Chapter

Phytobiotics, a Natural Growth Promoter for Poultry

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Abstract

Genetic advance aimed at accelerating the growth rate of slaughter birds have reduced the natural resistance of poultry to infections. It also increased susceptibility to stress, which resulted in deterioration of the welfare and productivity of poultry. Additionally, intensive poultry production poses a risk of exposure of chickens to unfavorable zoo-hygienic conditions and contamination with pathogens from the external environment (bedding, water, feed, hen house staff, sick birds in the flock). Due to the potential production losses, measures are taken to improve the health and effectiveness of bird rearing, for example by using growth stimulants and improving the composition of the gastrointestinal microbiome and improving metabolism and the work of the immune system. The addition of phytobiotics to feed or drinking water supports digestion and metabolism in the body, stimulates the growth and development of a useful microbiome, limits the multiplication and adhesion of pathogens, and improves the structure and functioning of enterocytes. The aim of this study is to present the health benefits resulting from the use of phytobiotics in poultry production, as well as to make people aware of the dangers of incompetent incorporation of herbs into feed mixtures or into drinking water. Due to the fact that not all species of animals react equally to a given plant, the selection of plant materials should be carefully considered and matched to the expected benefits. By using phytobiotics you can improve growth and performance of broiler chickens, through greatly improve digestion and nutrient assimilation. Plant additives can improve health through stimulate immunity and increase resistance to stress. Using of phitobiotics improve the quality of meat and eggs, increase the weight of valuable parts of carcass (pectoral and leg muscles) and stimulate laying. Unfortunately, due to the potentially toxic effect of an excess of certain herbs on the work of the liver, and the adverse changes in the palatability of eggs, use caution in the use some herbs e.g. of garlic, turmeric, rapeseed, alfa alfa, shiny privet or moringa.

Keywords: phytobiotic, plant additive, poultry nutrition, performance and metabolism, toxic plants

1. Introduction

The using of plant additives, the so-called phytobiotics, been known to man since ancient times, when herbs were used both in the prevention and treatment of people and farm animals. Already great civilizations: Egyptian, Chinese, Greek and Roman successfully used the specific properties of herbs and plant additives [1]. Numerous observations of the animals' reactions allowed for the use of specific

herbs in the treatment of a given disease, as well as eliminating the use of those species of plants that are potentially harmful or toxic. At present, the intensive development of analytical techniques allows the identification of a whole range of biologically active substances in plants, responsible for their beneficial effects. In poultry practice can use plant additives, in both fresh and dried, fermented or freeze-dried, as well as water or alcohol extracts made on their basis [2]. In poultry rearing, in addition to basic nutrients, minerals and vitamins, feed additives are successfully used. According to the regulation of the European Parliament and of the Council [Regulation (EC) No 1831/2003], a feed additive is defined as "a substance, micro-organism or chemical substance intentionally added to a feed for the purpose of improving feed properties, meeting nutritional requirements of animals, positively influencing genetics and production animal characteristics and welfare and to increase livestock production". One such additive is phytobiotics [Regulation (EC) No 1831/2003]. The phytobiotics can expected to regulate digestive processes, support the secretion of digestive enzymes and bile, increase appetite, improve the absorption of nutrients and act to support, and also detoxification of the body. Plant supplements may, however, also act more specifically, i.e. inhibit the growth of pathogenic microorganisms, regulate the gastrointestinal microbiome, stimulate the immune, reproductive and endocrine systems, have antioxidant and antiallergic properties, accelerate wound healing, stimulate blood circulation, inhibit inflammation and promote epithelial regeneration intestines and intestinal villi, and even improve the quality of eggs or meat. The most of the active antioxidants plant, are secondary metabolites bilonging to the classes of isoprene, flavonoids and glucosinolates derivatives, and their properties could also use to shape the characteristics of food of animal origin. In practice many plant substances have been used successfully to improve egg laying, egg quality and meat quality [3–6]. The use of antibiotics as growth promoters (AGP) in livestock has been banned in year 2005, due to concerns about their residues in animal tissues and subsequent induction of bacterial resistance. Accordingly, phytobiotics are gaining in importance as possible alternatives to antibiotic growth promoters because they are natural, readily available, non-toxic and residue-free [7–9]. The phytobiotics raw materials can be herbal extracts or parts of plants (leaves, rhizomes, roots, flowers or bark, bulbs, stems, as well as fruits and seeds), in which the accumulation of biologically active substances is greatest. In addition, isolated pure bioactive substances are used, e.g. essential oils, dyes (mainly carotenoids, anthocyanins), alkaloids, glycosides, phenolic acids, phytosterols, flavonoids, etc. It is worth remembering, however, that often the desired effect of phytobiotics is not constant and fully predictable in advance [6]. Contradictory results from the use of plant additives may result from the natural variability of the composition of plant secondary metabolites, their diversity and environmental conditions for plant growth, harvest time, maturity, as well as the method and duration of conservation, storage or processing. In addition, the conditions of the analytical method required to obtain the bioactive substances themselves from plants, the method of extracting these substances from the plant are important; and possible synergism or antagonism in the case of mixtures of substances, or the presence of toxic and anti-nutritional components for a given animal species, and also microbiological contamination of plants product [1, 6]. Many researchers question results about anti-diarrheal, antiseptic, antimicrobial, and anti-inflammatory properties of plants, especially because of the variations found in biological indicators in vivo studies. It is important to note that the positive effects will depend on the animal species, the productive category, environmental conditions, and characteristics of the plant material used [2].

The aim of this study is to present the health benefits resulting from the use of phytobiotics in poultry production, as well as to make people aware of the dangers

of incompetent incorporation of herbs into feed mixtures or into drinking water. Due to the fact that not all species of animals react equally to a given plant, the selection of plant materials should be carefully considered and matched to the expected benefits.

2. The influence of phytobiotics on the processes taking place in the birds' organism

2.1 The influence of phytobiotics on growth and performance of broiler chickens

The use of plant additives in poultry rearing can improve the absorption, use and absorption of valuable nutrients, and also stimulate the immune system. Phytogenic feed additives very often improve palatability and feed conversion, which in turn can lead to improved efficiency of poultry rearing (body weight, feed

Plant	Used part/ material	Active component	Beneficial effect	References
Cinnamon (*Cinnamomum zeylanicum*)	bark, leaves/ cinnamon oil	cinnamaldehyde eugenol, phenolic and polyphenolic substances	improves of appetite and digestion; enhances of antioxidant status; actions antimicrobial and blood purifying; alleviation of adverse effect of environmental stress; chemopreventive effect	[6, 10–12]
Garlic (*Allium sativum*)	crushed bulbs	allicin, ajoene, allyldisulfide, vinyldithiin, phytosterols, mucilages, pectins, flavonoids	improves immunity by increasing the titer of antibodies, stimulating the activity of lysozyme and increases the phagocytic activity of macrophages; chemopreventive effect, actions antiseptic and alleviate adverse effect of environmental stress; improves of digestion and the blood lipid profile; improve of growth and FCR	[11, 13–16]
Coneflower (*Echinacea purpurea*)	leaves root/ dried herb, water and alcohol extracts, root	polysaccharides, flavonoids, polyphenolic acids - mainly chlorogenic acid and caffeic acid, alkylamides, polyacetylenes	immunomodulatory - stimulates phagocytic activity of macrophages, increases the activity of lysozyme, increases the titer of antibodies; antimicrobial, antitumor, antidiabetic, and antioxidant, digestion stimulant, improves of growth and FCR	[6, 8, 14, 17–22]
Moringa (*Moringa oleifera*)	leaves/ extracts	chlorogenic acid, caffeicacid, ascorbic acid, flavonoids, phenolics and carotenoids	improves in egg production and decreases FCR; alleviates adverse effect of environmental stress; improves in egg production and decreases FCR; alleviates adverse effect of environmental stress; antioxidant activity	[2, 10, 23–25]
Pappermint (*Mentha piperita)*	leaves/ powder	menthol, terpenes	enhances of appetite and stimulate of digestion; causes decrease of FCR; it works antiseptic; improves in the laying performance, quality and freshness of eggs, and an color or the chemical composition of yolk	[14, 23, 26–28]

Plant	Used part/ material	Active component	Beneficial effect	References
Turmeric (*Curcuma longa*)	rhizome/ powder	curcuminoids, turmerones,	improves the blood lipid profile; improves digestion - choleretic, increases appetite; action antioxidative; anticarcinogenic; antihepatotoxic and immunomodulatory - stimulates the production of interferon; chemopreventive effect	[29, 30]
Aloe vera (*Aloe barbadensis*)	leaves/water extracts, powder, gel powder	anthraquinones polisaccharides (mainly icemannan) vitamins, enzymes, salicylic acid, anthraquinones and lignin, aminoacids	immunomodulation - stimulates the activity of granulocytes and granulocytic enzymes (myeloperoxidase, peroxidase), increases the titer of antibodies; alleviate adverse effect of environmental stress; action antidiabetic, and antioxidant - decreasing the lipid peroxidation and increasing the antioxidant status; stimulation of digestion - improve absorption of nutrients from the intestine, improve of intestinal microflora; improve of performance and FCR; increasing and providing protection to the vital phisiological organ like liver and kidney	[29–33]
Ginger (*Zingiber officinale*)	roots/ extracted basic oil	monoterpenes and sesquiterpenes	improves body weight gain due to stimulation of digestive enzymes and improvement of overall digestion, inhibits the growth of harmful bacteria in the intestinal tract due to antimicrobial activity lead to assimilation of nutrients, improves carcass traits, decreases abdominal fat; immunomodulation - increases the activity of lysozyme; chemopreventive effect	[28]

Table 1.
Effect of different herbs on the physiological functions and performance of poultry.

consumption, feed conversion, daily weight gain, mortality, etc.) (**Table 1**) [34]. According to Wenk et al. [13], dietary plant extracts strongly stimulate the endocrine system and indirect metabolism of nutrients. Many plant additives, including cinnamon, ginger, garlic, fenugreek, oregano, ribwort plantain, thyme, sage, marjoram, echinacea, lemon balm, cumin, peppermint, nettle, chamomile, sea buckthorn, milk thistle whether alfalfa, can stimulate metabolism and the absorption of nutrients, prevent inflammation of the digestive tract, has a tonic effect, prevent diarrhea, improve intestinal immunity and the composition of the microbiome (by competing with pathogens, the gut microbiome increase enterocytes permeability and nutrient absorption, and creates a protective biofilm that limits or inhibits the colonization and multiplication of pathogenic bacteria), has antiparasitic, anti-inflammatory and antioxidant properties, which in turn improve the birds' health. The effect of limiting the multiplication and adhesion of pathogens is the improvement of the structure and functioning of enterocytes, as well as acceleration of the maturation of cells of the intestinal immune system and strengthening of the immune response [14].

Moreover, the addition of phytobiotics increases the secretion and activity of digestive enzymes and the speed of digestion, stimulates the work of the pancreas and liver [35]. According to Rao et al. [36] Lee et al. [37] and Jang [38], essential oils and plant extracts administered in the feed of broilers, stimulate the secretion of amylase, maltase, trypsin and pancreatic lipase. Additive 100 ppm and 200 ppm essential oil derived from cinnamon do diet of chickens causes an improvement in the live weight gain and the health of broilers and feed conversion ratio (FCR) [10]. The addition of garlic or turmeric powder at 0.5% to the chickens' diet, can improve of broiler growth and feed conversion ratio (FCR) and decreased mortality rate [11, 15]. The improvement in yield may be related to the presence of various important alkaloids that have a positive effect on the health of broilers. For example, the sanguinarine is an alkaloid with excellent biological properties [17], positively influencing gastric motility, fermentation process and intestinal histomorphology [18]. Hernandez et al. [19] showed that the supplementation of diet by Rosmarinus officinal is, carvacrol, cinnamonaldehyde and capsaicin can improve feed digestibility in broilers. Aroche et al. [2] suggested that polyphenols, and especially tannins obtained from the leaves of *A. occidentale*, have the ability can bind to saliva lubricating proteins by hydrogen bonds; therefore, an increase of this metabolite in the diet could reduce the passage of the digesta in the gastro-intestinal tract and decrease the feed intake by a higher state of satiety in this period. However, an excess of tannins can provoke metabolic disturbances leading to an antinutritional influence, such as inhibiting the absorption of iron and sulfur containing amino acids causing anemia and depression of growth. The addition of calendula or corn to the diet improves the color of the broiler carcass, giving the skin a yellow tint. The addition of mint and pansy to the chickens diet increases the proportion of unsaturated acids change the fatty acid profile in the meat, while hops, nettle and lemon adversely change the fatty acid profile in meat, increasing the proportion of polyunsaturated fats [20]. Al-Kassie [10]; El-Ghousein et al. [21]; and Najafi et al., [22] showed a very beneficial effect of thyme on the efficiency of poultry rearing also. The addition of phytobiotics to water or feed also improves egg production, chemical composition and egg quality. For example, ginger essential oil or powder ginger (100–150 μl/kg body weight), when applied to water or poultry feed, can improve improves laying performance, chemical composition and egg quality. The use of plant additives in poultry rearing may contribute to increasing the weight of eggs and the thickness and strength of their shells, as well as stimulating the laying rate and contributing to the extension of the laying period [8, 39, 40]. The addition of garlic powder (1–5%), ginger, mulberry, black cumin, black seed, thyme, mentha and goldthread to the diet of laying hens increases the weight of the egg, the protein content of the egg and egg yolk antioxidants contain [9, 28, 41–46]. Swain et al. [47] observed that the addition of moringa leaf flour to the diet of chickens (5 g/kg) can also increases egg production (increases the number of eggs laid and improves their consumption quality). An important advantage of using phytobiotics in egg production is also the can improve egg quality and the vitelline membrane integrity besides enhancing antibody titer against Newcastle disease, as well as the color of the yolk and the quality of the protein, and eggs' freshness [42, 48, 49]. In practice, a factor contributing to increasing the yolk color intensity in a slow-ranging system is supplementing the diet with plants that are a source of xanthophylls, especially lutein, present in pumpkin, marigold, corn kernels, parsley or chives [40, 42, 50]. Supplementing the diet with plant ingredients or biologically active substances of herbs can improve the nutritional value of table eggs. Often, using phytobiotics in the diet of laying hens can reduces the amount of cholesterol in the yolk, the excess of which in the diet promotes the development of atherosclerosis in humans and stimulates the development of harmful free radical reactions in blood vessels. To reduce cholesterol in the yolk worth applying addition of garlic,

ginger, black cumin, black seed, nettle, black tea, sage, thyme and mentha [43, 44, 51–53]. For this purpose, eggs are enriched with polyunsaturated fatty acids, and the oxidative stability of the yolk's lipids is improved. Using of ginger in layer diets can also advantageously increase activity of antioxidants enzymes and decreased content of MDA (harmful product of lipid peroxidation) and cholesterol in yolk [28, 54, 55]. Swain et al. [47] observed that additive of moringa leaf meal to chicken diet (5 g/kg) causes decrease of feed conversion ratio (FCR). Cayan et al. [55] observed that olive leaf powder added to chicken diet can increase yellowness in yolk color and decrease of yolk cholesterol content about 10%. Sunder et al. [56] showed that daily consumption of Indian mulberry (*Morinda citrifolia*) powder by hens increases the egg weight and the thickness of the egg shell. According to Cayan et al. [55] supplementation of the diet of laying hens with 0.1 and 0.5% the addition of thyme, improves feed conversion and egg production. Santoso et al. [57] reported that supplementation 5% addition of papaya leaf extract can improve body weight gain and carcass quality in broiler chickens, and increase egg protein content. The scientific literature contains also numerous reports indicating that phytobiotics do not significantly affect growth performance, feed conversion ratio and the survival rate of poultry but regulate the physiological functions of the organism (metabolism, activity of important enzymes, the level of minerals or blood composition) [5, 58, 59].

2.2 Influence of phytobiotics on the course of physiological reactions

Phytobiotic additives allow to regulate the course of physiological reactions, often conditioned by the activity of appropriate enzymes and hormones, at the level of metabolic biochemical changes in cells [5, 59, 60]. Plant additives can also improve the course of physiological functions, thus improving the performance of birds (**Table 2**) [14]. The use of e.g. cinnamon oil, garlic, echinacea, narrow-leaved

Plant	Used part/ material	Active component	Beneficial effect	References
Cinnamon (*Cinnamomum zeylanicum*)	bark, leaves/ cinnamon oil	cinnamaldehyde, eugenol, phenolic and polyphenolic substances	increase the proportion of HDL cholesterol, reduction of total cholesterol and triacylglycerols level, decrease lactate dehydrogenase, creatine kinase and β-hydroxybutyrate dehydrogenase activity, normalize the activity of aminotransferases	[6, 8, 10, 61]
Garlic (*Allium sativum*)	crushed bulbs	allicin, ajoene, allyldisulfide, vinyldithiin, phytosterols, mucilages, pectins, flavonoids	increase of HDL content, decrease of total cholesterol and triacylglycerols level,	[60]
Coneflower (*Echinacea purpurea*)	leaves root/ dried herb, water and alcohol extracts	polysaccharides, flavonoids, polyphenolic acids - mainly chlorogenic acid and caffeic acid, alkylamides, polyacetylenes	increase of HDL content, decrease of total cholesterol and triacylglycerols level	[59]

Plant	Used part/ material	Active component	Beneficial effect	References
Lavender *(Lavandula angustifolia)*	the whole plant, oil	hydrocarbons, alcohols, ketones, esters, aldehydes, oxides, and ethers coumarins and organic acids	beneficially effects on lipids' digestion and absorption due enhance the synthesis and excretion of bile acids in the liver, it could improve the lipids' digestion and absorption, decrease of total cholesterol	[6]
Pappermint (*Mentha piperita*)	leaves/powder	menthol, terpenes	decrease of total cholesterol, triacylglycerols, LDL and glucose level, increase of HDL level,	[14, 26, 27, 62]
Nettle (*Urtica dioica*)	leaves, root/ water extracts	organic acids carotenoids flavonoids tannins organic compounds, phytoestrogens, sterols, fatty acids	improves serum lipid profile, decrease of triglycerides and total cholesterol in the blood;	[51]
Ginger (*Zingiber officinale*)	roots/ extracted basic oil	monoterpenes and sesquiterpenes	improves serum lipid profile, decreases of triglycerides and total cholesterol serum features, total protein, globulin and antioxidant enzymes were elevated	[28]
Oregano (*Origanum vulgare*)	leaves/oil	terpenoids: carvacrol and thymol, polyphenols	increase of HDL content, decrease of total cholesterol and triacylglycerols level, oxidative stability of the produced meat	[63]
Shinyprivet (*Ligustrum lucidum*)	bark, twigs, flowers / water decoctions	nuzenide, oleuropein, oleanolic acid, betulin	decrease levels of cholesterol, LDL cholesterol, triglycerides and alanine aminotransferase activity, increased blood serum level of HDL	[64]

Table 2.
Effect of different herbs on the biochemical components of poultry blood.

lavender, mint, nettle, ginger, oregano and shiny privet in the diet of chickens can to reduce the level of triacylglycerols in the blood, increase the proportion of HDL cholesterol (due to inhibition of 3-hydroxy-3-methylglutaryl reductase coenzyme A, a key enzyme in the synthesis of cholesterol), and also favorably reduce or normalize the activity of aminotransferases [6, 8, 51, 59, 60, 64, 65], as well as lactate dehydrogenase, creatine kinase and β-hydroxybutyrate dehydrogenase [6].

Moreover, Krauze et al. [6] thinking, that the increase in NEFA levels in the blood of chickens suggests a very beneficial, inhibitory effect of cinnamon oil on the synthesis of triacylglycerols, due to the use of glycerol for glucose synthesis in the process of gluconeogenesis [66]. Of course, there are many examples of the use of plant additives that stimulate physiological reactions in the world literature. Fenita et al. [67] declared that adding a 3% addition of noni powder to feed can lower cholesterol and triglycerides in the blood of chickens, even below 50%. The research concerns various doses, forms and frequency of use, both extracts and dried material, or extracted biologically active substances, administered with feed or drinking water. It is also important to add that other forms of plant additives also, which have recently become very popular, are used for this purpose, i.e. fermented

products, e.g. from soybean or rapeseed, improving the metabolic profile of poultry [68, 69]. Research has shown that herbal supplements can also reduce stress in poultry. Maryati et al. [70] and Muthmainnah et al. [71] believe that a 5% addition of essential oil from basil leaves to chickens improves the hematological profile of their blood. Such an additive can be, for example, aloe, which, by reducing the level of corticosterone in the blood, reduces the organism's susceptibility to stress factors and improves bird welfare. Moreover, the addition of sage, nettle or lemon to the diet of chickens reduces the stress response before slaughter [72].

2.3 Antimicrobial influence of phytobiotics and their influence on intestinal morphometry

Among the many plant additives the strongest antibacterial and antifungal properties can oils and plant extracts of thyme, echinacea, oregano, sage, garlic and cinnamon, rich in polyphenols. [72, 73]. The antimicrobial action of plant bioactive substances (polyphenols, especially flavonoids; and also tannins, coumarins, triterpenoids, isoprene derivatives, glucosinolates and alkaloids) is based on the disintegration of pathogen cell membrane structures what causing the migration of valuable ions from the pathogen's cell to the external environment, thus reducing their virulence [34, 74]. Research by Pasqua et al. [75] it have shown that limonene or cinnamic aldehyde can even destroy the structure of long-chain fatty acids in the cell membranes of *E. coli* bacteria. It has been suggested that the hydrophobicity of essential oils plays a key role in promoting the penetration of the phospholipid layer of the mitochondrial and cellular membrane of bacteria, leading to leakage of critical cell components and ions leading to cell death of these pathogens [76]. According to Castillo et al. [77] phytobiotics have a probiotic effect, and by selectively regulating the composition of the intestinal microbiota, they help maintain the eubiosis state [73, 77]. The results of the research conducted by the research team represented by Castillo et al. [77] showed, that a mixture of cinnamaldehyde, capsaicin and carvacrol stimulates the increase in the number of lactobacilli in the gastrointestinal tract. On the other hand, the results of the research by Jamroz [78] indicate that the herbal extract containing 5% carvacrol, 3% cinnamaldehyde and 2% capsicum oleoresin causes the formation of a thick layer of mucus on the chickens' stomach wall and jejunum. The formation of such a film reduces the possibility of the adherence of pathogens to the intestinal epithelium, which reduces the number of *Escherichia coli* and *Clostridium perfringens* bacteria and fungi in the intestines of birds. Stabilization of the intestinal microflora is particularly important in the critical periods of the animal production cycle, characterized by high susceptibility to health disorders, e.g. during chick rearing, change type of food, which is related to the age of birds, or, for example, the creating corals in turkeys. The addition of phytobiotics makes the birds less vulnerable to bacteria, toxins and other unwanted bacterial metabolites, such as ammonia and biogenic amines [79]. According to Puvača et al. [80] a significant number of bioactive substances present in essential oils leads to a reduction of the *Clostridium sp*. population in the digestive tract and poultry feces. Recently, high hopes have been associated with the use of preparations based on cinnamon, e.g. bark, powder or oil, containing cinnamic acid or aldehyde, stimulating the growth of lactobacilli in the gastrointestinal tract. Cayan et al. [55] suggested that supplementation diet of laying hens with 0.1 and 0.5%, the addition of thyme reduces the content of *E. colifecal*. The results of the research [6] showed that the use of a commercial preparation containing cinnamon oil (0.25 mL/L of drinking water) is able to improve the microbiome and morphometry of the small intestine of broiler chickens. Interesting results of research on the administration of plant additives were presented by Maryati et al. [70] and

Muthmainnah et al. [71] who showed that a 5% addition of essential oil from basil leaves administered to the feed can have antibacterial activity against *S. aureus* and *E. coli*. This oil owes its antibacterial properties to hydrocarbons, alcohols, esters, phenols (contains 1–19% of eugenol, iso-eugenol), phenolic ether (contains 3–31% methyl clavicol, 1–9% methyl eugenol), numerous oxides and ketones. Another valuable plant additive administered with the feed that reduces the production of toxic ammonia in the digestive tract of chickens is *Yucca schidigera* extract, which contains numerous saponins. Nazeer et al. [81] claims that such an addition significantly reduces the activity of urease in the intestines and feces in broilers fed with such an extract. It should be emphasized that the advantage of herbs is the selectivity of their antibacterial action, which will not be observed when using antibiotics. The antibiotic limits the multiplication of both harmful and beneficial bacteria, while the herbal extract used, for example, from cinnamon, thyme and oregano, only limits the growth of pathogenic bacteria. It should be noted, however, that such an effect is achieved with highly concentrated herbal extracts containing a mixture of various bioactive substances [79].

2.4 The influence of plant additives on bird immunity

From plant additives, stimulating the immune system, it is expected to improve the immune status, and consequently to streng then, the immunity of animals, improve their health and productivity. Plant preparations administered in the diet can increase the phagocytic activity of macrophages, increase the titer of antibodies and stimulated B and T lymphocytes, increase the level of lysozyme, stimulate the synthesis of interferon or have a chemopreventive effect (see **Table 1**). Herbs that stimulate the immune system include, among others: garlic, Echinacea, cinnamon, plantain, aloe, arnica, oregano, nettle and ginseng. The substances with a strong immunostimulatory effect are mainly: polyphenols, sulfur compounds, alkaloids, terpenes, saponins, essential oils and tannins [82]. The main components of valuable essential oils are lipophilic, liquid and volatile components, i.e. alcohols, aldehydes, esters, ethers, ketones, phenols and terpenes [83]. According to Aroche et al. [2], inclusion of mixed powder with *Anacardium occidentale* (60%), *Psidium guajava* (20%), and *Morinda citrifolia* (20%) to chicken diet can help with a quick immune system response and to improve immunity. This supplement exerts a beneficial immune effect, through an increase in the immunoglobulin G (IgG) concentration and with a synthesis of appropriate immune cells (macrophages). An increased immunoglobulin concentration has been associated with a benefit in the immune status, and IgG (with IgA) are the main immunoglobulins protecting against pathogenic microorganisms, mainly to intestinal level. IgG is one of the main defense barriers during the bacterial attack in the gastrointestinal tract (GIT), and the early proliferation of this cell is essential to improve the feed efficiency in these animals. The level of serum antibodies is an important indicator to know the effect of a natural product on immune response in animals [2]. Similar opinion has Tajodini et al. [84] who using artichoke powder (*Cynara scolymus*) in the diet of broilers found that this product significantly increased serum antibodies, resulting in a higher activity of the immune system. The results of the research [6] showed that the use of a preparation containing cinnamon oil (0.25 mL/L of drinking water) could improve the metabolism, and on the chickens' immunity.

2.5 Antioxidant effect of phytogenic substances

The health-promoting effect of plant antioxidants results from their protective counteracting both during the formation and the impact of reactive oxygen

species. The results of the research showed that the antioxidant activity of herbs reduces the risk of cancer, heart disease, hypertension and stroke; and in the case of food of animal origin, it can minimize the rancidity process, delay the formation of toxic oxidation in products and keeps maintain the nutritional quality of the product [85]. Oxidation processes that generate free radicals, take place in the organism of animals in a continuous manner. Nevertheless, they are counterbalanced by complex antioxidant mechanism (enzymatic and non-enzymatic antioxidants) that minimize the toxic effects of the effects of reactive oxygen species (ROS). ROS are responsible for damaging lipids, proteins and DNA, as well as for disrupting immune defense. This may lead to qualitative changes in animal tissues, reducing their health, as well as lowering the quality of animal products (meat, milk, eggs), and also shortening their shelf life [72]. Antioxidant properties have polyphenols, especially flavonoids, tannins, phenols, terpenes and hydrolysable proanthocyanins, which are responsible for maintaining the correct level of glutathione in cells and for the protection of membrane lipids against peroxidation. Among the flavonoids, hesperidin, diosmin, dolphinin, epicatechin, resveratrol, kaempferol, quercetin and luteolin, which are particularly rich in citrus fruits and grapes, have the strongest antioxidant properties [85]. According to Caillet et al. [86], these compounds can inhibit the formation of ROS and form stable complexes (so-called chelates) with transition metals (Cu^{2+} and Fe^{2+}), thus preventing Fenton and Haber-Weiss reactions. Flavonoids break the cascade of free radical reactions (capturing lipid and alkoxy free radicals) leading to lipid peroxidation, thus protecting other antioxidants (especially cytosolic ascorbate and biological membranes tocopherol). The group of herbs with antioxidant properties includes many plants [87] but the strongest antioxidant potential is shown by cloves (total antioxidants: 125.50–465.32 mmol/100 g), oregano (total antioxidants: 96.64–137.50 mmol/100 g), marjoram (total antioxidants: 55.80–92.31 mmol/100 g) and sage (total antioxidants: 34.88–91.20 mmol/100 g) [88, 89]. The antioxidant effect of herbs is manifested through modification of the activity of antioxidant enzymes, increasing the total antioxidant potential blood plasma (FRAP) or its components, as well as by protecting lipids against the peroxidation process, consisting in oxidative damage to the structures of lipid components of tissues and decreasing level of oxidation products, especially lipids (especially malondialdehyde, dienes and lipid hydroperoxides) [87]. Studies have shown that in the case of poultry rearing, rosemary, oregano, calendula, sage, cloves, garlic, ginger and saffron are primarily used, preventing the lipid oxidation processes in meat [90, 91] and in eggs [92]. Shirzadegan [93] found that supplementing the diet of chickens with a mixture containing green tea extract, cinnamon, garlic and chicory in the proportion of 25:15:45:14 in the amount of 2,5; 5,0 and 7,5 g/kg of feed improves antioxidant status and hepatic superoxide dismutase activity, which protects hepatocytes from the harmful effects of lipid peroxidation. The results of the research [6] on chicken showed that the use of a preparation containing cinnamon oil (0,25 mL/L of drinking water) increased of anti-oxidants level in the blood. Faix et al. [94] also states that the components of cinnamon oil increase the activity of antioxidant enzymes, thereby inhibiting lipid peroxidation. Lambert et al. [95] suggests that some plant additives, especially in an inappropriate dose, may show a pro-oxidative effect, intensifying the oxidation reactions in the system and in the food. Plant components with such characteristics include coriander, cardamom, verbena, sage, eucalyptus, lemon, and tarragon.

2.6 The harmful and toxic plants for poultry

In free-range breeding, poultry loves to roam the garden and treat all plants, especially garden flowers (e.g. marigolds), flowers and fruits of pumpkins and

zucchini, and weeds, e.g. dandelions, as potential food. Of course, abundant supplies of fresh fruit, vegetables and garden greens are part of their balanced diet, but not all garden plants are good for breeding birds. In fact, some are toxic and many biologically active plant compounds can cause poisoning, disease and even death. The possibility of consumption of toxic plants by birds exposes potential consumers of animal products to poisoning, due to the fact that toxic substances easily penetrate into meat or eggs. World centers dealing with the issues of plant toxicity to livestock publish lists of plants classified according to the degree of toxicity, sensitivity of individual animal species, or according to the content of toxins [96]. The main potentially toxic compounds are alkaloids, mainly purine and quinoline, occurring in plants in the form of salts of organic acids [97, 98]. They contain heterocyclic systems with an oxygen or nitrogen atom in their molecule and are basic in nature. Such compounds are present p. e. in coffee, tea, monkshood and poppy seeds. The next ones are glycosides, which give the plant a characteristic taste and smell (e.g. amygdalin) or color (flavones, anthocyanins). Some of them have a bacteriostatic effect (sinigrin present in horseradish). The protein - myosin, can cause reproductive disorders, such as loss of coat or feathers [99]. On the other hand, aminopropionitrile, present in the lupine, contributes to the deformation of the skeleton, especially the long bones and the chest. Essential oils, aromatic oils in the form of colorless liquids can also be toxic. The chemical composition of these forms of plant additives is often very diverse (aliphatic and aromatic compounds, terpenes, alcohols, phenols, hydrocarbons, aldehydes, ketones and esters). Resins, which are a mixture of organic acids, alcohols, phenols, esters and carbohydrates, or photosensitizing compounds (photosensitizing) are also dangerous for animals. Insoluble calcium oxalates can take the form of kidney stones in the kidneys, and their genesis comes from the oxalic acid found in many vegetables and grasses [97–100]. The content of potentially toxic substances is also influenced by the climate, soil type, companionship of other plants, as well as the method of storage and processing. Often the forage may be contaminated with toxic weed kernels. The seeds of *Senna occidentalis* (formerly called *Cassia occidentalis*) are among such dangers. The entire plant is toxic, but the most toxic, is dianthrone (anthraquinone derivative) has been identified in the outer and inner shells. It turned out that this substance can cause the characteristic mitochondrial myopathy with impaired mitochondrial function, damage to the biological membrane and swelling of this organelle, leakage of the mitochondrial matrix, and disintegration of mitochondrial combs [101]. The results of the research by Gotardo et al. [102] showed that the toxic dianthrone caused damage to the ovaries in laying hens, yolk leakage around the hair follicles, probably due to an increase in the fragility and permeability of the vitelline membrane itself. This membrane is a protein extracellular matrix surrounding the oocyte filled with yolk, and by preventing the yolk from mixing with the protein, it constitutes a kind of barrier to microbial infection [103]. The inner layer of the vitelline membrane is synthesized in the ovary, prior to ovulation, in the form of a three-dimensional network of thick glycoprotein fibrils. Assuming that the metabolic energy cost of follicle development and egg production in laying hens is high, and the toxic dianthrone damages the structure and function of mitochondria and leads to depletion of glycogen energy reserves, losses can be significant [104, 105]. If we take into account that anthraquinone affects mitochondrial functions, leading to glycogen depletion in cells, it can be assumed that the direct action of this compound in the ovary would lead to lower energy production in this organ, and consequently affect egg formation, possibly due to an increase in the fragility and/or permeability of the vitelline membrane. It is well known that toxins such as aflatoxin and the alkaloid pyrrolizidine plants can endanger egg production too [106]. The following plants are particularly dangerous for poultry:

yew, rhubarb, periwinkle, oak teres, nightshades, lupine, lobelia, holly, foxglove, ferns, bulbs of garden plants, beans, azalia and apricots. The acorns, that fall from oaks in autumn, contain tannic acid, which can cause a lack of appetite and diarrhea [107]. Dangerous oxalates can be found in rhubarb, sorrel and spinach; but cut twigs, fallen needles, and yew berries containing cardiotoxic taxin alkaloids can also cause poisoning. While oxalates interfere with kidney function, yew taxols cause cardiac arrhythmias and even lead to death [108]. Nightshades plants (i.e. tomatoes, peppers, eggplant, bittersweet and Jerusalem cherry, potatoes) can be harmful to poultry. Nightshades plants contain glycoalkaloids that cause loss of appetite, increased salivation, reduced heart rate and difficulty breathing. Growers should pay particular attention to raw potato skins, which are particularly dangerous to poultry. Lupine contains quinolizidine alkaloids, which may deteriorate the nutritional and organoleptic quality of poultry meat, and cause nervousness, depression, muscle tremors and convulsions in birds [109]. Lobelia contains toxins belonging to the pyridine alkaloids that can cause neurological changes, weakness, faster breathing and lack of motor coordination in poultry. The shiny green leaves and red berries of holly have a low level of toxicity, however the leaves contain highly poisonous saponins that can cause red blood cell damage, vomiting, diarrhea and drooling in chickens [110]. All parts of the beautiful foxglove (seeds, flowers, stems and leaves), who produces bright tubular flowers with mottled insides, are toxic [111, 112]. A specific variety of fern called the "bracken fern" can cause poisoning in chickens, weight loss and muscle tremorswhich, and to lead to anemia. Many varieties of garden plant bulbs (daffodils, irises, narcissi, tulips) contain highly toxic alkaloids that lower blood pressure and disrupt the heart, causing neurological changes and causing diarrhea. Raw beans contain haemagglutinins that are highly toxic to chickens, damaging and clumping blood erythrocytes [99, 112]. In azaleas, all parts of the plant are highly toxic and can cause digestive disorders, weakness, neurological disorders and loss of motor coordination, as well as damage to cardiomyocytes. Apricot leaves and kernels contain highly toxic cyanogenic glycosides, which cause symptoms such as seizures, breathing problems and low blood pressure. When leaves are exposed to frost, drought or disease, the level of toxicity increases [111, 112]. Due to the potential toxicity of some herbs, and the use of incorrect doses (too large doses) of herbs with a potentially beneficial effect, it is definitely more advantageous to use ready-made, standardized phytobiotic additives for poultry, where the manufacturer precisely specifies a safe and effective dose of the preparation with a standardized amount of active substances.

3. Conclusion

Summarizing the impact of phytobiotics used in poultry rearing, it can be noted that these additives:

1. improve growth and performance of broiler chickens, through greatly improve digestion and nutrient assimilation, and modify the composition of the intestinal microbiota and improve intestinal morphometry.

2. stimulate physiological reactions, especially immunity, but they also favorably modify the blood lipid profile, increase the antioxidant defense of the body, as well as increase resistance to stress.

3. they improve the quality of meat and eggs, increase the weight of valuable parts of carcass (pectoral and leg muscles) and stimulate laying.

4. due to the potentially toxic effect of an excess of certain herbs on the work of the liver, and the adverse changes in the palatability of eggs, use caution in the use some herbs e.g. of garlic, turmeric, rapeseed, alfa alfa, shiny privet or moringa.

4. Conclusions for practice

Due to the health-promoting properties of herbs and plant preparations, it is worth using such supplements in practice, because in this way you can increase the effects of chicken rearing and improve the quality of meat and eggs. The best results can be obtained by using proven and well-known plant additives, especially cinnamon, ginger, coneflower, nettle or aloe. Increasing the intensity of the yolk color desired by egg consumers can be obtained by feeding the laying hens with calendula, pumpkin, chives or parsley.

In large poultry farms, the easiest solution is to use ready-made plants' preparations to drinking water or feed.

Conflict of interest

The authors declare no conflict of interest.

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