Effectiveness of using iodine-containing additives in meat products for child nutrition

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Abstract. Topical data on the prophylaxis of iodine deficiency conditions in children and adults are given. The results of a study on the effectiveness of using iodine-containing additives BioIod, iodcasein or iodized salt in meat products designed for childhood nutrition are presented. The use of iodine-containing additives BioIod or iodcasein in meat products for prophylaxis of iodine deficiency conditions in children’s nutritional products was effective. With that, the highest effectiveness was observed for the BioIod additive, which was proved by experiments on hypothyroid model animals. Iodized salt has the least protective effect in iodine deficiency conditions.

1. Introduction

Iodine deficiency is the only and, according to the data of world statistics, the most common cause of brain damage and mental disorders that can be prevented [1,2]. Actively growing children and adolescents comprise a special risk group regarding the development of iodine deficiency diseases. Even slight nutritional deficiency of iodine reduces their intellectual abilities. There are different options of iodine prophylaxis. The most effective and economically advantageous option is mass iodine prophylaxis that consists of supplementation of food products with various iodine-containing additives.

The biologically active additive iodcasein, intended for use in food products and known in the pharmacy chain as Iodactiv, was developed earlier and has become widespread. Iodcasein is an organic iodine compound incorporated into a milk protein molecule. It is used to treat iodine deficiency, and when administered in excess, it is excreted from the body while not entering the thyroid gland, since iodine splits from the milk protein by the action of the liver enzymes produced during iodine deficiency. When a person is iodine sufficient, these liver enzymes are not produced and iodine is naturally excreted from the body without absorption into the blood [3,4]. Recently, a new organic iodine additive has appeared on the market, i.e. BioIod, which is an analogue of natural iodotyrosine contained in animal and plant food products, the consumption of which the human body is evolutionally adapted to.

Nowadays, the diet of preschool and school-age children in the city of Moscow and other regions in Russia includes cooked sausages, ham products and minced meat semi-finished products for child nutrition manufactured according to legal national standards. Iodine supplementation amounting to 20-30% of children’s daily physiological norm by using iodcasein is stipulated in these products [5,6].
2. Materials and methods
The mass fraction of iodine was determined in meat products for baby food by the inversion-voltammetric method. The child nutritional products, Detskaya cooked sausage and Detskyi schnitzel were prepared with BioIod, iodcasein or iodized salt added at appropriate levels. Schnitzel were cooked, and all cooked meat products were stored until the end of their shelf-lives. Iodine content in the sausages was examined before and after cooking and in the schnitzel before and after production of raw product. Then, iodine content of all cooked meat products was determined during storage.

A laboratory animal study consisted of two stages and lasted 50 days, during which time the rats consumed the diets prepared for rat groups 1-5 (below). Firstly, rats were prepared as a model of hypothyroidism (iodine deficiency) during days 1-25. Secondly, the drug Mercazolil was administered to rats daily intragastrically at a dose of 50 mg/kg body weight from day 26 to day 50 to stimulate hypothyroidism (iodine deficiency).

Rats were randomized by weight into five groups (control, intact and three experimental), with the components below included in their diets. Rats in groups 2-4 received diets enriched with iodine, providing 30 % of the animals’ average daily requirement for iodine:
1) Control group – diet containing semi-finished products without iodine-containing additives;
2) Diet containing semi-finished meat product with iodcasein;
3) Diet containing semi-finished meat product with BioIod;
4) Diet containing semi-finished meat product with iodized salt;
5) Intact group – diet was the standard vivarium diet.

Rats were stunned then euthanized using CO₂ on day 25 (pre-hypothyroidism) or day 50 (hypothyroid). Blood was taken from the cardiac ventricles of stunned animals. Levels of three thyroid hormones, thyroxine (T4), triiodothyronine (T3) and thyroid-stimulating hormone (TSH) in blood sera of rats were measured using standard enzyme linked immunosorbent assays.

3. Results and discussion
The effectiveness of BioIod compared to iodcasein and iodized salt in sausages and ready-to-eat culinary meat products for child nutrition for prophylaxis of iodine deficiency diseases in children was studied.

In the first stage of the study, the amounts of iodine in the iodine-containing additives and iodized salt were determined so appropriate application rates for dietary enrichment could be calculated (Figure 1).

![Figure 1. Iodine content in iodine-containing additives used in the study](image)

In order to provide a consumer with a dose of 40 μg of iodine (when consuming 100 g of a product per day on the basis of the total amount of iodine in the additive), the additive application rate for Detskaya cooked sausage and Detskyi schnitzel, without regard for losses during cooking and storage, would be 1.3 g/100kg and 1.6 g/100 kg, respectively, for BioIod; 0.4 g/100kg and 0.5 g/100 kg, respectively, for iodcasein, and; 640 g/100kg and 500 g/100 kg, respectively, for iodized salt. In production of Detskyi schnitzel, however, the application of iodized salt does not ensure 30% of the recommended daily dose. To ensure the required amount of iodine, it would be necessary to add double
the amount of salt that is regulated in this product, so the use of iodized salt alone is unacceptable in this child nutritional product.

Iodine loss before and after cooking and during storage of Detskaya cooked sausages (Figure 2) and the meat product Detskyi schnitzel (Figure 3) was examined.

Figure 2. Changes in iodine content in Detskaya cooked sausage during storage

At the end of the shelf-life of Detskaya cooked sausages for child nutrition, iodine loss was 50% in iodized salt supplemented sausages, 15% in iodcasein supplemented sausages and 5% in BioIod supplemented sausages.

The BioIod application rate of 1.35 g/100 g of unsalted raw material, determined on the basis of the iodine content in BioIod, did not ensure an iodine content of 30 μg in the finished Detskaya cooked sausage. Also, iodine loss (5% of the initial content) occurred in Detskaya cooked sausage at the end of the shelf-life. Therefore, the actual required BioIod application rate would be 2.2 g/100 kg of unsalted raw material.

Figure 3. Changes in iodine content in Detskyi schnitzel during storage. *Stored product underwent cooking at 180°C to a temperature of 90°C in the center

At the end of the shelf-life of Detskyi schnitzel for child nutrition, iodine loss was more 70% in iodized salt supplemented schnitzel, 68.8% in iodcasein supplemented schnitzel and 20.7% in BioIod supplemented schnitzel.

The BioIod application rate 1.7 g/100 g of unsalted raw material, determined on the basis of the iodine content in BioIod, did not ensure an iodine content of 40 μg in the finished Detskyi schnitzel. Also, iodine loss (20.7% of initial content) occurred in Detskyi schnitzel at the end of the shelf-life. Therefore, the actual required application rate of BioIod would be 3.5 g/100 kg of unsalted raw material.
The effectiveness of iodine-containing additives based on the milk protein casein or whey protein compared to iodized salt in the composition of meat minced semi-finished products for child nutrition was examined. The prophylaxis effect of meat products enriched with iodine-containing additives was studied using model, iodine-deficient laboratory rats on the basis of hormonal parameters. Prehypothyroidism (day 25) and final, hypothyroidic (day 50) blood hormone (T3, T4 and TTG) levels were measured in rats (Figures 4 and 5).

Analysis of animal hormonal status on day 25 showed serum T4 levels did not significantly differ between animals that did not consume iodine-enriched diets and animals that were injected with iodine-enriched products. At the same time, serum T3 levels in animals consuming diets enriched with milk or whey proteins (groups 2 and 3) were higher than in control and intact animals. T3 levels in group 4 animals that consumed meat products with iodized salt were lower than in control and intact animals. Lower serum TSH levels were found in all animals consuming iodine-enriched diets than in animals consuming the control diet and intact animals (Figure 4).

Thus, the decrease in serum TSH levels in group 3 animals, and increases in serum T3 and T4 levels may indicate that BioIod-enriched meat products indirectly stimulated the production of thyroid hormones, which, in turn, likely changed the functional activity of the immune system and individual populations of immunocompetent cells, in particular, the differentiation of immature lymphoid cells. It should be stressed that in group 4 animals that consumed meat semi-finished products enriched with iodized salt, T3 levels increased (up to 17%), but T4 and TSH levels significantly decreased (reduction of up to 30%).

In the second stage of the model animal study (groups 1-4), clinical symptoms of developing hypothyroidism of different severity were observed – there was a decrease in motor activity (hypodynamia), an increase in goiter, detected by palpation, and a slight decrease in appetite. The most pronounced changes were observed on days 10-15 from the beginning of the modeling of the disease in animals (day 26) in groups 1 (control) and 4 (diet with iodized salt).
Figure 5. Thyroid hormone levels in the blood serum of animals after simulation of hypothyroidism (day 50)

The levels of thyroid hormones in the sera of control animals consuming a diet with meat products containing no added iodine (group 1) and in group 2 (diet with meat products containing iodcasein) and group 3 (diet with meat products containing BioIod) animals were measured and compared, and the following can be stressed. In control animals (group 1), a significant decrease in T4 (1.8-fold) and T3 (2.3-fold) occurred; the level of TSH, on the contrary, increased 1.4-fold (Figures 4 and 5). In group 2 and 3 animals, consuming diets with iodine-containing meat products based on iodine-containing milk protein (casein) and iodine-containing whey protein, respectively, the serum levels of hormones changed only slightly after hypothyroidism was induced. A slightly better effect of iodine deficiency correction was achieved when the meat products were enriched with iodine-containing whey protein (BioIod; group 3) compared to the intact group, since the level of T4 was restored by 98.1%, T3 by 100% and TSH by 89.3% (Figures 4 and 5).

4. Conclusion

In animals that consumed meat products enriched with iodized salt for 25 days, after the development of iodine deficiency, there was a decrease, due to iodine deficiency, in the serum thyroid hormones T4, T3 and TSH compared to intact animals. Enrichment of meat products with additives based on iodine-containing whey proteins and iodine-containing milk proteins (casein) has a protective effect in rats that are a model of iodine deficiency. It is likely that organically bound iodine is absorbed relatively well, thereby contributing to the development of an optimal amount of TSH and the formation of T4 in suitable amounts, compensating for the lack of iodine.

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