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ANTIOXIDANT POTENTIAL OF SOME PLANTS OF *BRASSICACEAE* BURNETT AND *POACEAE* BARNHART.

Objective *— to estimate the antiradical scavenging ability of extracts of some plants of Brassicaceae Burnett and Poaceae Barnhart. species, to evaluate the total antioxidant activity of plants in the conditions of M.M. Gryshko National Botanical Garden of the NAS of Ukraine.*

Material and methods. *Plant material of this investigation — species, varieties and cultivars of Brassicaceaae and Poaceae families: Brassica campestris f. annua D.C. (BCA), B. campestris f. biennis D.C.× B. napus f. biennis D.C., cv. Innovatsiia (BCBNI), B. campestris f. biennis D.C. × B. rapa L. × B. napus f. biennis D.C. (BCBRBN), B. juncea (L.) Czern. (BJ), B. juncea (L.) Czern. f. biennis, cv. Annushka (BJA), B. napus f. biennis D.C., f. EROF-5 (BNE-5), B. rapa L. (BR), B. rapa subsp. rapifera Metzger (BRR), Raphanus sativus L. var. oleiformis Pers. (RSO), Miscanthus sacchariflorus (Maxim.) Benth., cv. Snihopad (MSS), M. sinensis Anderss. f. ESBMK-6 (MSE-6), Panicum virgatum L. f. PB (PVPB), P. virgatum L. f. PL (PVPL), Sorghum bicolor (L.) Moench. f. ETSSDF-11 (SBE-11), S. nigrum Roemer & Schultes f. ETSSCHF-1 (SNE-1), S. saccharatum (L.) Moench. cv. Medove (SSM), S. sudanense (Piper) Stapf (SS), S. technicum (Koern.) Bait. et Trab. (ST). The antioxidant activity of methanol and aqueous extracts based on the discoloration reaction on the solution of DPPH (2,2-diphenyl-1-picrylhydrazyl free radical) was determined according to Brandt-Williams et al. The determination of content of ascorbic acid was conducted according to V.P. Krishchenko, the content of carotene — according to B.P. Pleshkov.*

Results. *The antioxidant activity of methanol extracts of plants of Brassicaceae was registered in the range from 16.94±0.15 (BCA) to 36.91 ± 0.26 (BRR) % and aqueous extracts — from 26.53 ± 0.34 (BJ) to 65.85 ± 0.30 (RSO) %. This parameter for methanol extracts of Poaceae species was in range from 31.13 ± 0.32 (MSE-6) to 86.48 ± 0.49 (SNE-1) % and aqueous extracts — from 33.10 ± 0.47 (ST) to 83.14 ± 0.46 (PVPB) %. It was determined concentration of ascorbic acid from 118.67 ± 9.90 (BJA) to 566.61 ± 38.37 (BNE-5) mg% and carotene — from 0.48 ± 0.01 (BJA) to 3.11 ± 0.07 (BJ) mg% for Brassicaceae plants. Content of ascorbic acid in range from 11.80 ± 0.85 (PVPB) to 77.39 ± 1.29 (SS) mg% and carotene — from 0.05 ± 0.00 (PVPB) to 0.62 ± 0.02 (PVPL) mg% was identified for Poaceae plants.*

Conclusions. *This study showed that plant raw material of investigated plants is a valuable source of antioxidants and vitamins. Methanol and water extracts of plants of Poaceae had higher antiradical activity against DPPH radical than extracts of plants of Brassicaceae. The higher level of ascorbic acid and carotene was observed in extracts of plants of Brassicaceae. The minimal content of ascorbic acid and carotene found for BJA (Brassicaceae) and PVPB (Poaceae).*

Key words: *Brassicaceae*, *Poaceae*, antioxidant activity, 2,2-diphenyl-1-picrylhydrazyl (DPPH), ascorbic acid, carotene.

Antioxidants are compounds capable to either delay or inhibit the oxidation processes which occur under the influence of atmospheric oxygen or reactive oxygen species. They are used for the stabilization of polymeric products of petrochemicals, foodstuffs, cosmetics and pharmaceuticals [28]. In nature there are a wide variety of naturally occurring antioxidants which are different in their composition, physical and chemical properties, mechanisms and site of action. Some of the main categories can be described as follows: enzymes, high molecular weight compounds, low molecular weight compounds, minerals, vitamins etc. [21]. Antioxidants are involved in the defense mechanism of the organism against the pathologies associated with the attack of free radicals. The evaluation of the total antioxidant capacity may be an appropriate tool to determine the additive antioxidant properties of plant foods.

There is great number of methods for determination of antioxidant capacity of foods and beverages based on different principles. One of the most widespread methods of investigation of antioxidant activity is free radical scavenging activity with DPPH radical [24].

The *Brassicaceae* Burnett (*Cruciferae*) or mustard family includes many economically important

edible and industrial, oilseed, vegetable, condiment and fodder crop species. The most important edible oil crop is canola or oilseed rape (*Brassica napus)*; while mustard condiment crops include: *Brassica juncea* — Indian mustard and *Sinapis alba* — white mustard. Many *Brassica* species are also important vegetable crops, e.g., cole crops (*Brassica oleracea*). Several species, e.g., *Brassica carinata*, *Camelina sativa*, *Crambe abyssinica*, *Eruca vesicaria*, have potential as new edible oil/protein crops, biodiesel fuel crops, or platforms for bioproducts or molecular farming [35]. *Poaceae* Barnhart. that yield food and fodder are well known from times immemorial and considerable amount of research work has been carried on them. But the grasses that yield therapeutically important products are among the least studied in the *Poaceae* family. The species of *Poaceae* screened for phytochemical constituents seemed to have the potential to be source of useful drug compounds and also to improve the health status of the animals as a result of the presence of various components that are vital for good health. These can be incorporated in other foods as nutraceuticals for effective and proper metabolism as well as for the maintenance of good physiological state in man and animals [12].

The antioxidant properties of cultivated plants are usually well recognized. There is, however, little data about some species from *Brassicaceae* and *Poaceae*. Therefore further studies must be carried out.

Material and methods

Plant material was collected in M.M. Gryshko National Botanical Garden of the NAS of Ukraine. The species, cultivars and varieties of crop plants belonging to *Brassicaceae* (9 samples) and *Poaceae* (9 samples) family were used to investigate: *Brassica campestris* f. *annua* D.C. (BCA), *B. campestris* f. biennis D.C.× *B. napus* f. *biennis* D.C., cv. Innovatsiia (BCBNI), *B. campestris* f. *biennis* D.C. × × *B. rapa* L. × *B. napus* f. *biennis* D.C. (BCBRBN), *B. juncea* (L.) Czern. (BJ), *B. juncea* (L.) Czern. f. *biennis*, cv. Annushka (BJA), *B. napus* f. *biennis* D.C., f. EROF-5 (BNE-5), *B. rapa* L. (BR), *B. rapa* subsp. *rapifera* Metzger (BRR), *Raphanus sativus* L. var. *oleiformis* Pers. (RSO), *Miscanthus sacchariflorus* (Maxim.) Benth., cv. Snihopad (MSS), *M. sinensis* Anderss. f. ESBMK-6 (MSE-6), *Panicum virgatum* L. f. PB (PVPB), *P. virgatum* L. f. PL (PVPL), *Sorghum bicolor* (L.) Moench. f. ETSSDF-11 (SBE-11), *S. nigrum* Roemer & Schultes f. ETSSCHF-1 (SNE-1), *S. saccharatum* (L.) Moench. cv. Medove (SSM), *S. sudanense* (Piper) Stapf (SS), *S. technicum* (Koern.) Bait. et Trab. (ST).

Plant raw material collected from the experimental collections of Cultural Flora department of M.M. Gryshko National Botanical Garden of the NAS of Ukraine. All biochemical analyses were conducted using the above-ground part of plants in the stage of flowering (*Brassicaceae*) and seed ripening (*Poaceae*). To determine antioxidant activity of plants was investigated dried above-ground part of plants. Antioxidant capacity of the methanolic, ethanolic and aqueous extracts was determined according to Brand-Williams et al. (1995) against DPPH radical (2.2-diphenyl-1-picrylhydrazyl) [15]. This method based on reaction of radical discoloration. The procedure of determination of optical density measured with 2800 UV/VIS Spectrophotometer, UNICO at wavelength 515 nm. Dry mass (1 g) of investigated plants mixed with 25 ml of solvent. Extraction was carried out with methanol and water during 12 hours with constant stirring on shaker. 0.1 ml of antioxidant solution was added to 3.9 ml of methanol DPPH· solution (25 mg of radical per 100 ml of methanol with further delution). Absorbance of radical solution was in range 0.700—0.800. Optical density of the solution was measured after adding sample immediately and after 10 min of incubation in the dark. Obtained results were calculated in percentage by using formula: $(A_0—A_{10})/A_0 \cdot 100$ (A_0 — absorbance of the control solution (containing only DPPH•); A_{10} — absorbance in the presence of the plant extract in DPPH• solution).

The content of ascorbic acid determined according to V.P. Krishchenko [2]. The concentration of ascorbic acid (AA) of the acid extracts determined by a 2.6-dichlorophenol-indophenol method that based on the reduction properties of AA. The content of carotene determined according to B.P. Pleshkov [3]. The procedure carried out in petrol extracts by spectrophotometric method

using 2800 UV/VIS Spectrophotometer, Unico. Mixtures were left in a shaker for 2 hours and their absorbance was measured at the wave length of 440 nm. Mean values of three replicates and standard deviations are given in Table 1-4. Experimental data were evaluated by using Excel 2010.

Results and discussions

The genus *Brassica* L. is the most important one within the *Brassicaceae*, which includes some crops and species of great worldwide economic importance and medical such as *Brassica juncea* L., *B. oleracea* L., *B. napus* L. and *B. rapa* L. [8, 20, 23]. *Brassica* foods are very nutritive, providing nutrients and health-promoting phytochemicals such as vitamins, carotenoids, fiber, soluble sugars, minerals, glucosinolates and phenolic compounds [26, 29]. Cruciferous vegetables are relatively abundant sources of antioxidant substances with potential anticarcinogenic and antimicrobial activity [6, 14, 16, 17, 18, 30].

As shown in Table 1 the methanol extracts of investigated plants of *Brassicaceae* have antioxidant ability from 16.94 (BCA) to 36.91 (BRR) %. We also measured the antioxidant activity of water extracts. Results of investigation showed that water extracts of these plants inhibited radical solution in range from 26.53 (BJ) to 65.85 (RSO) %.

As reported Kucukboyaci et al. (2012), species of genus *Raphanus* is good candidates for a rich

Table 1. **The total antioxidant activity of some crop plants of *Brassicaceae* Burnett.**

Species, forms and variety	Short name	% of inhibition of	
		methanol extract	water extract
Brassica campestris f. *annua* D.C.	BCA	16.94 ± 0.15	37.41 ± 0.50
Brassica campestris f. *biennis* D.C.× *B. napus* f. *biennis* D.C., cv. Innovatsiia	BCBNI	21.54 ± 0.22	50.62 ± 0.43
Brassica campestris f. *biennis* D.C. × *B. rapa* L. × × *B. napus* f. *biennis* D.C.	BCBRBN	25.01 ± 0.49	65.66 ± 0.20
B. juncea (L.) Czern.	BJ	19.16 ± 0.17	26.53 ± 0.34
B. juncea (L.) Czern. f. *biennis*, cv. Annushka	BJA	19.79 ± 0.05	54.19 ± 0.49
B. napus f. *biennis* D.C., f. EROF-5	BNE-5	30.83 ± 0.31	60.79 ± 0.69
B. rapa L.	BR	19.86 ± 0.29	62.96 ± 0.43
B. rapa subsp. *rapifera* Metzger	BRR	36.91 ± 0.26	60.63 ± 0.55
Raphanus sativus L. var. *oleiformis* Pers.	RSO	21.01 ± 0.23	65.85 ± 0.30

Table 2. **The total antioxidant activity of some crop plants of *Poaceae* Barnhart.**

Species, forms and variety	Short name	% of inhibition of	
		methanol extract	water extract
Miscanthus sacchariflorus (Maxim.) Benth., cv. Snihopad	MSS	39.43 ± 0.46	59.09 ± 0.11
M. sinensis Anderss., f. ESBMK-6	MSE-6	31.13 ± 0.32	45.38 ± 0.22
Panicum virgatum L., f. PB	PVPB	40.81 ± 0.08	83.14 ± 0.46
P. virgatum L. f. PL	PVPL	35.80 ± 0.31	40.16 ± 0.45
Sorghum bicolor (L.) Moench, f. ETSSDF-11	SBE-11	64.31 ± 0.27	57.37 ± 0.47
S. nigrum Roemer & Schultes, f. ETSSCHF-1	SNE-1	86.48 ± 0.49	64.13 ± 0.54
S. saccharatum (L.) Moench, cv. Medove	SSM	31.34 ± 0.27	39.40 ± 0.28
Sorghum sudanense (Piper) Stapf	SS	74.11 ± 0.54	42.24 ± 0.42
S. technicum (Koern.) Bait. et Trab	ST	34.44 ± 0.20	33.10 ± 0.47

source of natural antioxidants and minerals [10]. As reported Borc et al. (2015), the same species has an antioxidant capacity of 12.0—75.0 % depending on variety [33]. According to Agarwal and Varma (2014), aqueous extracts of plants of *Raphanus sativus* have a potent antioxidant ability of 78.17 % [7]. Some results showed the radical inhibition of extracts of these plants of 18.70 % [22]. When comparing these results with those obtained from given literature in the same assay for *B. rapa*, it could be noticed that plant extracts of turnip exhibits high antioxidant capacity up to 72 % [27]. Also, Beltagi (2014) obtained data that different organs extracted by different solvents showed the antiradical activity by DPPH-method in range from 11.11 to 84.75 % [13]. Our previous data concerning antioxidant activity of representatives of *Brassicaceae* showed that plant raw material of *Camelina sativa* (L.) Crantz has antioxidant scavenging ability of 25.67—55.88 % in methanol extracts and 47.18—84.60 % in water extracts [1].

Species of genus *Miscanthus*, *Panicum* and *Sorghum* are economically, energetically and ecologically viable energy crop. These plants have high biomass productivity, high input use efficiency, broad geographic adaptability, low environmental risk, and low production cost [25, 31].

Our results showed that methanol extracts of plants of *Poaceae* family were in range from 31.13 (MSE-6) to 86.48 (SNE-1) % (Table 2). Water extracts showed percentage of inhibition from 33.10 (ST) to 83.14 (PVPB) %.

As reported Balcerek et al. (2009), methanol extracts of *M. sinensis* characterized by radical scavenging activity of 27.00 % [9]. In our experiment it was by registered more than 4 %. Devi et

Table 3. **The total content of ascorbic acid and carotene in above-ground part of plants of *Brassicaceae* Burnett.**

Species, forms and variety	Short name	Ascorbic acid, mg%	Carotene, mg%
Brassica campestris f. *annua* D.C.	BCA	353.86 ± 14.75	1.77 ± 0.03
Brassica campestris f. *biennis* D.C.× *B. napus* f. biennis D.C., cv. Innovatsiia	BCBNI	549.56 ± 33.81	1.93 ± 0.07
Brassica campestris f. *biennis* D.C. × *B. rapa* L. × × *B. napus* f. *biennis* D.C.	BCBRBN	383.97 ± 27.33	2.73 ± 0.11
B. juncea (L.) Czern.	BJ	563.51 ± 28.33	3.11 ± 0.07
B. juncea (L.) Czern. f. *biennis*, cv. Annushka	BJA	118.67 ± 9.90	0.48 ± 0.01
B. napus f. *biennis* D.C., f. EROF-5	BNE-5	566.61 ± 38.37	2.74 ± 0.09
B. rapa L.	BR	460.96 ± 5.76	1.73 ± 0.27
B. rapa subsp. *rapifera* Metzger	BRR	290.09 ± 17.23	2.47 ± 0.11
Raphanus sativus L. var. *oleiformis* Pers.	RSO	187.07 ± 14.27	3.05 ± 0.21

Table 4. **The total content of ascorbic acid and carotene in above-ground part of plants of *Poaceae* Barnhart.**

Species, forms and variety	Short name	Ascorbic acid, mg%	Carotene, mg%
Miscanthus sacchariflorus (Maxim.) Benth., cv. Snihopad	MSS	13.64 ± 0.72	0.16 ± 0.02
M. sinensis Anderss., f. ESBMK-6	MSE-6	17.16 ± 1.24	0.17 ± 0.01
Panicum virgatum L., f. PB	PVPB	11.80 ± 0.85	0.05 ± 0.00
P. virgatum L. f. PL	PVPL	13.94 ± 1.27	0.62 ± 0.02
Sorghum bicolor (L.) Moench, f. ETSSDF-11	SBE-11	35.12 ± 0.77	0.31 ± 0.05
S. nigrum Roemer & Schultes, f. ETSSCHF-1	SNE-1	33.86 ± 1.26	0.33 ± 0.05
S. saccharatum (L.) Moench, cv. Medove	SSM	22.98 ± 1.08	0.26 ± 0.02
S. sudanense (Piper) Stapf	SS	77.39 ± 1.29	0.39 ± 0.08
S. technicum (Koern.) Bait. et Trab	ST	26.63 ± 0.80	0.30 ± 0.06

al. (2012) identified that samples of red sorghum bran extracted in acidified methanol had significantly higher antioxidant activity than those extracted in methanol. This implies that the acidified methanol is a more powerful solvent than methanol in extracting red sorghum antioxidants (scavenging effect was up to 95.0 %) [19].

Vitamin A and C are the popular antioxidants, which play a crucial role in preventing peroxidation damage in the biological system [21]. Ascorbic acid is an antioxidant with therapeutic properties, which plays a key role in activating the immune response, wound healing, osteogenesis, detoxifying the organism, iron absorption, collagen biosynthesis, preventing the clotting of blood vessels, and many other metabolic processes [28].

The results demonstrated the accumulation of ascorbic acid in *Brassicaceae* plants in range from 118.67 (BJA) to 566.61 (BNE-5) mg% (Table 3).

Some results showed that content of vitamin C (measured as ascorbic acid and dehydroascorbic acid) of *Brassicaceae* leaves ranges among 64—104 mg per 100 g per fresh weight [5]. According to Singh et al. (2007), investigated *Brassica* vegetables have maximum mean of ascorbic acid content of 52.9 mg%, our samples showed higher results [34]. Acikgoz (2016) detected the content of ascorbic acid in *Brassica rapa* L. subsp. *chinensis* L. was 44.27 mg% in late autumn period [4].

Carotenoids such as α- and β-carotene present in dark green leafy vegetables of *Brassicaceae* might be involved in the prevention of several diseases related to oxidative stress [11]. Carotenoids are efficient antioxidants protecting plants against oxidative damage. Vitamin C, for instance, the most powerful water-soluble antioxidant in human blood plasma acts as regenerator for vitamin E in lipid system [32].

We determined that content of total carotene in above-ground part of investigated plants was from 0.48 (BJA) to 3.11 (BJ) mg% (Table 3). As reported Singh et al. (2007), it was found content of carotene from 0.01 to 0.81 mg% for different *Brassica* vegetables [34].

The content of vitamins in *Miscanthus*, *Panicum* and *Sorghum* species were analyzed (Table 4). The represented data revealed that concentration of ascorbic acid ranged from 11.80 (PVPB) to 77.39 (SS) mg%. Content of carotene in investigated samples wasn't high but ranged from 0.05 (PVPB) to 0.62 (PVPL) mg%.

Conclusions

From the results of this study it can be concluded that plants from families *Brassicaceae* and *Poaceae* are important source of antioxidants and vitamins such as ascorbic acid and carotene. Experiment showed that methanol and aqueous extracts of plants of *Poaceae* (up to 80 %) had significantly higher antiradical activity then the one of *Brassicaceae* (up to 35 % and 65 % respectively). Better result of antioxidant capacity showed plant extracts of BRR and SNE-1 in methanol solvent and RSO and PVPB — in aqueous. It should be noted that for plants BJA (*Brassicaceae*) and PVPB (*Poaceae*) the content of ascorbic acid and carotene was minimal.

1. *Біохімічна* характеристика сировини *Camelina sativa* (L.) Crantz / О.М. Вергун, Д.Б. Рахметов, О.В. Шиманська [та ін.] // Інтродукція рослин. — 2017. — № 2 (74). — С. 80—89.
2. *Крищенко В.П.* Методы оценки качества растительной продукции / В.П. Крищенко. — М.: Колос, 1983. — 192 с.
3. *Плешков Б.П.* Практикум по биохимии растений / Б.П. Плешков. — М.: Колос, 1985. — 256 с.
4. *Acikgoz F.E.* Seasonal variations on quality parameters of Pak Choi (*Brassica rapa* L. subsp. *chinensis* L.) / F.E. Acikgoz // Advances in Crop Science and Technology. — 2016. — Vol. 4, N 4. doi: 10.4172/2329-8863.1000233
5. *A comparative* study of flavonoid compounds, vitamin C, and antioxidant properties of baby leaf *Brassicaceae* species / A. Martinez-Sanchez, A. Gil-Izquierdo, M.I. Gil, F. Ferreres // Journal of Agricultural and Food Chemistry. — 2008. — Vol. 56. — P. 2330—2340.
6. *A comparative* study of phytochemical analyses and in vitro antimicrobial activity of three important vegetables from *Brassicaceae* family / M.S. Prasad, S. Joshi, K. Narendra [et al.] // International Journal of Research in Ayurveda and Pharmacy. — 2015. — Vol. 6, N 6. — P. 767—772. doi: 10.7897/2277-4343.066143
7. *Agarwal K.* Radical scavenging ability and biochemical screening of a common asian vegetable — *Raphanus sativus* L. / K. Agarwal, R. Varma // International Journal Pharmaceutical Sciences Review and Research. — 2014. — Vol. 27, N 1. — Article No. 23. — P. 127—134.

8. *Anitha T.* Studies on in vitro antioxidant properties of *Brassica* vegetables / T. Anitha, R. Divya dharsini // International Journal of Pharmaceutical, Chemical and Biological Sciences. — 2014. — Vol. 4, N 4. — P. 1061—1065.
9. *Antioxidant* activity and total phenolic compounds in extracts of selected grasses (Poaceae) / M. Balcerek, I. Rak, G. Majtkowska, W. Majtkowski // Herba Polonica. — 2009. — Vol. 55, N 3. — P. 14—21.
10. *Antioxidant* activity total phenolic content of aqueous extract from *Raphanus raphanistrum* L. / N. Kucukboyci, A. Guvenc, N. N. Turan, A. Aydin // Turkey Journal of Pharmaceutical Sciences. — 2012. — Vol. 9, N 1. — P. 93—100.
11. *Antioxidant* properties of *Brassica* vegetables / P. Soengas, T. Sotelo, P. Velasco, M.E. Cartea // Functional Plant Science and Biotechnology. — 2011. — Vol. 5, N 2. — P. 43—55.
12. *Babu R.* Phytochemical screening of underutilized species of *Poaceae* / R. H. Babu, N. Savithramma // Journal of Pharmacy Reaserch: BioMedRx. — 2013. — Vol. 1, N 10. — P. 947—951.
13. *Beltagy A.M.* Investigation of new antimicrobial and antioxidant activities of *Brassica rapa* L. / A.M. Beltagy // International Journal of Pharmacy and Pharmaceutical Sciences. — 2014. — Vol. 6, N 6. — P. 84—88.
14. *Bioactive* compounds content and total antioxidant activity of two savoy cabbages / A.M. Fernandez-Leon, M. Lozano, D. Gonzales [et al.] // Czech Journal of Food Sciences. — 2014. — Vol. 32, N 6. — P. 549—554.
15. *Brand-Williams W.* Use of free radical method to evaluate antioxidant activity / W. Brand-Williams, M.E. Cuvelier, C. Berset // LWT — Food Science and Technology. — 1995. — Vol. 28, N 1. — P. 25—30.
16. *Chemical* and biological assays of *Brassica rapa* subsp. chinensis (L.) Hanelt / M. S. Rahman, N. Jahan, M. Khatun, M. A. Rashid // Bangladesh Journal of Botany. — 2015. — Vol. 44, N 2. — P. 327—332.
17. *Chemical* composition, antimicrobial and antioxidant properties of seed oil plants of North-East India: A review / P. Saha, A. D. Talukdar, S. Singh Ningthoujam [et al.] // TANG (Humanitas Medicine). — 2015. — Vol. 5, N 3. — P. 1—22. doi: http://dx.doi.org/ 10.5667/tang.2015.0010
18. *Devi J.R.* Studies on antioxidant and antimicrobial activities of purified sulforaphane from *Brassica oleraceae* var. rubra / J.R. Devi, E.B. Thangam // Journal of Pharmacy Research. — 2012. — Vol. 5, N 7. — P. 3582—3584.
19. *Devi P.S.* DNA damage protecting activity and free radical scavenging activity of anthocyanins from red sorghum (*Sorghum bicolor*) bran / P.S. Devi, M.S. Kumar, S.M. Das // Biotechnology Research International. — 2012. — Article ID 258787. doi:10.1155/2012/258787
20. *Hepatoprotective* effects from the leaf extracts of *Brassica juncea* in CCl_4 induced rat model / A. Walia, R. Malan, S. Saini [et al.] // Der Pharmacia Sinica. — 2011. — Vol. 2, N 4. — P. 274-285.
21. *Gupta V.K.* Plants as natural antioxidants / V.K. Gupta, S.K. Sharma // Natural Product Radiance. — 2006. — Vol. 5, N 4. — P. 326—334.
22. *Kim J.K.* Total phenolic and flavonoid contents and antioxidant activities of two *Raphanus sativus* L. cultivars (Cherry Belle and Valentine) / J.K. Kim, T.B. Baskar, S.U. Park // Biosciences Biotechnology Research Asia. — 2016. — Vol. 13, N 1. — P. 31—36. — http://dx.doi.org/10.13005/ bbra/1999
23. *Kwak Y.* Anti-cancer activities of *Brassica juncea* leaves in vitro / Y. Kwak, J. Lee, J. Ju // EXCLI Journal. — 2016. — Vol.15. — P. 699—710. — http://dx.doi.org/10.17179/excli2016-586
24. *Marinova G.* Evaluation of the methods for determination of the free radical scavenging activity by DPPH / G. Marinova, V. Batchvarov // Bulgarian Journal of Agricultural Science. — 2011. — Vol. 17, N 1. — P. 11—24.
25. *Miscanthus*: a fast-growing crop for biofuels and chemicals production / N. Brosse, A. Dufour, X. Meng [et al.] // Biofuels, Bioproducts and Biorefening. — 2012. doi: 10.1002/bbb
26. *Nahak* G. Antioxidant potential and nutritional values of vegetables: a review / G. Nahak, M. Suar, R.K. Sahu // Research Journal of Medicinal Plants. — 2014. — Vol. 8, N 2. — P. 50—81. doi: 10.3923/rjmp.2014.50.81
27. *Nutritional* facts and free radical scavenging activity of turnip (*Brassica rapa*) from Pakistan / M.K. Saeed, S. Anjum, I. Ahmad [et al.] // World Applied Sciences Journal. — 2012. — Vol. 19, N 3. — P. 370—375. doi: 10.5829/idosi.wasj.2012.19.03.691
28. *Pisoschi A.M.* Methods for Total Antioxidant Activity Determination: A Review / A. M. Pisoschi, G. P. Negulescu // Biochemistry and Analytical Biochemistry. — 2011. — Vol. 1, N 1. doi:10.4172/2161-1009.1000106
29. *Podsedek A.* Natural antioxidants and antioxidant capacity of Brassica vegetables: a review / A. Podsedek // LWT — Food Science and Technology. — 2007. — Vol. 40. — P. 1—11.
30. *Prasad M.P.* Antimicrobial potential of Brassicaceae family against clinical isolates / M.P. Prasad // International Journal of Pure and Applied Bioscience. — 2014. — Vol. 2, N 2. — P. 158—162.
31. *Soil* and variety effects on the energy and carbon balances of Switchgrass-derived ethanol / P. Woli, J.O. Paz, D. J. Lang [et al.] // Journal of Sustainable Bioenergy Systems. — 2012. — Vol. 2. — P. 65—74. — http://dx.doi.org/10.4236/jsbs.2012.24010
32. *Stahl W.* Antioxidant activity of carotenoids / W. Stahl, H. Sies // Molecular Aspects of Medicine. — 2003. — Vol. 24. — P. 345—351.

33. *Total* phenolic content and antioxidant capacity of Radish as influenced by the variety and vegetative Stage / M.D. Bors, C.A. Semeniuc, S. Socaci [et al.] // Bulletin UASVM Food Science and Technology. — 2015. — Vol. 72, N 1. — P. 77—81. doi 10.15835/buasvmcn-fst:11087
34. *Variability* of carotenes, vitamin C, E and phenolics in *Brassica* vegetables / J. Singh, A.K. Upadhyay, K. Prasad [et al.] // Journal of Food Composition and Analysis. — 2007. — Vol. 20. — P. 106—112.
35. *Warwick S.I.* Brassicaceae in Agriculture / S.I. Warwick // Genetics and Genomics of the *Brassicaceae*. Plant Genetics and Genomics: Crops and Models. — New York: Springer, 2011. — P. 33—65. — http://dx.doi.org/10.1007/978-1-4419-7118-0_2

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REFERENCES

1. *Vergun, O.M., Rakhmetov, D.B., Shymanska, O.V., Fishchenko, V.V., Druz, N.G. and Rakhmetova, S.O.* (2017), Biohimichna harakterystyka syrovyny *Camelina sativa* (L.) Crantz [Biochemical characteristic of plant raw material of *Camelina sativa* (L.) Crantz]. Introdukciya Roslyn [Plant Introduction], vol. 74, N 2, pp. 80—89.
2. *Krischenko, V.P.* (1983), Metody ocenki kachestva rastitelnoy produkcii [Methods for evaluating of quality of plant production]. Moscow: Kolos, 192 p.
3. *Pleshkov, B.P.* (1985), Prakticum po biohimii rasteniy [Plant biochemistry workshop]. Moscow: Kolos, 256 p.
4. *Acikgoz, F.E.* (2016), Seasonal variations on quality parameters of Pak Choi (*Brassica rapa* L. subsp. *chinensis* L.). Advances in Crop Science and Technology, vol. 4, N 4. doi: 10.4172/2329-8863.1000233
5. *Martinez-Sanchez, A., Gil-Izquierdo, A., Gil, M.I. and Ferreres, F.* (2008), *A comparative* study of flavonoid compounds, vitamin C, and antioxidant properties of baby leaf *Brassicaceae* species. Journal of Agricultural and Food Chemistry, vol. 56, pp. 2330—2340.
6. *Prasad, M.S., Joshi, S., Narendra, K., Nadiya, S.K., Masthani, S.K., Phani, N.P. and Satya, A.K.* (2015), A comparative study of phytochemical analyses and in vitro antimicrobial activity of three important vegetables from *Brassicaceae* family. International Journal of Research in Ayurveda and Pharmacy, vol. 6, N 6, pp. 767—772. doi: 10.7897/2277-4343.066143
7. *Agarwal, K. and Varma, R.* (2014), Radical scavenging ability and biochemical screening of a common asian vegetable — *Raphanus sativus* L. International Journal Pharmaceutical Sciences Review and Research, vol. 27, N 1, article N. 23, pp. 127—134.
8. *Anitha, T. and Divya dharsini, R.* (2014), Studies on in vitro antioxidant properties of *Brassica* vegetables. International Journal of Pharmaceutical, Chemical and Biological Sciences, vol. 4, N 4, pp. 1061—1065.
9. *Balcerek, M., Rak, I., Majtkowska, G. and Majtkowski, W.* (2009), Antioxidant activity and total phenolic compounds in extracts of selected grasses (*Poaceae*). Herba Polonica, vol. 55, N 3, pp. 14—21.
10. *Kucukboyci, N., Guvenc, A., Turan, N.N. and Aydin, A.* (2012), Antioxidant activity total phenolic content of aqueous extract from *Raphanus raphanistrum* L. Turkey Journal of Pharmaceutical Sciences, vol. 9, N 1, pp. 93—100.
11. *Soengas, P., Sotelo, T., Velasco, P. and Cartea, M.E.* (2011), Antioxidant properties of *Brassica* vegetables. Functional Plant Science and Biotechnology, vol. 5, N 2, pp. 43—55.
12. *Babu, R. and Savithramma, N.* (2013), Phytochemical screening of underutilized species of *Poaceae*. Journal of Pharmacy Reaserch: BioMedRx, vol. 1, N 10, pp. 947—951.
13. *Beltagy, A.M.* (2014), Investigation of new antimicrobial and antioxidant activities of *Brassica rapa* L. International Journal of Pharmacy and Pharmaceutical Sciences, vol. 6, N 6, pp. 84—88.
14. *Fernandez-Leon, A.M., Lozano, M., Gonzales, D., Ayuso, M.C. and Fernandez-Leon, M.F.* (2014), Bioactive compounds content and total antioxidant activity of two savoy cabbages. Czech Journal of Food Sciences, vol. 32, N 6, pp. 549—554.
15. *Brand-Williams, W., Cuvelier, M.E. and Berset, C.* (1995), Use of a free radical method to evaluate antioxidant activity. LWT — Food Science and Technology, vol. 28, N 1, pp. 25—30.
16. *Rahman, M.S., Jahan, N., Khatun, M. and Rashid, M.A.* (2015), Chemical and biological assays of *Brassica rapa* subsp. chinensis (L.) Hanelt. Bangladesh Journal of Botany, vol. 44, N 2, pp. 327—332.
17. *Saha, P., Talukdar, A.D., Singh Ningthoujam, S., Choudhury, M.D., Lutfun, N., Nahar, D., Sarker, S.D. and Basar, N.* (2015), Chemical composition, antimicrobial and antioxidant properties of seed oil plants of North-East India: A review. TANG (Humanitas Medicine), vol. 5, N 3, pp. 1—22. doi: http://dx.doi.org/10.5667/tang.2015.0010
18. *Devi, J.R. and Thangam, E.B.* (2012), Studies on antioxidant and antimicrobial activities of purified sulforaphane from *Brassica oleraceae* var. rubra. Journal of Pharmacy Research, vol. 5, N 7, pp. 3582—3584.
19. *Devi, P.S., Kumar, M.S. and Das, S.M.* (2012), DNA damage protecting activity and free radical scavenging activity of anthocyanins from red sorghum (*Sorghum bicolor*) bran. Biotechnology Research International, Article ID 258787. doi:10.1155/2012/258787
20. *Walia, A., Malan, R., Saini, S., Saini, V. and Gupta, S.* (2011), Hepatoprotective effects from the leaf extracts of *Brassica juncea* in CCl_4 induced rat model. Der Pharmacia Sinica, vol. 2, N 4, pp. 274—285.
21. *Gupta, V.K. and Sharma, S.K.* (2006), Plants as natural antioxidants. Natural Product Radiance, vol. 5, N 4, pp. 326—334.

22. *Kim, J.K., Baskar, T.B. and Park, S.U.* (2016), Total phenolic and flavonoid contents and antioxidant activities of two *Raphanus sativus* L. cultivars (Cherry Belle and Valentine). Biosciences Biotechnology Research Asia, vol. 13, N 1, pp. 31—36. http://dx.doi.org/10.13005/bbra/1999
23. *Kwak, Y., Lee, J. and Ju, J.* (2016), Anti-cancer activities of *Brassica juncea* leaves in vitro. EXCLI Journal, vol.15, pp. 699—710. http://dx.doi.org/10.17179/excli2016-586
24. *Marinova, G. and Batchvarov, V.* (2011), Evaluation of the methods for determination of the free radical scavenging activity by DPPH. Bulgarian Journal of Agricultural Science, vol. 17, N 1, pp. 11—24.
25. *Brosse, N., Dufour, A., Meng, X., Sun, Q. and Ragauskas, A.* (2012), *Miscanthus*: a fast-growing crop for biofuels and chemicals production. Biofuels, Bioproducts and Biorefening. doi: 10.1002/bbb
26. *Nahak, G., Suar, M. and Sahu, R.K.* (2014), Antioxidant potential and nutritional values of vegetables: a review. Research Journal of Medicinal Plants, vol. 8, N 2, pp. 50—81. doi: 10.3923/rjmp.2014.50.81
27. *Saeed, M. K., Anjum, S., Ahmad, I., Alim-un-Nisa, Ali, S., Zia, A. and Ali, S.* (2012), Nutritional facts and free radical scavenging activity of turnip (*Brassica rapa*) from Pakistan. World Applied Sciences Journal, vol. 19, N 3, pp. 370—375. doi: 10.5829/idosi.wasj.2012.19.03.691
28. *Pisoschi, A.M. and Negulescu, G.P.* (2011), Methods for Total Antioxidant Activity Determination: A Review. Biochemistry and Analytical Biochemistry, vol. 1, N 1. doi:10.4172/2161-1009.1000106
29. *Podsedek, A.* (2007), Natural antioxidants and antioxidant capacity of Brassica vegetables: a review. LWT — Food Science and Technology, vol. 40, pp. 1—11.
30. *Prasad, M.P.* (2014), Antimicrobial potential of Brassicaceae family against clinical isolates. International Journal of Pure and Applied Bioscience, vol. 2, N 2, pp. 158—162.
31. *Woli, P., Paz, J.O., Lang, D.J., Baldwin, B.S. and Kiniry, J.R.* (2012), Soil and variety effects on the energy and carbon balances of Switchgrass-derived ethanol. Journal of Sustainable Bioenergy Systems, vol. 2, pp. 65—74. http://dx.doi.org/10.4236/jsbs.2012.24010
32. *Stahl, W. and Sies, H.* (2003), Antioxidant activity of carotenoids. Molecular Aspects of Medicine, vol. 24, pp. 345—351.
33. *Bors, M.D., Semeniuc, C.A., Socaci, S., Varva, L., Moldovan, O., Vlaic, R. and Tofana, M.* (2015), Total phenolic content and antioxidant capacity of Radish as influenced by the variety and vegetative Stage. Bulletin UASVM Food Science and Technology, vol. 72, N 1, pp. 77—81. doi 10.15835/buasvmcn-fst:11087
34. *Singh, J., Upadhyay, A.K., Prasad, K., Bahadur, A. and Rai, M.* (2007), Variability of carotenes, vitamin C, E and phenolics in *Brassica* vegetables. Journal of Food Composition and Analysis, vol. 20, pp. 106—112.
35. *Warwick, S.I.* (2011), *Brassicaceae* in Agriculture. In: Genetics and Genomics of the *Brassicaceae*. Plant Genetics and Genomics: Crops and Models, New York: Springer, pp. 33—65. http://dx.doi.org/10.1007/978-1-4419-7118-0_2

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АНТИОКСИДАНТНИЙ ПОТЕНЦІАЛ РОСЛИН РОДИН *BRASSICACEAE* BURNETT ТА *POACEAE* BARNHART.

Мета — дослідити антирадикальну дію екстрактів деяких представників родин *Brassicaceae* Burnett та *Poaceae* Barnhart. для оцінки загальної антиоксидантної активності рослин в умовах Національного ботанічного саду імені М.М. Гришка НАН України.

Матеріал та методи. Рослинний матеріал дослідження — види, форми та сорти рослин-представників *Brassicaceae* та *Poaceae*: *Brassica campestris* f. annua D.C. (BCA), *B. campestris* f. *biennis* D.C.× *B. napus* f. *biennis* D.C., cv. Innovatsiia (BCBNI), *B. campestris* f. *biennis* D.C. × *B. rapa* L. × *B. napus* f. *biennis* D.C. (BCBRBN), *B. juncea* (L.) Czern. (BJ), *B. juncea* (L.) Czern. f. *biennis*, cv. Annushka (BJA), *B. napus* f. *biennis* D.C., f. EROF-5 (BNE-5), *B. rapa* L. (BR), *B. rapa* subsp. *rapifera* Metzger (BRR), *Raphanus sativus* L. var. *oleiformis* Pers. (RSO), *Miscanthus sacchariflorus* (Maxim.) Benth., cv. Snihopad (MSS), *M. sinensis* Anderss. f. ESBMK-6 (MSE-6), *Panicum virgatum* L. f. PB (PVPB), *P. virgatum* L. f. PL (PVPL), *Sorghum bicolor* (L.) Moench. f. ETSSDF-11 (SBE-11), *S. nigrum* Roemer & Schultes f. ETSSCHF-1 (SNE-1), *S. saccharatum* (L.) Moench. cv. Medove (SSM), *S. sudanense* (Piper) Stapf (SS), *S. technicum* (Koern.) Bait. et Trab. (ST). Антиоксидантну активність метанольних та водних екстрактів, в основі якої лежить реакція знебарвлення розчину ДФПГ (2,2-дифеніл-1-пікрилгідразил-вільний радикал), визначали за Brandt-Williams et al., вміст аскорбінової кислоти — за В.П. Крищенком, каротину — за Б.П. Плешковим.

Результати. Антиоксидантна активність метанольних екстрактів рослин родини *Brassicaceae* становила від 16,94 ± 0,15 (BCA) до 36,91 ± 0,26 (BRR) %, водних — від 26,53 ± 0,34 (BJ) до 65,85 ± 0,30 (RSO) %, метанольних екстрактів рослин родини *Poaceae* — від 31,13 ± 0,32 (MSE-6) до 86,48 ± 0,49 (SNE-1) %, водних — від 33,10 ± 0,47 (ST) до 83,14 ± 0,46 (PVPB) %, концентрація аскорбінової кислоти у рослин родини *Brassicaceae* — від 118,67 ± 9,90 (BJA) до 566,61 ± 38,37 (BNE-5) мг%,

каротину — від 0,48 ± 0,01 (BJA) до 3,11 ± 0,07 (BJ) мг%, у рослин родини *Poaceae* — відповідно від 11,80 ± ± 0,85 (PVPB) до 77,39 ± 1,29 (SS) мг% та від 0,05 ± ± 0,00 (PVPB) до 0,62 ± 0,02 (PVPL) мг%.

Висновки. Рослинна сировина досліджених рослин є цінним джерелом антиоксидантів і вітамінів. Метанольні та водні екстракти рослин родини *Poaceae* мали вищу антирадикальну активність щодо ДФПГ-радикала, ніж екстракти рослин родини *Brassicaceae*. Найвищий рівень аскорбінової кислоти та каротину виявлено в екстрактах рослин родини *Brassicaceae*, мінімальний — у BJA (*Brassicaceae*) та PVPB (*Poaceae*).

Ключові слова: *Brassicaceae, Poaceae*, антиоксидантна активність, 2,2-дифеніл-1-пікрилгідразил (ДФПГ), аскорбінова кислота, каротин.

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АНТИОКСИДАНТНЫЙ ПОТЕНЦИАЛ РАСТЕНИЙ СЕМЕЙСТВ *BRASSICACEAE* BURNETT И *POACEAE* BARNHART.

Цель — исследовать антирадикальное действие экстрактов некоторых представителей семейств *Brassicaceae* Burnett и *Poaceae* Barnhart. для оценки общей антиоксидантной активности в условиях Национального ботанического сада имени Н.Н. Гришко НАН Украины.

Материал и методы. Растительный материал исследования — виды, формы и сорта растений семейств *Brassicaceae* и *Poaceae*: *Brassica campestris* f. annua D.C. (BCA), *B. campestris* f. *biennis* D.C.× *B. napus* f. *biennis* D.C., cv. Innovatsiia (BCBNI), *B. campestris* f. *biennis* D.C. × *B. rapa* L. × *B. napus* f. *biennis* D.C. (BCBRBN), *B. juncea* (L.) Czern. (BJ), *B. juncea* (L.) Czern. f. *biennis*, cv. Annushka (BJA), *B. napus* f. *biennis* D.C., f. EROF-5 (BNE-5), *B. rapa* L. (BR), *B. rapa* subsp. *rapifera* Metzger (BRR), *Raphanus sativus* L. var. *oleiformis* Pers. (RSO), *Miscanthus sacchariflorus* (Maxim.) Benth., cv. Snihopad (MSS), *M. sinensis* Anderss. f. ESBMK-6 (MSE-6), *Panicum virgatum* L. f. PB (PVPB), *P. virgatum* L. f. PL (PVPL), *Sorghum bicolor* (L.) Moench. f. ETSSDF-11 (SBE-11), *S. nigrum* Roemer & Schultes f. ETSSCHF-1 (SNE-1), *S. saccharatum* (L.) Moench. cv. Medove (SSM), *S. sudanense* (Piper) Stapf (SS), *S. technicum* (Koern.) Bait. et Trab. (ST). Антиоксидантную активность метанольных и водных экстрактов, основанную на реакции обесцвечивания раствора ДФПГ (2,2-дифенил-1-пикрилгидразил-свободный радикал), определяли по Brandt-Williams et al., содержание аскорбиновой кислоты — В.П. Крищенко, каротина — по Б.П. Плешкову.

Результаты. Антиоксидантная активность метанольных экстрактов растений семейства *Brassicaceae* составляла от 16,94 ± 0,15 (BCA) до 36,91 ± 0,26 (BRR) %, водных — от 26,53 ± 0,34 (BJ) до 65,85 ± 0,30 (RSO) %, метанольных экстрактов растений семейства *Poaceae* — от 31,13 ± 0,32 (MSE-6) до 86,48 ± 0,49 (SNE-1) %, водных — от 33,10 ± 0,47 (ST) до 83,14 ± 0,46 (PVPB) %, концентрация аскорбиновой кислоты у растений семейства *Brassicaceae* — от 118,67±9,90 (BJA) до 566,61 ± ± 38,37 (BNE-5) мг%, каротина — от 0,48 ± 0,01 (BJA) до 3,11 ± 0,07 (BJ) мг%, у растений семейства *Poaceae* — соответственно от 11,80 ± 0,85 (PVPB) до 77,39 ± ± 1,29 (SS) мг% и от 0,05 ± 0,00 (PVPB) до 0,62 ± ± 0,02 (PVPL) мг%.

Выводы. Растительное сырье исследованных растений является ценным источником антиоксидантов и витаминов. Метанольные и водные экстракты растений семейства Poaceae имели большую антирадикальную активность относительно ДФПГ-радикала, чем экстракты растений семейства *Brassicaceae*. Наивысший уровень аскорбиновой кислоты и каротина выявлен в экстрактах растений семейства *Brassicaceae*, минимальный — у BJA (*Brassicaceae)* и PVPB (*Poaceae*).

Ключевые слова: *Brassicaceae, Poaceae*, антиоксидантная активность, 2,2-дифенил-1-пикрилгидразил (ДФПГ), аскорбиновая кислота, каротин.