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BIOCHEMICAL CHARACTERISTICS OF PRO- AND ANTIOXIDANT POTENTIAL OF PLANT EXTRACTS IN DAIRY ENVIRONMENT

Actuality. *Due to the high content of antioxidants, vitamins, minerals in plant extracts, their use for inhibiting oxidative processes is gaining popularity. The antioxidant efficacy of aqueous extracts from basil seeds, grape leaves, robinia flowers and wheat grains can be investigated using cow and goat milk as a research medium.*

The purpose of the study. To determine the content of secondary metabolites in plant raw materials and to evaluate the pro- and antioxidant potential of aqueous plant extracts in dairy environment.

Material and methods. *Native cow and goat milk. Water extracts from grape leaves (Vitis vinifera L.), robinia flowers (Robinia pseudoacacia L.), basil seeds (Ocimum basilicum L.) and wheat grains (Triticum sp.). The aqueous extracts were prepared in a 3 : 10 ratio, followed by extraction at 90 °C temperature for 40 minutes. Analysis of secondary metabolites was carried out by reverse phase high performance liquid chromatography. To prepare extracts for HPLC analysis 0,3 g of finely ground materials were mixed with 20 mL of methanol (Merck, Germany) and the obtained mixtures were treated with ultrasound at 50 °C for 120 min. Syringe filters with PTFE membranes (0,22 µm pore size) were used for filtration of obtained extracts. The content of oxidation products of lipids and proteins, vitamin C, SH groups, reduced glutathione, catalase activity and ascorbate peroxidase were determined spectrophotometrically. Plant extracts were added in a volume of 3% of the milk volume.*

Research results. *Basil seeds have been found to have the highest levels of triglycerides and monoterpenoids, giving it a potential anti-inflammatory, bactericidal, anthelmintic and antispasmodic effect. Robinia flowers have the highest glycoside levels of anthocyanin, 4',7-dihydroxyflavone, apigenin, luteolin, and hydroxycinnamic acid derivatives, demonstrating their potent antioxidant potential and high levels of adaptation to biotic and abiotic stress. Instead, the highest levels of kaempferol and quercetin glycosides, simple phenols and chlorophyll A and B catabolites were found in the grape leaves. Such results demonstrate its likely anti-inflammatory and immunomodulatory effect. The poorest in the content of secondary metabolites was wheat grain.*

Also, as a result of the study, the most effective in terms of reducing the intensity of oxidation processes in milk and increasing its antioxidant potential was the extract from basil seeds. Extract from wheat grains showed the worst result in terms of increasing the antioxidant potential of milk and reducing the intensity of oxidation of proteins and lipids.

Conclusion. *The results obtained with milk may indicate a significant antioxidant potential of the studied plant extracts. These results can be used in crop production, as well as in the medical, pharmaceutical or food industries.*

Key words: *cow and goat milk, basil seeds, robinia flowers, grape leaves, wheat grains, secondary metabolites, pro- and antioxidant potential.*

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БІОХІМІЧНА ХАРАКТЕРИСТИКА ПРО- ТА АНТИОКСИДАНТНОГО ПОТЕНЦІАЛУ РОСЛИННИХ ЕКСТРАКТІВ У СЕРЕДОВИЩІ МОЛОКА

Актуальність. *Завдяки високому вмісту антиоксидантів, вітамінів, мінеральних речовин у рослинних екстрактах набуває популярності їх використання для гальмування окиснювальних процесів. Дослідити антиоксидантну ефективність вод-*

них екстрактів із насіння базиліку, листя винограду, квіток робінії та зерен пшениці можна за допомогою коров'ячого та козиного молока як середовища досліджень.

Мета дослідження *– визначити вміст вторинних метаболітів у рослинній сировині й оцінити про- та антиоксидантний потенціал водних рослинних екстрактів у середовищі молока.*

Матеріал і методи. *Нативне коров'яче та козине молоко. Водні екстракти з листя винограду (Vitis vinifera L.), квіток робінії (Robinia pseudoacacia L.), насіння базиліку (Ocimum basilicum L.) та зерен пшениці (Triticum sp.). Водні екстракти готувались у пропорції 3 : 10, з подальшою екстракцією за температури 90 °С, протягом 40 хвилин. Аналіз вторинних метаболітів проводили методом обернено-фазової високоефективної рідинної хроматографії. Екстракти для аналізу методом ВЕРХ були підготовлені так: 0,3 г перетертої рослинної сировини заливали 20 мл метанолу, отриману суміш обробляли ультразвуком за температури 50 °С протягом 120 хвилин. Отриманий екстракт фільтрували крізь шприцевий фільтр із PTFE мембраною (пори – 0,22 мкм). Вміст продуктів окиснення ліпідів і білків, вітаміну С, SH-груп, відновленого глутатіону, активність каталази й аскорбатпероксидази визначали спектрофотометрично. Рослинні екстракти додавали об'ємом 3% від об'єму молока.*

Результати дослідження. *Було встановлено, що насіння базиліку має найвищий рівень вмісту тригліцеридів і монотерпеноїдів, які надають йому потенційного протизапального, бактерицидного, антигельмінтного та спазмолітичного ефекту. Квітки робінії мають найвищі рівні глікозидів антоціану, 4',7-дигідроксифлавону, апігеніну, лютеоліну й оксикоричних кислот, що демонструє їхній потужний антиоксидантний потенціал і високий рівень адаптації до біотичного й абіотичного стресу. Натомість у листі винограду були виявлені найвищі рівні глікозидів кемпферолу та кверцетину, простих фенолів і катаболітів хлорофілу А і В. Такі результати демонструють його ймовірну протизапальну й імуномодулюючу дію. Найбіднішим за вмістом вторинних метаболітів виявилось зерно пшениці.*

Також у результаті дослідження найефективнішим у плані зниження інтенсивності окиснювальних процесів у молоці та підвищення його антиоксидантного потенціалу виявився екстракт із насіння базиліку. Екстракт із зерен пшениці продемонстрував найменшу ефективність у плані підвищення актиоксидантного потенціалу молока та зниження інтенсивності окиснення білків і ліпідів.

Висновок. *Результати, отримані з молоком, можуть свідчити про значний антиоксидантний потенціал досліджуваних рослинних екстрактів. Ці результати можуть бути використані в рослинництві, а також у медичній, фармацевтичній чи харчовій промисловості.*

Ключові слова: *коров'яче та козине молоко, насіння базиліку, квітки робінії, листя винограду, зерна пшениці, вторинні метаболіти, про- та антиоксидантний потенціал.*

Introduction. Actuality. Plant extracts are currently being actively researched and used in various sectors of the national economy, in particular in plant growing. In particular, antioxidants contained in plant extracts can effectively inhibit peroxidation processes (Ei, 2024, pp. 1–15).

Milk is a good medium to assess the pro- and antioxidant potential of plant extracts. This is due to the good balance of the pro- and antioxidant system in milk due to the high antioxidant content and moderate intensity of lipid and protein oxidation processes (Osypchuk, 2021; Maryam, 2024).

Our attention was drawn to extracts from grape leaves, robinia flowers, basil seeds and wheat grains. The plants used to prepare these extracts are affordable and have a high content of proteins, carbohydrates, free metabolites, antioxidants and minerals.

Basil (*Ocimum basilicum* L.) is found all over the world and is used in the food, pharmaceutical and cosmetic industries. However, the nutritional and functional properties of its seeds have been little studied. Basil seeds contain a high protein content (11,4–22,5 g/100 g), with all essential amino acids except tryptophan. Basil seeds also have a high content of linoleic acid (12–85,6 g/100 g) and minerals such as calcium, potassium and magnesium. Recently, it was found that basil seeds contain phenolic compounds: orientin, vicentine and rosmarinic acid (Bravo, 2021, pp. 1–18). The importance of basil seed consumption for the prevention of type 2 diabetes, cardiovascular diseases has been demonstrated. It has also been proven that basil extract is able to protect A549 cells from effects mediated by an infectious disease caused by Friedlander's wand (*Klebsiella pneumoniae*), suppressing cell death due to apoptosis (Arundhathu, 2022, pp. 1822–1835). Anti-inflammatory, antimicrobial, anti-ulcer, anticoagulant and antidepressant properties of basil seed extract are also known (Bravo, 2021, pp. 1–18).

In recent years, the study of the components of the antioxidant system of grape leaves (*Vitis vinifera* L.) has been gaining popularity. It was found that aqueous extracts of grape leaves have a high content of phenolic compounds (55,4 ± 0,1 mg/g of dry matter weight) (You-Mei, 2022, pp. 1–17). Dose-dependent inhibition of the proliferation of HepG2 hepatocarcinoma cells and breast cancer cells MCF-7 by the actions of grape leaf extract has been demonstrated (Selma, 2019, pp. 600–613).

The study of extracts from robinia flowers (*Robinia pseudoacacia* L.) is only gaining popularity. Robinia flowers have been proven to be rich in protein content (1,35–7,46 g/100g) (Jakubczyk, 2022, pp. 1–10). It has now been established that an extract from robinia flowers is able to suppress IL-1β-mediated angiogenesis by blocking IL-1β signaling, inhibiting IL-1 phosphorylation β-protein-kinases, and inhibiting mRNA expression IL-1β-induced proangiogenic factors, including VEGFA, FGF2, ICAM1, CXCL8 and IL6 (Kim, 2019, pp. 1901–1910). Thus, an extract from Robinia flowers may be a promising agent in antitumor therapy.

Wheat (*Triticum sp.*) is one of the most important cereals as a source of natural antioxidants. Wheat grain contains high content of bioactive compounds: phenol carboxylic acids (136,8–233,9 mcg/g), phytosterols (562,6–1 035,5 μg/g), tocopherols (19,3–292,7 μg/g), alkyl resorcins AP (99,9–316,0 μg/g). Also, the wheat grain contains chlorogenic, coffeic, ferulic, p-coumaric and sinapic acids. All these compounds are present in bound forms, in the form of esters (Jarvan, 2018, pp. 323–330). It is these substances that form the antioxidant potential.

The aim of the work is to determine the level of secondary metabolites in plant raw materials and to evaluate the pro- and antioxidant potential of aqueous plant extracts from grape leaves, robinia flowers, basil seeds and wheat grains in dairy environment.

Methods and organization of research. For the study, native cow and goat milk from a private farm and water extracts from grape leaves (*Vitis vinifera* L.), robinia flowers (*Robiinia pseudoacacacia* L.), basil seeds (*Ocimum basilicum* L.) and wheat grains (*Triticum aestivum* L.) were used. Plants were collected in the spring-summer period in the city of Korosten, Zhytomyr region. Drying was carried out in a well-ventilated room at a temperature of 23–28 °C without direct sunlight. The aqueous extracts were prepared in a 3 : 10 ratio, followed by extraction at 90 °C temperature for 40 minutes. Plant extracts were added in a volume of 3% of the milk volume. To prepare extracts for HPLC analysis 0,3 g of finely ground materials were mixed with 20 mL of methanol (Merck, Germany) and the obtained mixtures were treated with ultrasound at 50 °C for 120 min.

Analysis of secondary metabolites was carried out by the method of reverse-phase high-performance liquid chromatography on the basis of CSUSE "High-performance liquid chromatography (HPLC)" of M.M. Gryshko National Botanic Garden of the National Academy of Sciences of Ukraine. The separation of the samples was carried out on an Agilent 1100 chromatographic system with a 4-channel pump, vacuum degasser, autosampler, column thermostat and diode matrix detector. A two-eluent scheme was used (eluent A = 0,05 M aqueous solution of orthophosphoric acid H_3PO_4; B = acetonitrile/all eluents and additives Sigma –Aldrich, HPLC purity gradation) on a Poroshell column 120 EC-C18, 2,7 μm, 2,1 × 150 mm. Injection volume 2 μL. Detection occurred at wavelengths of 206 nm, 254 nm, 300 nm, 350 nm and 450 nm. Absorption spectra in the ultraviolet and visible ranges were recorded for all substances in order to establish the nature of secondary metabolites and attribute chromatographic peaks to certain groups of substances.

To estimate the quantity of phenols of various classes in the extracts, the integral intensities of respective signals were compared with those for reference substances (chlorogenic acid – for hydroxycinnamic acids, gallic acid – for simple phenols, rutin – for glucosides of quecetin and kaemferol, neohesperidin – for flavanones, ellagic acid – for ellagic acid derivatives, malvidin-3-O-glucoside – for anthocyanin derivatives, vitexin – for glycosides of apigenin and 4',7-dihydroxyflavone glycosides, orientin – for glycosides of luteolin, oleic acid – for triglycerides, isoflavone – for glycosides of isoflavones, lutein – for carotenoids, pheophorbide A – for catabolites of chlorophyll A and B). Calculation of compound content was performed according to equation 1.

$$c = \frac{A \cdot V}{RF \cdot m}, \qquad (1)$$

where: c – concentration of compound in raw material, mg/g;
A – peak area of compound;
RF – response factor of reference substance;
m – mass of the raw material used for preparation of the extract, g;
V – volume of extract, ml.

The content of TBA-positive products was evaluated spectrophotometrically by the formation of a trimetine complex of aldehydes with 2-thiobarbituric acid when heated to 100 °C (Osypchuk, 2021, pp. 94–98). The content of vitamin C was determined spectrophotometrically by the reaction of the vitamin with 2% metaphosphoric acid in the buffer of 2% metaphosphoric acid + 0,21M Na_3PO_4 in a ratio of 3 : 2 (pH 7,3–7,4) (Antonenko, 2016, pp. 1261–1270). The content of SH-groups in plant extracts was determined spectrophotometrically. The principle of the method for determining the level of common SH-groups is their reaction with KI and starch in phosphate buffer (pH = 7,6). To determine the non-protein SH-groups of the previous one, proteins were precipitated with trichloroacetic acid (Osypchuk, 2021, pp. 94–98). The content of reduced glutathione was determined spectrophotometrically as a result of its reaction with 5,5-dithiobis-2-nitrobenzoic acid (Berylak, 2021, pp. 148) with modifications. Catalase activity was determined spectrophotometrically by the formation of a stable complex of hydrogen peroxide with ammonium molybdate (Aebi, 1984, pp. 121–126). Ascorbate peroxidase activity was determined spectrophotometrically by reducing the level of H_2O_2 in phosphate buffer (pH = 7,8) in the presence of ascorbic acid and EDTA (Makano, 1981, pp. 867–880). The content of carbonyl products of protein peroxidation was determined by the interaction of oxidized amino acid residues of proteins with 2,4-dinitrophenylhydrazine (Meshchyshen, 1998, pp. 156–158) with modifications. Statistical processing of results was carried out using methods of mathematical statistics, using standard built-in functions of the package of specialized software MS Office Excel – 2010.

Research results and their discussion. Secondary metabolites of plant organisms (PSMs) perform different functions in providing interaction between plants and other organisms. Various constitutive and pathogen-induced phytochemicals provide natural plant immunity. Pathogenic microbial infections activate various protective reactions against numerous biotic and abiotic stresses, including pigmentation, pollen tube development, UV light stress, pathogenic infections, and phytophagy (Piasecka, 2015, pp. 948–964).

As a result of the study, it was found that of the four samples of dry raw materials, only the robinia flowers contains anthocyanin glycosides, ellagic acid derivatives, flavanone glycosides and isoflavones. This may be due to the peculiarities of the biochemical composition of flowers. Also, the robinia flowers contains a higher level of 4’,7-dihydroxyflavone glycosides by 99,4, 89,2 and 100%, compared to grape leaves, basil seeds and wheat grains, respectively. The level of flavonoids in the robinia flowers is 65, 100 and 97,5% higher, compared to grape leaves, basil seeds and wheat grains, respectively. The levels of luteolin and apigenin glycosides are also higher in the robinia flowers. In particular, the level of apigenin glycosides in the robinia flowers is 82,9, 100 and 98,2% higher, and the level of luteolin glycosides is 99, 100 and 100% higher, compared to grape leaves, basil seeds and wheat grains, respectively (table 1).

The level of hydroxicinnamic acid derivatives in the robinia flowers is 92,3, 100 and 100% higher, compared to grape leaves, basil seeds and wheat grains, respectively. These results demonstrate antioxidant potential and a high level of adaptation to biotic and abiotic stress.

Examining the grape leaves, it was found to contain the highest levels of kaempferol glycosides, quercetin, simple phenols and catabolites of chlorophyll A and B. In particular, the level of kaempferol glycosides is higher by 100, 100 and 85,7%, the level of quercetin glycosides is higher by 100, 100, and 88,6%, the level of simple phenols is higher by 100, 85,5 and 85,5%, the level of chlorophyll A catabolites is higher by 46,7, 100 and 93,4% and the level of chlorophyll B catabolites is higher by 36,4, 100 and 91%, compared to robinia flowers, basil seeds and wheat grains, respectively (table 1). The level of carotenoids in robinia flowers and grape leaves is the same and 100 and 80% higher, compared to basil seeds and wheat grains, respectively. Stilbenoids have only been found in grape leaves. Such results may be due to the biochemical features of the raw material was prepared and demonstrate the potential anti-inflammatory, immunomodulatory and inhibitory effect of plant raw materials against mycelial growth (Jessica, 2021; Qurat, 2022).

Table 1

Content of secondary metabolites in dry plant raw materials, mg/g

Class of substances	Robinia flowers	Leaves of grapes	Basil seeds	Wheat grains
Anthocyanin glycoside	0,9	–	–	–
4’,7-dihydroxyflavone glycosides	35,1	0,2	3,8	–
Ellagic acid derivatives	24,0	–	–	–
Flavonoids	4,0	1,4	–	0,1
Apigenin glycosides	16,7	2,9	–	0,3
Kaempferol glycosides	–	2,8	–	0,4
Luteolin glycosides	37,8	0,4	–	–
Quercetin gilcosides	–	3,5	–	0,4
Flavanone glycosides	24,6	–	–	–
Simple phenols	–	5,5	0,8	0,8
Isoflavones	4,7	–	–	–
Hydroxycinnamic acid derivatives	2,6	0,2	–	–
Stilbenoids	–	>0,1	–	–
Monoterpenoids and sterols	11,4	14,7	51,6	4,9
Triglycerides	–	–	133,5	–
Chlorophyll A catabolites	0,8	1,5	–	0,1
Chlorophyll B catabolites	0,7	1,1	–	0,1
Carotenoids	0,5	0,5	–	0,1

Examining basil seeds, they found that it has the highest levels of monoterpenoids, sterols and triglycerides. In particular, the level of monoterpenoids and sterols in the basil seeds is higher by 78, 71,6 and 90,6%, compared with robinia flowers, grape leaves and wheat grains, respectively (table 1). Triglycerides have only been found in basil seeds. This may be due to the presence of high lipid content in basil. Such results demonstrate the potential bactericidal, anti-inflammatory and anthelmintic potential of basil seed (Nimbkar, 2022, pp. 843–867).

Examining the wheat grains, it was found that it has the lowest level of all studied substances, compared with other plants (table 1).

An important role in maintaining the pro- and antioxidant balance is played by compounds containing SH-groups. Due to the presence of these groups in the free state, the compounds can exhibit antitoxic, antioxidant and immunomodulatory effects (Birsen, 2022, pp. 200–206). Also, compounds with an SH-group participate in conjugation and reduction reactions.

It was found that the content of total SH-groups in cow's milk is significantly lower by 10,4, 27,4 and 36%, compared to milk with extracts from grape leaves, robinia flowers and basil seeds, respectively (table 2).

Instead, the content of total SH-groups in goat milk is significantly lower by 67, 63,4, 76 and 54,8%, compared to milk with extracts from grape leaves, robinia flowers, basil seeds and wheat grains, respectively (table 2).

The content of non-protein SH-groups in cow milk is significantly lower by 45%, 35% and 4,5%, respectively, compared to milk with extracts from robinia flowers, basil seeds and wheat grains (table 2). Instead, the content of non-protein SH-groups in goat milk is significantly lower by 39 and 64%, respectively, compared to milk with extracts from grape leaves and robinia flowers. Instead, the content of non-protein SH-groups in goat milk with an extract from wheat grains is 28% lower compared to native goat milk (table 2). This may be due to the peculiarities of the biochemical composition of milk and wheat grains. A significant difference between native goat milk and milk with basil seed extract has not been established. This may be due to the low content of non-protein SH groups in basil seeds.

Examining the content of protein SH-groups, it was found that their level in cow's milk is significantly lower by 29, 13 and 36,6%, respectively, compared to milk with extracts from grape leaves, robinia flowers and basil seeds (table 2). Instead, the content of protein SH-groups in native goat milk is significantly lower by 38, 83,6 and 40 times, respectively, compared to milk with extracts from grape leaves, basil seeds and wheat grains (table 2). This may be due to the low content of protein SH-groups in goat milk (Osypchuk, 2021, pp. 94–98).

Examining the content of reduced glutathione, it was found that its content in cow's milk with extracts from grape leaves, robinia flowers, basil seeds and wheat grains is higher by 27,6, 28,8, 40 and 12,5%, respectively, compared to cow's milk without extracts (table 3).

Instead, the content of reduced glutathione in goat milk with an extract from grape leaves, robinia flowers and basil seeds is 3, 6,9 and 12% higher, respectively, compared to milk without extracts (table 3).

Table 2

Content of total, protein and non-protein SH-groups in cow and goat milk with plant extracts

	Total SH-group content, mmol/l	Content of protein SH-groups, mmol/l	Content of non-protein SH-groups, mmol/l
Native cow milk	69,01 ± 2,04	45,02 ± 1,46	23,98 ± 1,30
Cow milk + grape leaves	76,80 ± 2,05*	63,50 ± 2,20*	13,3 ± 0,20*
Cow milk + robinia flowers	95,06 ± 3,80*	51,80 ± 1,90*	43,26 ± 1,80*
Cow milk + basil seeds	108,05 ± 4,50*	71,03 ± 2,80*	37,02 ± 1,09*
Cow milk + wheat grains	70,14 ± 3,02	45,02 ± 2,02	25,12 ± 0,90
Native goat milk	23,10 ± 1,60	0,88 ± 0,05	22,22 ± 1,30
Goat milk + grape leaves	70,13 ± 3,80*	33,60 ± 1,00*	36,53 ± 2,02*
Goat milk + robinia flowers	63,14 ± 2,90*	1,88 ± 2,60	61,26 ± 3,90*
Goat milk + basil seeds	96,50 ± 4,10*	73,60 ± 1,80*	22,9 ± 2,00
Goat milk + wheat grains	51,06 ± 1,09*	35,08 ± 1,03*	15,98 ± 1,80*

Notes: * – probable differences ($p < 0,05$) compared to native milk without extracts.

Table 3

Reduced glutathione content and catalase and ascorbate peroxidase activity in cow and goat milk with plant extracts

	Reduced glutathione content, µmol/ml	Catalase activity, µmol/ml per min	Ascorbate peroxidase content, µmol/ml per min
Native cow milk	4,20 ± 0,95	0,020 ± 0,001	0,27 ± 0,01
Cow milk + grape leaves	5,81 ± 0,90	0,020 ± 0,001	0,30 ± 0,01*
Cow milk + robinia flowers	5,90 ± 0,90	0,021 ± 0,002	0,32 ± 0,01*
Cow milk + basil seeds	7,02 ± 1,0*	0,023 ± 0,001*	0,41 ± 0,01*
Cow milk + wheat grains	4,84 ± 0,61	0,020 ± 0,0015	0,27 ± 0,01
Native goat milk	9,50 ± 0,60	0,033 ± 0,001	0,30 ± 0,01
Goat milk + grape leaves	9,82 ± 0,60	0,033 ± 0,002	0,30 ± 0,02
Goat milk + robinia flowers	10,20 ± 0,72	0,040 ± 0,001*	0,31 ± 0,02
Goat milk + basil seeds	10,80 ± 0,70	0,042 ± 0,002*	0,37 ± 0,01*
Goat milk + wheat grains	9,53 ± 0,60	0,033 ± 0,002	0,30 ± 0,01

Notes: * – probable differences ($p < 0,05$) compared to native milk without extracts.

Catalase activity increased significantly only in cow milk with basil seed extract by 13%, compared to milk without extracts (table 3). In goat's milk, catalase activity increased in milk with extracts from robinia flowers and basil seeds by 17,5 and 21,4%, respectively, compared to milk without extracts (table 3).

The activity of ascorbate peroxidase in cow milk with extracts from grape leaves, robinia flowers and basil seeds is 10, 15,6 and 34% higher, respectively, compared to milk without extracts (table 3). In goat milk, the activity of ascorbate peroxidase increased only in milk with basil seed extract by 19,7%, compared to milk without extracts (table 3).

The content of vitamin C in cow milk also significantly increased only in milk, which was matched by extract from basil seeds, compared to milk without extracts. There was no significant difference between goat milk and milk with plant extracts (table 4).

The content of TBA-positive products in cow milk with extracts from grape leaves, robinia flowers, basil seeds and wheat grains is significantly lower by 14,9, 9,6, 30,8 and 17,6%, respectively, compared to cow milk without extracts (table 4). Instead, the content of TBA-positive products in goat milk with extracts from grape leaves, robinia flowers, basil seeds and wheat grains is significantly lower by 21,3, 13,6, 29,1 and 16,2%, respectively, compared to milk without extracts (table 4).

An important indicator indicating the intensity of free radical processes, including protein oxidation, is the content of carbonyl oxidation products of proteins. They are divided into neutral aldehyde-dinitrophenylhydrazones (absorption spectrum 356 nm), neutral ketone-dinitrophenylhydrazones (absorption spectrum 370 nm), basic aldehyde-dinitrophenylhydrazones (absorption spectrum 430 nm) and basic ketone-dinitrophenylhydrazones (absorption spectrum 530 nm) (Meshchyshen, 1998, pp. 156–158) with modifications.

It was found that the content of neutral aldehyde oxidation products of proteins in cow milk with extracts from grape leaves, robinia flowers, basil seeds and wheat grains reliably lower by 19,6, 24, 45 and 10,9%, the content of neutral ketone products is lower by 17,8, 15,5, 46,7 and 2,3%, the content of basic aldehyde products is lower by 23,4, 19,1, 29,8 and 4,3%, the content of basic ketone products is lower by 18,4, 20,4, 40,8 and 18,4%, respectively, compared to milk without extracts (table 5).

Instead, it was found that in goat milk with extracts from grape leaves, Robinia flowers, basil seeds and

Table 4

Content of vitamin C and TBA-positive products in cow and goat milk with plant extracts

	Vitamin C content, mol/l	**Content of TBA-positive products, μmol/l**
Native cow milk	0,270 ± 0,004	401,7 ± 9,3
Cow milk + grape leaves	0,291 ± 0,02	341,9 ± 10,7*
Cow milk + robinia flowers	0,270 ± 0,03	363,2 ± 10,7*
Cow milk + basil seeds	0,293 ± 0,01*	277,8 ± 10,7*
Cow milk + wheat grains	0,283 ± 0,01	331,2 ± 10,7*
Native goat milk	0,297 ± 0,02	331,2 ± 10,7
Goat milk + grape leaves	0,298 ± 0,03	260,7 ± 4,3*
Goat milk + robinia flowers	0,301 ± 0,02	286,3 ± 18,7*
Goat milk + basil seeds	0,299 ± 0,02	235,0 ± 10,7*
Goat milk + wheat grains	0,297 ± 0,02	277,7 ± 10,7*

Notes: * – probable differences ($p < 0,05$) compared to native milk without extracts.

Table 5

Content of carbonyl products of protein peroxidation in cow and goat milk with plant extracts, nmol/ml

	356 nm	**370 nm**	**430 nm**	**530 nm**
Native cow milk	348,49 ± 7,6	340,90 ± 0,5	356,06 ± 7,6	371,22 ± 1,15
Cow milk + grape leaves	280,30 ± 7,6*	280,30 ± 7,6*	272,70 ± 0,5*	303,03 ± 7,6*
Cow milk + robinia flowers	265,15 ± 20,04*	287,90 ± 7,6*	287,90 ± 7,6*	295,50 ± 0,5*
Cow milk + basil seeds	191,97 ± 7,6*	181,80 ± 0,5*	250,00 ± 5,7*	219,70 ± 2,0*
Cow milk + wheat grains	310,60 ± 7,6*	333,30 ± 7,6	340,90 ± 0,5*	303,03 ± 7,6*
Native goat milk	409,10 ± 0,5	409,10 ± 13,1	431,80 ± 0,5	439,40 ± 7,6
Goat milk + grape leaves	318,20 ± 13,1*	303,03 ± 7,6*	295,50 ± 0,5*	303,03 ± 3,6*
Goat milk + robinia flowers	378,80 ± 7,6*	363,60 ± 0,5*	356,06 ± 7,6*	348,50 ± 3,4*
Goat milk + basil seeds	287,90 ± 15,2*	272,70 ± 0,5*	280,40 ± 7,6*	333,30 ± 6,2*
Goat milk + wheat grains	378,80 ± 7,6*	409,10 ± 0.5	409,10 ± 0,5*	401,50 ± 1,7

Notes: * – probable differences ($p < 0,05$) compared to native milk without extracts.

wheat grains content of neutral aldehyde products reliably lower by 22,2, 7,4, 29,6 and 7,9%, the content of neutral ketone products is lower by 25,9, 11,1, 33,3 and 0%, the content of basic aldehyde products is lower by 31,6, 17,5, 35,1 and 5,3%, the content of basic ketone products is lower by 31, 20,7, 24,1 and 8,7%, respectively, compared to goat milk without extracts (table 5).

Conclusions. As a result of research, it was found that basil seed has the highest level of triglycerides and monoterpenoids, which give it a potential anti-inflammatory, bactericidal, anthelmintic and antispasmodic effect. Robinia flowers has the highest levels of anthocyanin, 4',7-dihydroxyflavone, apigenin, luteolin glycosides and hydroxycinnamic acid derivatives, demonstrating its powerful antioxidant potential and high level of adaptation to biotic and abiotic stress. Instead, the highest levels of kaempferol and glycosides of quercetin, simple phenols and catabolites of chlorophyll A and B were found in the grape leaves. Such results demonstrate the probable anti-inflammatory and immunomodulatory effect of grape leaves. The poorest in terms of secondary metabolites was the wheat grains.

Also, as a result of the study, the most effective in terms of reducing the intensity of oxidation processes in milk and increasing its antioxidant potential was the extract from basil seeds. Extract from wheat grains showed the worst result in terms of increasing the antioxidant potential of milk and reducing the intensity of oxidation of proteins and lipids. The results obtained with milk may indicate a significant antioxidant potential of the studied plant extracts. These results can be used in crop production, as well as in the medical, pharmaceutical or food industries.

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Anishchenko V.N. – conducting chromatographic studies;
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