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THE INFLUENCE OF POLYPHENOL EXTRACT FROM DANDELION ON THE PHYSIOLOGICAL STATE OF THE ORGANISM OF BREEDING ROOSTERS

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Abstract

This paper includes the study of specialized scientific bibliographic sources and the research of the influence of polyphenols on the improvement of the state of oxidative stress on the organism of breeding rooster. It is established that dandelion polyphenols have a beneficial influence and have the ability to stop and block reactive forms of oxygen through fermentative and non-fermentative antioxidant systems. All these changes are observed in the obtained results. It is established that there is an increase of superoxide dismutase (SOD) in the experimental group compared to the corresponding control group 159.6±0.69 and 110.93±0.30 u/c, as well as catalase indicates significant changes in the experimental group versus the corresponding control group 35.0±0.53 and 26.23±0.37 µM/L, which provides reliable protection of the organism against the toxic effects of high concentrations of superoxide anion radical and hydrogen peroxide.

***Key words**: breeding roosters, polyphenols, antioxidants, oxidative stress, food ration.*

INTRODUCTION

Fundamental and applied research is currently being carried out in multiple research institutions, directed in all directions of studying biologically active compounds of plant origin. In particular, research on antioxidants (AO) is of particular interest. These substances are able to significantly diminish or modify the oxidation of the substrate (Bekker et al., 2004), which can be widely used in the pharmaceutical, food, cosmetology, veterinary medicine and other industries. It is known that plants can be rich sources of antioxidants, such as phenols, flavonoids, carotenoids, tocopherol, ascorbic acid etc. (Katalinic et al., 2006).

Living organisms are protected from the influence of free radicals by the antioxidant system, which contains fermentative and non-fermentative substances, capable of completely neutralizing the harmful influence of these toxic substances (Iashin, 2008). The decrease in the activity of the antioxidant system and therefore the increase in the concentration of free radicals in the organism is linked to a multitude of unfavorable factors, such as radioactive and ultraviolet irradiation, worsening of the ecological situation, permanent stresses, unsupervised administration of veterinary drugs, use of feed contaminated with different pollutants etc.

The harmful effects of free radicals in the case of oxidative stress can be reduced by regular consumption of certain nutrients with antioxidant activity. The main natural antioxidants are flavonoids, aromatic hydroxy acids, anthocyanins, vitamins C and E, carotenoids etc.

Anthocyanins are of exceptional importance because due to the charge of the oxygen atom in the C ring, anthocyanidins and anthocyanins penetrate cell membranes more easily (Ehlenfeldt et al., 2001).

Polyphenols occupy a significant place among the most important classes of natural compounds, which determine the biologically active influence on the tissues and organs of the body with the maintenance of their functions at an optimal level of their activity. Most flavonoids give living organisms anti-inflammatory influence, antioxidant protection and many other positive effects for their proper functioning. Currently, it is considered that flavonoids are indispensable components of the food ration of animals and humans. In plants flavonoids are found in free form and in the form of glycosides, their content varies from 0.5 to 5% (Petrova, 1986; Smirnova, 1986). According to research (Kalashnikov et al., 1985) the content of flavonoids in the aerial part of the plant does not exceed 3.5%.

According to modern concepts, free radicals and other forms of reactive oxygen species (ROS) play a significant role in regulating the basic functions of the cell. It should be noted that ROS, depending on the strength of the pathogenic factor affecting the cell, can act either as inducers of adaptation processes or as inducers of apoptosis. In addition, ROS are able to directly influence the destructive effect on cellular structures, as well as the initiation of free radical oxidation of lipids, proteins, nucleic acids, which is the basis of the pathogenesis of many disorders of organs and systems of living organisms (Sazontova et al., 2005; Shabanov et al., 2010). ROS realizes its physiological and pathological effects in close interaction with other regulatory factors of the intra - and extracellular metabolic process, modifying their activity (Lukyanova et al., 2013; Novikov et al., 2013).

Of all the cellular components most subject to attack by ROS are mitochondria, as a result of damage to membrane lipids, proteins, DNA and even their death. Moreover, the death of mitochondria does not require any additional proteins other than those that are present in itself.

Mitochondria possess a protective system against ROS, which includes the enzymes superoxide dismutase (neutralization of superoxide anion into hydrogen peroxide), peroxidase and glutathione peroxidase (degradation of hydrogen peroxide), as well as glutathione, reduced form of coenzyme Q, ascorbic acid and other low molecular weight antioxidants.

When mitochondria cease to cope with the problem of ROS detoxification that they form, regardless of the listed defense mechanisms, the so-called "oxidative stress" develops in the cell. As a result of excessive formation of oxygen radicals, the latter begin to perform mainly destructive functions, rather than serve as signaling molecules. Specific changes in cellular components take place: membrane structures are damaged due to lipid peroxidation (LPO), proteins are oxidized to tyrosine, cysteine and serine residues, DNA damage, a change in the redox potential of the cell due to oxidation of glutathione and NAD(P)H. Is observed the destruction of mitochondrial structures from the membrane to mitochondrial DNA (mtDNA) (Murphy, 2004).

ROS have a damaging effect primarily on mitochondrial membranes. In particular, under the action of ROS in the internal membrane protein of mitochondria, which provides conjugate ATP/ADP transfer, oxidation of Sh-Group Cys-56, which promotes the formation of a nonspecific mitochondrial channel (mPTP), permeable to low molecular weight substances (Pojilova et al., 2014). ROS significantly affects the concentration of calcium ions in the matrix of mitochondria and cell cytoplasm, causing the pumping of Ca^{2+} into the cytoplasm from the extracellular and intracellular space, and into the matrix - from the cytoplasm, by activating calcium transporters (Ghosh et al., 1995).

Mitochondrial DNA (mtDNA) is also a vulnerable target for the pathogenic action of ROS. The high concentrations of reactive oxygen species in mitochondria and the weak repair system between these organelles increase the frequency of mtDNA mutations compared to nuclear DNA. Oxygen radicals cause specific substitutions in the DNA molecule. Thus, the hydroxyl radical has a harmful effect on DNA due to oxidation of bases, their modification and damage to chromosomes. Such mutations can lead to pathology and cell death or to its malignant transformation. MtDNA damage is particularly dangerous due to the gradual, long-term accumulation of mutations under the long-term effect of ROS. A number of important and unique mitochondrial proteins are encoded in the mitochondrial genome, and the damage to the genes responsible for them leads to the dysregulation

of their expression and their subsequent functioning (Skulachev, 2012).
Since the formation of ROS in the cells of aerobic organisms occurs continuously, then in the cells there is a system of protection against their harmful influence. Protecting cells from excess ROS, and the oxidative damage caused by them, is achieved through the functioning of the antioxidant system, which includes oxidizing antienzymes, low molecular weight compounds and those that form a redox buffer, vitamins, albumins, free fatty acids and metal ion complexes.
Antioxidant enzymes that neutralize ROS include superoxide dismutase (SOD), catalase and peroxidase. SOD catalyzes the dismutation of two superoxide molecules to form hydrogen peroxide and oxygen. Isoforms of this enzyme are present in all cellular compartments, where superoxide can form. Hydrogen peroxide formed during superoxide dismutation is neutralized by catalase or glutathione and thioredoxin-peroxidases in peroxisomes.
The intracellular redox status is assisted by the thiol system and primarily by glutathione (GSH) and thioredoxin (TRX), which create a buffer system to maintain a more reduced amount compared to the conditions of the extracellular environment. Glutathione is one of the main intracellular antioxidants, which participates in maintaining the redox status due to the neutralization of hydrogen peroxide: $H_2O_2 + 2GSH \rightarrow 2H_2O + GSSG$. Regeneration of reduced glutathione (GSH) from glutathione disulfide (GSSG) occurs by means of glutathione reductase: $GSSG + NADPH + H+ \rightarrow 2GSH + NADP +$. Under the conditions of oxidative stress due to the rapid oxidation of glutathione, the ratio GSH/GSSG decreases, but it can very quickly restore to the initial level. In the case of depletion of GSH in any tissue, it can be supplied due to its release into the blood from the storage (liver) (Urso et al., 2003). Thioredoxin acts as a reducer of disulfide bonds in proteins and an electron donor for TRX-eroxidase, at the same time it does not affect the production of ROS or the reduced amount of glutathione. Thioredoxin is reduced by thioredoxin reductase and NADPH (Li et al., 2002).
The free radical formation processes hypochlorite anion and hydroxyl radical are located in the cytoplasm and are monitored by cytoplasmic enzymes or natural water-soluble antioxidants. For example, taurine is able to block the hypochlorite anion in the form of a chloramine complex, carnosine (dipeptide) and its derivatives will neutralize the hydroxyl radical. A major importance for the prevention of lipid peroxidation, which is initiated in the hydrophobic space of cell membranes and the destruction of fatty acid radicals, is α-tocopherol, being located in membranes. Having a high concentration in biological membranes prevents their damage by free radicals. Tocopherol interrupts the chain reactions of lipid peroxide formation, transforming into a radical, which regenerates both with the help of water-soluble active reducing agents such as ascorbate and glutathione, and with the help of hydrophobic ubiquinol. From the point of view of antioxidant protection, ubiquinol is the most effective form of coenzyme Q_{10}.
The regulation of ROS formation can be achieved in two ways: through the direct influence on oxygen free radicals and their binding (direct antiradical action) and through the way of fortifying of antioxidant activity (first of all, the activity of antioxidant protection enzymes). However, the use of nutrients rich in anthocyanins, phenols, polyphenols, etc. it can be aimed both at eliminating the primary damage induced by ROS, which are the basis of the pathogenesis of functional disorders of the organs and systems of the animal and human organism, and at blocking the apoptosis induced by them (Kiricek et al., 2004).
The negative role of ROS and oxidative stress has been demonstrated in many dysfunctions of living organisms. For example, during hypoxia, it is confirmed that antioxidants weaken the disorders associated with hypoxia (Marcova et al., 2013; Novikov et al., 2011). Therefore, antioxidants are used in the complex correction of hypoxic states (Levcenkova et al., 2012; Cekman et al., 2014). Antioxidant therapy is widely used today for ischemic diseases in cardiology and neurology, for toxic liver damage, systemic connective tissue diseases and other ailments (Kriucova et al., 2013; Shabanov et al., 2010).

Special attention in scientific research is attracted by the so-called "physiologically compatible antioxidants" (PCAO), representing in themselves modified natural antioxidants (Novikov et al., 2007). PCAO are conjugated redox factors, maintaining homeostasis indices within normal physiological limits and returning homeostasis indices to normal values in pathological situations or extremals. A particularity of PCAO is their ability towards compatibility, which is represented as more important compared to the antioxidant activity. They are able as a component part of one or another physiological system to influence molecular targets and cause deviations in the oxidation-reduction potential of the cell, synchronized with cell cycles or other biological cycles. PCAO very effectively regulates free radical oxidation reactions and the redox status of the cell (Novikov et al., 2013).

Therefore, the research of these biologically active substances, the development of methods for their isolation, the determination of their chemical structure and the study of the dependence of biological activity on chemical structure in order to create new preparations with antioxidant effect is an important and urgent problem of biomedicine. The interaction of free radicals of oxygen with proteins leads to a variety of reticular disorders and other cellular components, such as protein fragmentation, specific damage to the protein molecule, which changes its structure and affects the functional activity of the protein.

Inhibitors of reactive oxygen species (ROS) form the basis of the body's defense system against the excessive generation of active oxygen metabolites (AOM). In fact, the body's defense against AOM is a universal complex system of chemical and biochemical reactions that occur at different biological levels and taking place through different mechanisms, involving various high and low molecular weight compounds, such as redox enzymes, polypeptides, some vitamins, amino acids, polyphenols etc. (Zencov et al., 2001; Budnikov et al., 2005).

MATERIALS AND METHODS

The study was carried out on 10 breeding roosters and they were divided into two groups of five roosters each: a control group and an experimental group, which were administered *per os* in a dose of 2 ml hydroalcoholic polyphenol extract from dandelion with a total amount of antioxidants of 0.27 g gallic acid equivalent per 100 gr. The extract was administered during two cycles of spermatogenesis. Hematological, biochemical indices and amino acids in blood serum and seminal plasma were studied. Spectrophotometric methods and the Folin-Ciocalteu method were used to determine the total amount of antioxidants. The total amount of antioxidants was determined on the SF-5400 UF spectrophotometer.

RESULTS AND DISCUSSIONS

In order to determine the influence of biologically active substances obtained by hydroalcoholic extraction from dandelion, hematological indices of roosters from the experimental group and the control group were studied. The research results are presented in Table 1.

Table 1. Hematological indices of the reproductive roosters included in the experiments for study the action of dandelion polyphenols

Groups	Leukocytes, 10^9/L	Erythrocytes, 10^12/L	Hemoglobin, g/L	Hematocrit, %	Mean corpuscular hemoglobin MCH, pg	Mean corpuscular volume MCV, fl	MCH concentration g/dL
Control	38.6± 4.3	3.45±0.25	139.3±5.5	46.3±2.25	39.4±0.57	131.5±0.87	30.5±0.16
Experimental	41.3±3. 2	3.67±0.08	143.3±2.08	47.2±1.22	39.0±0.21	128.4±1.58	30.3±0.45

Leukocytes represent those components of the blood that are involved in the defense against pathogens and in the identification of active pathologies. Although they represent only 1%

of the blood volume, being, nevertheless, key elements of the immunity of each individual organism, their role in the immune response is a huge and indispensable. From the obtained results we observe changes in their content, in the control group having a content of 38.6±4.3, and in the experimental group the value is 41.3±3.2 - 10^9/L, which testifies to us about a positive influence of dandelion extract on these blood elements.

Erythrocytes, in turn, also have different roles in living organisms, such as: transporting oxygen and carbon dioxide, amino acids, hormones (through their absorption on the surface of erythrocytes), participate in immunological processes, in maintaining blood pH etc., also changes are observed in their content for the control group having a value of 3.45±0.25, and for the experimental group indicating a value of 3.67±0.08 - 10^12/L.

The hemoglobin also shows changes in its content with a value for the control group of 139.3±5.5, and for the experimental group 143.3±2.08 g/L.

Based on the experimental results that are presented in table 1, a change and stabilization of all the investigated hematological indices is observed.

In addition to studying the hematological indices, some biochemical indices of the antioxidant system were also studied. The research results are presented in Table 2.

Table 2. The fermentative antioxidant status in the blood serum of the reproductive roosters included in the experiment to study the action of dandelion polyphenols

Groups	SOD, u/c	G-GTP, u/L	Catalase, μM/L	G-S-T, nM/sL
Control	110.93±0.30	9.33±0.40	26.23±0.37	19.21±0.38
Experimental	159.6±0.69	11.4±0.44	35.0±0.53	30.41±0.52

Superoxide dismutase (SOD) plays an important role in protecting cells from the damaging effect of the radical anion superoxide and is rightfully considered the main enzyme of the intracellular antioxidant system. SOD not only stabilizes cell membranes by preventing lipid peroxidation, but by decreasing oxygen levels, it protects catalase and glutathione peroxidase. The results of the research show an increase of the SOD value up to 159.6±0.69 compared to the control group with a value of 110.93±0.30 u/c.

SOD activity is regulated by compounds containing SH groups: glutathione, cysteine and others, as well as indirectly by glutathione metabolism enzymes. The results are presented in table 3. The latter, together with catalase and peroxidases have different substrate specificities, providing the detoxification of hydrogen peroxide. However, a noticeable disadvantage of this enzymatic process is the formation of hydrogen peroxide, which is prone to the generation of highly reactive hydroxyl radicals, but is reduced to water mainly by catalase and glutathione peroxidase.

Catalase in combination with SOD forms a reliable protection of the body against the toxic effects of high concentrations of superoxide anion radical and hydrogen peroxide. At the same time, the minimum controlled level (<50 μM) of these biomolecules, which are necessary under physiological conditions for the implementation of many cellular processes, is maintained. The results of the research show us a higher activity of catalase in the experimental group with a value of 35.0±0.53, compared to the control group with a value of 26.23±0.37 μM/L.

Glutathione peroxidases (GPO) are the most important enzymes that ensure the inactivation of reactive oxygen species by destroying both H_2O_2 molecules and lipid hydroperoxides. These enzymes catalyze the reduction of peroxides with the participation of the tripeptide - glutathione (γ-glutamylcysteinylglycine). GPOs are able to neutralize not only H_2O_2, but also various lipid peroxides synthesized in the body upon activation of POL processes. Glutathione peroxidase protects proteins, lipids, nicotinamide coenzymes from oxidative attack and restores lipid peroxides.

In addition to the ability to reduce hydrogen peroxide and fatty acid hydroperoxides, GPO provides protection to aerobic organisms against the highly toxic peroxynitrite by reducing it to the nitrite anion. In addition, glutathione-S-transferases are involved in the isomerization of steroids and prostaglandins and are involved in the metabolism of other endogenous substances. In particular, GST may be involved in the synthesis of leukotrienes, supporting the inflammation process. Therefore, a positive influence of the polyphenol extract of dandelion is observed on the indices of the fermentative antioxidant status in the blood serum of breeding roosters.

In addition to studying the hematological indices and the fermentative antioxidant status, the comparative content of the combined functional groups of free amino acids in the blood serum, seminal plasma and reproductive cells of breeding roosters and their distribution depending on the biological material studied were also investigated. The research results are presented in Table 3.

Table 3. Comparative content of combined functional groups of free amino acids in blood serum (mcm/100 ml), seminal plasma (mcm/100 ml) and reproductive cells (mcm/100 g) of breeding roosters

Amino acids	Blood serum	Seminal plasma	Reproductive cells
Σ Nonessential amino acids	301.59±34.10	1642.21±106.50	70.66±0.27
Σ Essential amino acids	104.15±15.90	154.57±11.90	33.31±2.80
Σ Immunoactive amino acids	136.53±23.95	846.57±56.29	46.01±0.18
Σ Glycogenic amino acids	164.79±22.06	330.33±10.49	35.66±0.91
Σ Ketogenic amino acids	40.54±8.49	56.87±6.96	10.84±0.20
Σ Proteinogenic amino acids	405.74±48.74	1796.78±118.40	103.96±3.07
Σ Sulfur-containing amino acids	23.54±7.43	79.16±12.07	6.74±0.23

From the results of the research, it can be seen that the proportion of immunoactive amino acids in the blood serum is 31.23%, while in seminal plasma and reproductive cells it is much higher - respectively 44.90% and 41.57% of the total amino acid content. Likewise, from the obtained data, we observe that the proportion of sulfur-containing amino acids is almost the same in the blood serum (5.38%), seminal plasma (4.20%) and reproductive cells (6.09%).

The ratio of proteinogenic amino acids to the total volume of free amino acids is 92.82% in blood serum, 95.30% in seminal plasma and 93.94% in reproductive cells, that is, it is practically identical. Interestingly, at the same time, the share of the fund of essential amino acids in the blood serum is 23.83%, seminal plasma 8.20%, and in reproductive cells they are much higher - 30.09%.

CONCLUSIONS

The inclusion in the food ration of antioxidant substances of plant origin beneficially influences the protein, lipid and carbohydrate metabolism at any level of organization of the tissues and systems of living organisms.

The relevance of studying this problem is constantly increasing due to the convincing scientific results regarding the role of ROS not only in maintaining homeostasis, but also in the development of cellular pathology and dysfunctions of the animal organism in general.

It is important to note that, despite the great interest in the use of antioxidants to prevent and reduce the consequences of biological disorders associated with oxidative stress, further research is needed to study the effect of these compounds on the antioxidant status and on the level of oxidative stress in the body of bioobjects.

The results of this study allow us to conclude that the spectra of free amino acids of both seminal plasma and spermatozoa indicate changes in which they can cause pathologies of metabolic processes in spermatozoa.

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