhdenija* [Phenolic compounds of plant origin]. Moskva, Mir, 239 p.
4. Grabovecka, O.A. (2011), *Azymina trylopateva (Asimina triloba* (L.) Dunal) v Stepu Ukrayiny: introdukcija, biologija, reprodukcija. Avtoref. dys.... kand. biol. nauk [The pawpaw (*Asimina triloba* (L.) Dunal) in the Steppe of Ukraine : introduction, biology, reproduction]. Kyiv, 21 p.
5. Zaprometov, M.N. (1971), *Fenolnye soedinenija i ih biologicheskie funkciony* [The phenolic compounds and their biological functions]. Moskva, Nauka, 185 p.
6. Klimenko, S.V. (2012), *Azymina vo vseh ipostasjakh* [The pawpaw of all guises]. Ogorodnik [Gardener], N 3, pp. 38—40.
7. Klyshev, L.K., Bandjukova, V.A., and Aljukina, L.S. (1978), *Flavonoidy rastenij* [The flavonoids of plants]. Alma-Ata, Nauka, 220 p.

8. *Minaeva, V.G.* (1978), Flavonoidy v ontogeneze rastenij i ih prakticheskoe ispolzovanie [The flavonoids in plant ontogenesis and their practical use]. Novosibirsk, Nauka, 255 p.
9. *Bailey, L.H.* (1947), The standard cyclopedia of horticulture. New York, MacMillan, vol. 1, 1200 p.
10. *Darrow, G.M.* (1975), Minor temperate fruit. In: J. Janick and J.N. Moore (eds.). Advances in fruit breeding. West Lafayette, Purdue Univ. Press, pp. 276—277.
11. *Layne, D.R.* (1996), The pawpaw *Asimina triloba* (L.) Dunal: A new fruit crop for Kentucky and the United States. Hort Science, vol. 31, pp. 777—784.
12. *Pomper, K., Lowe, J., Crabtree, S. and Keller, W.* (2009), Identification of annonaceous acetogenins in the ripe fruit of the North American pawpaw (*Asimina triloba*). Journal of Agricultural and Food Chemistry, vol. 57, pp. 8339—8343.

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ДИНАМІКА ВМІСТУ ФЛАВОНОЇДІВ У НАДЗЕМНИХ ОРГАНАХ СОРТІВ І ФОРМ *ASIMINA TRILOBA* (L.) DUNAL

Азими́на трилопатева (*Asimina triloba* (L.) Dunal) — нова рослина, інтродукована з Північної Америки у різні регіони України. Азими́ну широко вирощують у багатьох країнах Європи як цінну харчову, лікарську і декоративну рослину. В умовах інтродукції в Україні адаптаційні властивості азими́ни на біохімічному рівні не досліджено. Одним з важливих показників адаптації рослин є накопичення флавоноїдів, вторинних метаболітів фенольної природи. Флавоноїди виявляють поліфункціональну дію у рослинах, беручи участь у багатьох процесах життєдіяльності, відіграють важливу роль у процесах формування репродуктивних органів та імунітету рослин. Наведено результати дослідження динаміки накопичення флавоноїдів у культиварів та форм азими́ни на півдні та півночі України на етапах найважливіших процесів життєдіяльності — у період активного росту, цвітіння, досягання плодів під час підготовки і переходу рослин до органічного спокою. Встановлено, що вміст флавоноїдів, як інди-

катор накопичення вторинних метаболітів, хоч і не має вирішального значення у процесі комплексної адаптації, але є показником біохімічних перетворень у специфічних екологічних умовах, преадаптаційних процесів акліматизації рослин в умовах інтродукції.

Ключові слова: *Asimina triloba*, азими́на, флавоноїди, надземні органи, Північний Лісостеп України, Південний Степ України.

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ДИНАМИКА СОДЕРЖАНИЯ ФЛАВОНОИДОВ В НАДЗЕМНЫХ ОРГАНАХ СОРТОВ И ФОРМ *ASIMINA TRILOBA* (L.) DUNAL

Азими́на трехлопастная (*Asimina triloba* (L.) Dunal) — новое растение, интродуцированное из Северной Америки в разные регионы Украины. Азими́ну широко культивируют во многих странах Европы как ценное пищевое, лекарственное и декоративное растение. В условиях интродукции в Украине адаптационные свойства азими́ны на биохимическом уровне не изучены. Одним из важных показателей адаптации растений является накопление флавоноидов, вторичных метаболитов фенольной природы. Флавоноиды проявляют полифункциональное действие в растениях, участвуя во многих процессах жизнедеятельности, играют важную роль в процессах формирования репродуктивных органов и иммунитета растений. Приведены результаты исследования динамики накопления флавоноидов у культиваров и форм азими́ны на юге и севере Украины на этапах важнейших процессов жизнедеятельности — в период активного роста, цветения, созревания плодов, во время подготовки растений к органическому покою. Установлено, что содержание флавоноидов как индикатор накопления вторичных метаболитов, хотя и не имеет решающего значения в процессе комплексной адаптации, однако является показателем биохимических преобразований в специфических экологических условиях, преадаптационных процессов акклиматизации растений в условиях интродукции.

Ключевые слова: *Asimina triloba*, азими́на, флавоноиды, надземные органы, Северная Лесостепь Украины, Южная Степь Украины.