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Applying Spruce Needle Extractives in Broiler Chicken Feeding

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Abstract. Spruce needle extractive substances were produced from a forestry by-product – green biomass of spruce needles. Spruce needle extracts contain a significant amount of natural biologically active substances. During our investigations the evaluation of biologically active substances from spruce needle total extract and of neutral extracts was carried out to assess their effects on innovative composition broiler chicken meat. The feeding trial was conducted with cross Ross 308 broiler chickens by adding the spruce needle total extract and, separately, neutral extract substances to the composition of broiler chickens' diet. Using spruce needle extractive substances increased live weight on average by 4.31–7.58% ($P < 0.05$) and decreased feed conversion by 6.28–7.33% in comparison with the control group. The use of neutral extract substances in the poultry diet improved the composition of fatty acids, increased the amount of total carotenoids by 0.45–0.57 mg kg^{-1} and decreased the cholesterol level by 11.16–23.66 mg $100g^{-1}$ in meat.

Key words: broiler chickens, meat quality, spruce needle extractives

INTRODUCTION

Complexes of natural biologically active substances can be extracted by nonpolar organic solvent from spruce needle biomass and could be utilized to substitute for synthetic preparations in animal diets. The major active ingredients in the biologically active substance of pine and spruce needle total extract are chlorophyll and its derivates: carotenoids, vitamin E, vitamin K, phytosterols, polyprenols, squalene, sodium salts of resin acids (balsamic compounds) and essential oils (Andersons et al., 1983; Ievins et al., 1976).

The previously mentioned biologically active substances have a broad therapeutic and prophylactic influence on poultry and on the human organism.

By including the determined biologically active substances contained by spruce needle extracts in the poultry diet, fatty acids, antioxidants, and vitamins desirable for human organisms are transferred from the feed to poultry meat. Other researchers (Leskanich & Noble, 1997) have confirmed that the transfer of biologically active substances from feed to production takes place, resulting in products of innovative composition enriched with biologically active spruce needle extract natural substances.

In the 1970's, only the following biologically active complexes were extracted from pine needles and pine needle biomass extracts: chlorophyll – carotene paste,

sodium chlorophylline, provitamin concentrate, etc. A small number of investigations were carried out on chlorophyll – carotene paste utilization in poultry feeding (Vitina et al., 1989).

The investigative data testified that the inclusion of pine needles' chlorophyll – carotene paste and oils in poultry feed increased live weight by 12.0–16.0% and improved immunity, increasing the functional activity of blood immunocytes, the quality of circulating immune complexes, protein, albumen, beta – gamma globulins and lysozyme (Remeze & Andersons, 1999). The investigations of improved poultry meat and egg quality by using pine needle products have not been carried out.

According to our data, spruce needle biomass contains higher amounts of biologically active substances (β–carotenoids, fatty acids, vitamins. etc.) in comparison with pine needle biomass (Ievins et al., 1986). Therefore the aim of our investigations was to evaluate the influence of spruce needles' total extractives and, separately, neutral extract group substances on broiler chicken productivity and meat quality by specifying the amount of ω–3 fatty acids and carotenoids in broiler chicken meat and to point to its possible use to obtain broiler chicken meat with innovative composition.

MATERIALS AND METHODS

The investigation was carried out with cross *ROSS 308* broiler chickens from 0 to 42 days age (n = 300; Table 1).

Table 1. Experimental design.

Group	Feeding programme	
	Basic diet	Additives of biologically active substances complex
1st group – control	Basic diet *	–
2nd group – trial	Basic diet	Total extractive substances from spruce needle biomass
3rd group – trial	Basic diet	Neutral extractives substances from spruce needle biomass

*the content complies with the standard requirements (Management Essentials, 1999).

The basic diet composition was the same for all broiler chicken groups. In the diet, the content of crude protein and metabolizable energy at the different ages was on average 19.0–24.0% and 11.90–12.80 MJ kg^{-1}. From the age of 7 days, the spruce needle total extractives-containing additive was added to the second group of broiler chickens in doses of 0.04–0.05%. To the diet of the 3rd group, the spruce needle neutral extractives substances additive that was obtained by extraction from the total extractives mass was added in doses of 0.04–0.05%. Additives used were in the form of paste, and were dark green in colour.

The main indices of poultry productivity and meat quality were recorded and evaluated during the investigation period. The gas chromatography method was used for fatty acids and carotenoids analyses, the Blur colorimetric method, for cholesterol analysis. The statistical analysis was performed using SPSS17. Statistical significance was declared at $P < 0.05$. The data were presented as means and standard errors.

RESULTS AND DISCUSSION

During the trial cross ROSS 308 the broiler chickens' productivity was high. On average, the broiler chicken live weight at age 42 days ranged from 3.12–3.36 kg, live weight gain per day was from 73.32–78.97 g and feed consumption for obtaining 1 kg of live weight (feed conversion) was within limits from 1.77–1.91 kg kg^{-1} (Table 2).

Table 2. Productivity of broiler chickens.

Parameters	1st group	2nd group	3rd group
Live weight at the age of 42 days, g	3,123 ± 51	3,360 ± 57	3,258 ± 54
% to control	–	7.58*	4.31*
Live weight gain per day, g	73.32	78.97	76.48
% to control	–	7.71	4.31
Feed conversion, kg kg^{-1}	1.91	1.79	1.77
% to control	–	6.28	7.33

*$P < 0.05$

By including a composition of spruce needle total extractives and neutral extractives substance additives in their diet, the broiler chickens' live weight for sale increased by 4.31–7.58%; correspondingly, the live weight daily gain increased by 4.31–7.71% and feed conversion positively decreased by 6.28–7.33% in comparison with the control group ($P < 0.05$). A similar stimulating effect on the chickens' live weight gain was ascertained by feeding them the pine needle total extractives substance chlorophyll – carotene paste (Fishers, 1971).

By using the spruce needle total extractives-containing additive in the broiler chickens' diet, their live weight had a tendency to increase in comparison with the live weight of the 2nd and 3rd groups of chickens. The results can be connected with the comparative higher biologically active substances profile and amount in the total extractives additive.

From the consumer's point of view, the essential significance was the effect of spruce needle extractives on fatty acids, cholesterol and antioxidant (carotenoids) content in muscle tissue.

Muscle tissue of the broiler chickens contained on average 22.51–24.06% saturated, 48.90–45.80% monounsaturated, and 26.58–27.73% polyunsaturated (Table 3).

Supplementing the broiler chickens' diet with only a little (by 1.46–1.55%) spruce needle extractive decreased the undesirable amount of saturated fat in broiler chicken meat, and also promoted myristic fatty acid decrease. The amount of monounsaturated and polyunsaturated fat, desirable for the human organism, was increased correspondingly by 3.10–2.59% and 1.13–1.15% in broiler chicken muscle tissue ($P < 0.05$).

At the same time the ω–6 fatty acids level in muscle tissue was not influenced by the spruce needle extractives additives to the broiler chicken diet. The addition of spruce needle extractives increased the ω–3 fatty acids total amount by 0.53–0.57%, including an increase in eicosapentaenoic fatty acid by 0.11–0.13% and

docosahexaenoic fatty acid by 0.05–0.22% in the muscle tissue in comparison with the control group.

With the addition of spruce needle neutral extractives substances to the broiler chicken diet, eicosapentaenoic and docosahexaenoic fatty acids levels in the chickens' muscle tissue increased more in comparison with the spruce needle total extractive substances additive. The previously mentioned fatty acids have high significance for human health because they decrease cardiovascular disease risk factors (Connor, 2002; WHO, 2003).

Table 3. The quality of broiler chicken meat.

Parameters	1st group	2nd group	3rd group
Dry matter, %	30.32	23.80	25.54
Total protein, %	20.12	20.43	21.00
Total fat, %	6.42	4.13	5.50
Fatty acids, % of total lipids:			
Saturated (SFA)	24.06	22.60	22.51
including myristic acid	0.86	0.74	0.75
± SFA to control	–	− 1.46	− 1.55
Monounsaturated (MUFA)	45.80	48.39	48.90
including oleic acid	38.02	40.81	39.94
± MUFA to control	–	+2.59	+3.10
Polyunsaturated (PUFA)	26.58	27.71	27.73
± PUFA to control		+1.13	+1.15
∑ ω–6 fatty acid	21.27	21.83	21.89
including linoleic acid	19.27	20.38	20.33
∑ ω–3 fatty acid	5.31	5.88	5.84
± to control	–	+0.57	+0.53
including eicosapentaenoic (EPA)	0.45	0.56	0.58
including docosahexaenoic (DHA)	1.14	1.19	1.36
∑ (ω–6) : ∑(ω–3)	4.0 : 1	3.71 : 1	3.75 : 1
Total carotenoids, mg kg^{-1}	0.12	0.57	0.69
± to control	–	+0.45	+0.57
Cholesterol, mg $100g^{-1}$	72.32	61.16	48.66
± to control	–	−11.16	−23.66

Broiler chicken muscle tissue contained on average 0.12–0.69 mg kg^{-1} carotenoids and 48.66 – 72.32 mg $100g^{-1}$cholesterol (Table 3, Fig. 1).
By using spruce needle extractives supplements in broiler chicken feed, the carotenoids level increased in its muscle tissue by 0.45–0.57 mg kg^{-1} and decreased the cholesterol level by 11.16–23.66 mg $100g^{-1}$ in comparison with the control group ($P < 0.05$).

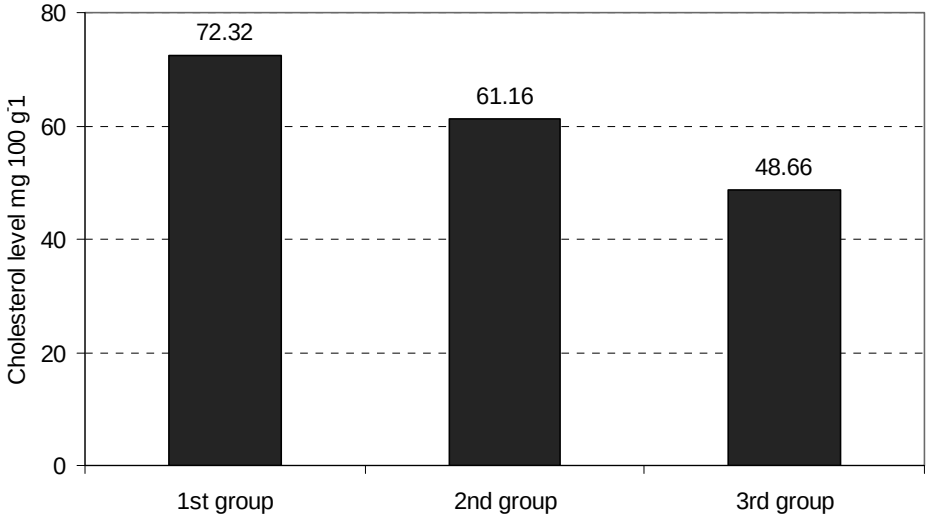

Figure 1. Cholesterol content in meat of broiler chickens.

We consider that it promoted the broiler chickens' metabolic processes and that these substances were carried over from diet to muscle tissue; as a result, innovative composition broiler chicken meat can be obtained.

We can ascertain that by using spruce needle total extractives or, separately, neutral extractive substances in the broiler chickens' diet it is possible to significantly improve meat quality.

CONCLUSIONS

Spruce needle total extractives and, separately, biologically active neutral extractives substances can be utilized in the diet of broiler chicken to improve poultry productivity and meat quality.

Adding spruce needle total and neutral extractives substances in broiler chickens diet in comparison with control group:

- Increases broiler chickens' live weight for sale by 4.31–7.58%, and decreases feed conversion by 6.28–7.33%;
- Improves meat quality by increasing carotenoid content by 0.45–0.57 mg kg^{-1} and the ω–3 fatty acids total content by 0.53–0.57% including eicosapentaenoic acid (EPA) by 0.11–0.13% and docosahexaenoic (DHA) by 0.05–0.22% and by decreasing the cholesterol level in meat by 11.16–23.66 mg 100 g^{-1}.

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