EFFECT OF STABLE IODINE PREPARATION ON THE QUALITY OF POULTRY PRODUCTS

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Summary. Lithuania is part of a region with endemic iodine deficiency. It is therefore recommended to supplement poultry feed with iodine, manganese and zinc.

The goal of the investigations was to quantify the accumulation of iodine in broiler meat, as well as in table eggs and in livers of laying hens using the stable concentrated iodine preparation instead of the usual potassium iodide.

Investigations were carried out at the Research Laboratory of Biological Diversity and Technologies of Vilnius Pedagogical University, Lithuania, and under field conditions on the broiler farm SC „Vilniaus paukštynas" and on the laying farm SC „Vievio paukštynas".

The inclusion of stable iodine concentrate into the drinking water (at 0.5 and 5 mg iodine/ l H_2O) increased the content of iodine in the meat of broilers by an average of 16 and 76%, compared with the control group receiving potassium iodide in the feed. Eggs from laying hens receiving feed with stable iodine concentrate (at levels of 1 and 4 mg iodine/kg feed) contained 24 and 196% more iodine than eggs of the control group. It was also established that addition of stable iodine concentrate to the feed of laying hens was increasing iodine levels in livers of the hens by 12,5 – 25% .

It can be proposed to promote iodine enriched poultry meat and eggs as functional food.

Keywords: iodine deficiency, broilers, laying hens, eggs, functional food.

STABILAUS JODO PREPARATŲ ĮTAKA PAUKŠTIENOS PRODUKTŲ KOKYBEI

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Santrauka. Lietuva priklauso regionui, kuriam būdingas endemiškas jodo trūkumas, todėl rekomenduojama paukščių lesalus papildyti mikroelemento jodo preparatais.

Bandymo tikslas – ištirti jodo kaupimąsi broilerių mėsoje, vištų dedeklių kiaušiniuose ir kepenyse, vietoj įprastinio priedo – kalio jodido į geriamąjį vandenį arba lesalus pridedant koncentruoto jodo.

Tyrimai atlikti Vilniaus pedagoginio universiteto Biologinės įvairovės ir technologijų laboratorijoje, o gamybinėmis sąlygomis – AB Vilniaus paukštynas ir AB Vievio paukštynas.

Tyrimų rezultatai parodė, kad į geriamąjį vandenį įdėtas stabilaus jodo koncentratas (dozė 0,5 ir 5 mg jodo/l H_2O) jodo kiekį broilerių mėsoje vidutiniškai padidino 16 ir 76 proc. palyginti su kontroline grupe, kurios lesalai buvo papildyti įprastu kalio jodidu. Vištų dedeklių, kurių lesalai buvo papildyti sausu stabilaus jodo koncentratu (dozė 1 ir 4 mg jodo/kg lesalų), kiaušiniuose nustatyta atitinkamai 24 ir 196 proc. didesnė jodo koncentracija nei kontrolinės grupės vištų kiaušiniuose. Taip pat nustatyta, kad sauso stabilaus jodo koncentratas 12,5–25 proc. padidino jodo koncentraciją dedeklių kepenyse.

Tokie tyrimų rezultatai įgalina vartotojams siūlyti jodu papildytą paukštieną ir kiaušinius kaip funkcinį maistą.

Raktažodžiai: jodo trūkumas, broileriai, dedeklės, kiaušiniai, funkcinis maistas.

Introduction. Iodine is one of the most important microelement of food having impact on consumer health. Around 800 million people worldwide suffer from iodine deficiency symptoms, especially in the developing world (http://en.wikipedia.org/wiki/Iodine). Symptoms of iodine deficiency may develop in humans and animals (Grossman, 1994).

At least 29 % of the world inhabitants experience health problems related to the iodine deficiency. 655 million people worldvide including 11% of European people develop an enlarged thyroid gland. 43 million of the inhabitants of our planet suffer from psychical disorders caused by iodine deficiency in the organism of their mothers during pregnancy (Helzel and Mano, 1989). Therefore improvement of iodine supply is still a great challenge for nutritionists.

In his study Flachowsky (Flachowsky, 2007) had pointed out that iodine requirements of humans depend on age, physiological stage and are differently evaluated by various scientific commitees (Table 1) It increases from 50 - 100 to 200 µg and more per day. Human organism requires more iodine during pregnancy and lactation.

There is also considerable variation of data regarding the tolerable upper levels of iodine intake of healthy humans pointed out by Flachowsky (Table 2) (Flachowsky, 2007).

As seen from the 2 tables above there is a low difference between requirements (Table 1, ~200 µg per day for adults) and the tolerable upper level (Table 2, ~600 µg per day, SCF 2002). It's obvious that the range between requirements and tolerable upper level is only about 1 : 3. Iodine belongs to both Supply Category 1 (high risk of deficiency) and to the High Risk Category (high risk of excess). Therefore more information is necessary to avoid iodine deficiences and to prevent iodine excess in human nutrition (Flachowsky, 2007).

Table 1. **Iodine requirements of humans depending on age, physiological stage and scientific committee** (in µg per day) (Flachowsky, 2007)

Age/ physiological stage	Scientific committee		
	WHO (2001)	USA DRI (2001)	D – A - CH (2000)
0 – 1 year		110 – 130	40 – 80
0 – 6 years	90		
1 – 8 years		90	
1 – 15 years			100 – 200
6 – 12 years	120		
9 – 13 years		120	
14 – 18 years/ adults	150	150	180 – 200
Pregnancy		220	
Pregnancy/lactation	200		
Lactation		290	260

Table 2. **Tolerable upper levels (UL) of iodine intake of healthy humans depending on age, physiological stage and scientific committee** (in µg per day) (Flachowsky, 2007)

Age/ physiological stage	Scientific committee			
	USA – FNB (2001)	SCF (2002)	WHO (1994)	D – A – CH (2000)
1 – 3 years	200	200	>1 mg (1000 µg per day are considered as safe	> 500 µg per day are considered as safe
4 – 6 years	-	250		
4 – 8 years	300	-		
7 – 10 years	-	300		
9 – 13 years	600	-		
11 – 14 years	-	450		
14 – 18 years	900	-		
15 – 17 years	-	500		
>19 / adults	1100	600		
Pregnancy	900	600		
Lactation	1100	600		

In 2005 the European Commission asked the European Food Safety Authority (FEEDAP) to evaluate the physiological requirements for iodine of different animal species and possible effect of this supplement on human and animal health or the environment. The FEEDAP Panel concluded that it is safe to supplement feed with iodine, but also stated that the current maximum addition levels for dairy cows and laying hens may be too high and could lead to exceeding the Upper Limit in humans. Reducing iodine to a maximum of 4mg/kg of complete feed for dairy cows and laying hens was suggested. The FEEDAP Panel also expressed the need for more and updated data on iodine requirement and tolerance in animals and on the impact of iodine supplemented feed on dietary iodine intake of humans (EFSA, 2005).

Numerous measures have been undertaken to improve iodine supply to human diets, e.g. using iodized salts (Zimmermann, 2004), other vehicles for iodine supplementation to food of plant or animal origin or supplementing iodine to animal feed in order to increase iodine content in the food of animal origin (Flachowsky, 2007).

Since 1987 human nutrition science proposed the concept of "functional food" as a possibility to design commonly used food products so that they not only have nutritional value, but also supplementary physiological effects on the human organism, reduce the risk of illnesses, and positively affect the immune system. The development of functional food is a modern challenge to improve human nutrition and disease prophylaxis (Schrauzer, 2000).

Poultry meat and eggs can also contribute to the increasing range of functional food (Eder *et al*., 2000). Biologically active substances, normally contained in poultry meat and eggs in variable quantities, can be increased by supplementing poultry feed with vitamins, minerals and specific microelements. It was established that iodine contained in eggs is readily assimilated by the human organism (Stanbury, 1996; Gružauskas *et al*., 2002; Jeroch *et al*., 2002).

Human health programs in many countries try to overcome iodine deficiency by encouraging the use of iodized salt as well as the production of iodine-enriched food (Flynn *et al*., 2003; EFSA, 2005). Solutions have been complicated by the fact that iodine is volatile, i.e. it is unstable and evaporates even if included in other chemical substances (Sirvydis *et al*., 2000; Semaška *et al*., 2001).

In 1998 Ukrainian researchers using special technology saturated water with biologically active iodine ions. The concentration with 20 mg iodine in 1 litre of water remains stable for a long time even if thermicaly processed. It is characterized by a high rate of assimilation in the human body.

Investigations on supplementing poultry and livestock feed with different forms and dosages of iodine have been carried out in different research units seeking to improve the quality of poultry products. At the Texas Agricultural Research Centre, Stanley and Bailey (1998) studied the effect of iodine enriched drinking water on broilers grown at different density. They found that adding 2 ppm iodine to the drinking water significantly improved broiler growth.

German and Lithuanian researchers carried out joint investigations on laying hens and found that supplementation of layer fed with 2 mg iodine/kg feed increased the amount of iodine in eggs to 43 µg compared to 11 µg eggs from hens on control feed with 0.5 mg iodine/kg feed (Jeroch *et al.*, 2002).

When the amount of iodine in the feed and in the yolk exceeds critical levels, negative reactions occur. Excess iodine in the feed of growing chickens may delay sexual maturity, in layer feed it may lead to gradual decrease in rate of production until at about 2500 mg iodine/kg feed ovulation stops completely. According to Czech researchers, prolonged feeding of excessive amounts of iodine has detrimental effects on egg production, body mass, yolk index and egg shell quality (Lichovnikova *et al*., 2003; Lewis, 2004). According to Baker *et al*. (2003), supplementing feed with bromine offers a possibility to overcome negative effects from overdosing iodine in chicken feed.

Turkish researchers supplemented layer feed with 3, 6, 12 and 24 mg/kg iodine in the form of calcium iodate. High supplementation levels (12 and 24 mg/kg) had undesirable effects on feed conversion ratio, egg weight, and albumen quality. Iodine supplementation to the feed significantly increased the iodine content of eggs, but only levels up to 6 mg/kg supplementation had no negative influence on egg production and egg quality (Yalçin *et al*., 2004).

Supplementing layer feed with different iodine and selenium combinations and dosages may fortify the immune system of laying hens (Zhigang *et al*., 2006).

Since Lithuania is a region of endemic iodine deficiency, the Research Laboratory of Biological Diversity and Technologies of Vilnius Pedagogical University has been trying to contribute to the knowledge on this subject. During 2000–2001 complex investigations it was found that the optimal amount of 10 – 12 µg iodine /l litre of water increased the nucleic acids and total albumen content in the blood of chickens, positively affected the thyroid function, growth rate as well as health. In the meat of broilers and laying hens as well as in egg yolks of hens receiving iodine-enriched water 3 – 5 times more iodine was found, compared with the control groups. The level of iodine in the muscle and liver tissue of 6 week old broilers was maximized by using 30 µg/dm^3 iodine in the drinking water. Total iodine in the muscles of iodine treated broilers was 4 -5 times higher than in the control group. Total iodine in egg yolks of laying hens receiving 15 µg/dm^3 iodine in drinking water at the age of 20, 22 and 24 weeks was 2-4 times higher than in the control group. The best livability of broilers (96%) was found at the level of 30 µg/dm^3 iodine in the drinking water (Sirvydis *et al*., 2000; Gudavičiūtė *et al*., 2002). In further experiments with broilers carried out in 2003–2004 at the Research Laboratory, the thyroid activity (functional state of thyroid gland) and the quantity of hormones in the blood serum of broilers were investigated. It was found that enriching drinking water with stable iodine water concentration in dosages of 0.5 mg / l H_2O and 5 mg / l H_2O decreased thyroid activity of the experimental broilers. It was found that amount of free thyroxin T4 depended on the dose of stable iodine in the drinking water. In the control group, receiving potassium iodide at 1 mg iodine/ 1 kg feed thyroid activity was higher. The high iodine dose of 5 mg /l water decreased liver mass of male and female broilers (Sirvydis *et al*., 2004; Kepalienė *et al*., 2006).

Iodine concentration in the thyroid is very high, about 30 times higher than in blood. Thyroid hormones are important for thermoregulation, energy metabolism, reproduction, tissue differentiation, growth and development, blood circulation and muscular activity. They control oxidation intensity of all cells, activity of other endocrine glands and food metabolism, especially of water and different minerals. The microelement iodine participates in the synthesis of thyroid hormones (thyroxin T4 and triiodine-thyronine T3). Thyroid activity interacts with the environment, and iodine deficiency or its excess may cause thyroid pathology. Chickens can sustain a certain amount of iodine deficiency without significant production loss, but serious thyroid hormone deficiency will result in reduced growth rate, egg production and hatchability as well as poor feathering (Grossman, 1992; Weetman, 1997).

Objectives of the report. The goal of the investigations was to quantify the accumulation of iodine in broiler meat, as well as in table eggs and in livers of laying hens using the stable concentrated iodine preparation instead of the usual potassium iodide.

Materials and methods. Investigations with Ross broilers and Hisex Brown layers were carried out at the Research Laboratory of Biological Diversity and Technologies of Vilnius Pedagogical University, Lithuania, and under field conditions on the broiler farm SC „Vilniaus paukštynas" and on the laying farm SC „Vievio paukštynas".

Stable iodine concentrate preparation (technical specifications (3559328 – 02: 2000, patent No 4752, Lithuania) in liquid form was used for enriching drinking water and in dry form – for adding to the feed of experimental groups.

For the broiler trial, sexed day-old chicks were randomly assigned to three groups, each with 50 ♂ and 50 ♀, and grown intermingled to 42 days of age. The control group received standard commercial broiler feed with added potassium iodide, the experimental groups the same basic feed without potassium iodide. Instead drinking water for these groups was enriched with liquid stable iodine concentrate at concentrations of 0.5 and 5 mg iodine/ l drinking water. The microelement iodine in the broiler meat was quantified with a gas chromatograph GC/ECD.

For the trial with laying hens, 120 adult hens, 47 weeks old, were assigned to three groups, 40 birds in each one. The control group received standard commercial layer mash with potassium iodide, the experimental groups - feed of the same composition but with added dry stable iodine concentrate preparation in concentrations of 1 and 4 mg iodine / 1 kg feed). After a feeding period of 3 weeks, the amount of iodine in the eggs and in livers of the layers was determined following the method described by Moxon and Dixon (1980).

Broilers and laying hens had ad libitum access to water from automatic equipment. The broilers were kept on deep litter, the laying hens in cages. Husbandry conditions for broilers and laying hens were complying with good commercial practices and with the Law of the Republic of Lithuania on the Care, Keeping and Use of Animals as well as secondary legislation – Order of the State Food and Veterinary Service of the Republic of Lithuania „On Veterinary Regulations on Breeding, Handling and Transportation of Laboratory Animals“ and „On the Use of Laboratory Animals in Scientific Experiments (LAW ON THE CARE, WELFARE AND USE OF ANIMALS; 2002). Data were analysed by ANOVA with the statistic software JMP (Version 5.1, SAS Institute). Differences between means were tested for significance by t-test.

Results. Table 3 shows the effect of the stable iodine concentrate on the amount of iodine in broiler meat compared to the control group.

Table 3. **The amount of iodine in the meat of broilers at 42 days of age**

Group No.	Feeding characteristics	Amount of iodine in broiler meat µg/100 g product	
		Male chickens	Female chickens
1	K + KI (Potassium Iodide) (dose: 1 mg iodine/kg feed)	6.5±0.33	5.1±0.23
2	K_1 + Stable iodine concentrate (dose: 0.5 mg iodine/l H_2O)	6.8±0.85	6.5±0.15*
3	K_1 + Stable iodine concentrate (dose: 5 mg iodine/l H_2O)	9.5±0.11*	10.5±0.16**

Note: Differences between the control and the trial groups is statistically significant with (*P<0.01), (**P<0.001).

In the meat of male and female broilers of group 2 (with 0.5 mg iodine/ l H_2O) the amount of iodine in the meat increased by 0.3 and 1.4 µg/100 g respectively or by 4.6 and 27.5 % compared with the control group. In group 3 (with 5 mg iodine / l H_2O) the meat of male chickens contained 3.0 µg/100 g or 46.1% more iodine than the control group, the meat of female chickens 5.4 µg/100 g or 105.9% more iodine than the control group (P<0.001). Whether the relatively higher accumulation rate of iodine in the meat of female broilers is typical or due to some sampling errors needs to be confirmed in independent trials with larger numbers.

The amount of iodine in the meat of broilers and in the egg yolks of laying hens receiving drinking water supplemented with iodine was 3 – 5 times higher than in the control groups (Gudavičiūtė *et al.,* 2002; Sirvydis *et al*., 2004; Kepalienė *et al.,* 2006).

The feeding trial with laying hens demonstrated that the amount of iodine in eggs was increased significantly by substituting potassium iodide with dry stable iodine concentrate at two different levels (Table 4).

Table 4**. Amount of iodine in eggs following three weeks of experimental feeding with stable iodine concentrate as iodine source**

Group No.	Feeding characteristics	Amount of iodine in eggs µg/100g
1	K + KI (Potassium Iodide) (dose: 1 mg iodine/kg feed)	5.8±0.09
2	K_1 + Stable iodine concentrate (dose: 1 mg iodine/kg feed)	7.2±0.08*
3	K_1 + Stable iodine concentrate (dose: 4 mg iodine/kg feed)	17.2±0.10**

Note: Differences between the control and the trial groups is statistically significant with (*P<0.01), (**P<0.001).

Using the same dose of 1 mg iodine/kg feed, the stable iodine concentrate increased the amount of iodine in the egg samples by 1.4 µg/100 g or 24 % over the control group ($P<0.01$). The higher level of 4 mg iodine/kg feed increased the amount of iodine by 11.4 µg/100 g or 196% over the control group ($P<0.001$).

From the results of our investigations (Tables 3, 4) it is evident that poultry meat and eggs produced in Lithuania will be deficient in iodine unless feed or drinking water are supplemented with iodine. Supplementing feed with the usual potassium iodide is not sufficiently effective because this element in potassium iodide saline is volatile and unstable in feed. The stable iodine concentrate can be used in poultry nutrition either in liquid or dry form as a good alternative.

Some authors report that iodine is transferred quite well into liver and other tissues of beef cattle and pigs. Concentration of iodine in liver tissues was clearly increasing with increased levels of iodine in the feed (Flachowsky, 2007).

Contens of iodine in livers of laying hens was investigated during trials in the Laboratory of Biological Diversity and Technologies of Vilnius Pedagogical University (Table 5).

Table 5. **Contens of iodine in liver of layers**

Grup No.	Feeding characteristics	Amount of iodine in liver µg/100g
1	K + KI (Potassium Iodide) (dose: 1 mg iodine/kg feed)	0.8±0.05
2	K_1 + Stable iodine concentrate (dose: 1 mg iodine/kg feed)	0.9±0.05**
3	K_1 + Stable iodine concentrate (dose: 4 mg iodine/kg feed)	1.0±0.05**

Note: Differences between the control and the trial groups is statistically significant with **$P<0.001$.

Data in the table 5 show that amount of iodine in livers of layers of the trial groups was higher in comparison with the control group. Under influence of the stable iodine concentrate addition to the feed (1mg iodine/kg feed) livers of trial group 2 contained 0.1 µg/100 g or 12.5% iodine more. Contens of iodine in livers of layers of the third group (4mg iodine /kg feed) was higher by 0.2 µg/100 g or by 25% in comparison with the control group.

Discussion and conclusions. In atatempt to satisfy requirements in human nutrition, producers of poultry meat and eggs are encouraged to develop value added products at more attractive margins than basic commodities in saturated markets. Iodine enriched eggs and poultry meat produced by chickens receiving feed or water with the appropriate level of stable iodine preparations can contribute significantly to the increasing range of functional food products.

During the investigations performed in Denmark sea weeds in the feed of laying hens were used and their drinking water was sterilized with iodine. The researchers stated that the iodine content of eggs may vary between 13 mcg and 170 mcg, reflecting the amount of iodine in the feed (Larsen *et al*, 2002).

In Polish feeding trials with Lohmann Brown laying hens, 1% premixes with 150 and 300 mg iodine /kg were compared. It was calculated that daily consumption of one iodine-enriched egg would supply 33 to 35 % of the recommended daily iodine intake (Dobrzański *et al.,* 2001).

It has been recommended to supplement feed with iodine compounds, especially those of vegetable stock, in which the amount of iodine is small and unstable. The main problem is instability of sodium iodide and potassium iodide. These salines are used most frequently but are not steady. The stable iodine concencentrate is available in liquid and dry form and is recommended in poultry feed instead of the unstable potassium iodide.

In different parts of the world new methods are being developed and research has been conducted to improve qualitative indices and nutrient value of eggs (Galobart *et al*., 2002; Jeroch *et al*., 2002; Yaroshenko *et al*., 2003; Gudavičiūtė *et al*., 2006).

Experiments in Lithuania have been carried out to enrich poultry products with the microelement iodine (Gudavičiūtė *et al*., 2002; Kepalienė *et al.,* 2006).

The inclusion of stable iodine concentrate into the drinking water (at 0.5 and 5 mg iodine/ l H_2O) increased the content of iodine in the meat of broilers by an average of 16 and 76%, compared with the control group receiving potassium iodide in the feed and averaged across males and females. Eggs from laying hens receiving feed with stable iodine concentrate (at levels of 1 and 4 mg iodine/kg feed) contained 24 and 196% more iodine than eggs of the control group. It was also established that addition of stable iodine concentrate to the feed of laying hens was increasing iodine levels in livers of the hens by 12.5 – 25%.

It can be proposed to promote iodine enriched poultry meat and eggs as functional food.

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