PROSPECTS FOR USING IODINE-CONTAINING ADDITIVES IN MEAT PRODUCTS FOR CHILD NUTRITION

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Abstract – This paper presents the analysis and possibilities for prevention of the prevalence of iodine deficiency conditions in children and adults. The results of the study on effectiveness of using iodized milk proteins and iodized salt in meat products for child nutrition are presented. It has been established in the experiments on laboratory animals that it is expedient to use iodized milk proteins for prophylaxis of iodine deficiency conditions. Use of iodized salt in meat products had the least protective effect in iodine deficiency conditions.

Key Words – iodized salt, casein, whey proteins.

I. INTRODUCTION

According to the data of the experts of World Health Organization (WHO), approximately 2 billion people in the world (i.e., about one third of the Earth's population) live in the conditions of iodine deficiency. Among them, 31% is child population including young, pre-school and school-age children. This number is significantly higher in Europe and is equal to about 52% [1,2]. Actively growing children and adolescents comprise a special risk group regarding the development of iodine deficiency diseases. Even mild deficiency of iodine in their nutrition reduces their intellectual development and further mental abilities. IQ of children with iodine deficiency in nutrition is at least 10-15% lower than IQ of children of the same age without iodine deficiency in their diet. Russia is a country, in which territory there are practically no regions with sufficient iodine content in water and soil. The problem of iodine deficiency in the Russian population aggravated after the radioactive emissions in Chernobyl, when iodine deficiency led to an increase in the risk of the emergence of irreparable consequences for thyroid gland function. Pregnant women and young children are especially sensitive to iodine deficiency in a body [3].

In the territories, where population has a natural predilection for goiter development as well as in the territories suffered from the Chernobyl accident, the results of IQ tests in children were lower than the average statistical indices, which influenced intellectual development of these children at the later time in their adult life [4]. According to the WHO recommendations, the main method of iodine deficiency elimination is use of iodized table salt enriched in potassium iodite or iodate [5]. The solution cannot be considered ideal. Excess of iodized salt in a body can have a toxic effect. It is contraindicated to individuals with autoimmune diseases, increased sensitivity to iodine, malignant tumor of thyroid gland, kidney diseases, hypertension and other pathologies [5].

At the end of 1990s, a biologically active additive on the basis of milk protein, casein, was developed in Russia, which has received wide acceptance from a pharmacy chain. It is an organic iodine compound incorporated into a milk protein molecule. In iodine deficiency, it is utilized, and under its excess, it is excreted from a body not entering the thyroid gland since iodine splits out of milk protein under the action of the liver enzymes produced in iodine deficiency. When a body is iodine sufficient, the enzymes are not produced and iodine is naturally excreted from a body without entering the blood [6].

At present, another organic iodine preparation on the basis of whey proteins has appeared in the market, which is an analogue of the natural iodotyrosine contained in animal and plant food products, to which consumption a human body is evolutionally adapted.

Nowadays, a diet of preschool and school-age children in Russia includes various meat products

– cooked sausages, ham products, minced semi-finished products and ready-to-eat culinary meals. In these products, iodine supplementation in the amount of 20-30% of the daily physiological norm of a child is provided [7-9].

The aim of this work was to study the effectiveness of using different iodine preparations for cooked sausage enrichment, which facilitate prevention of iodine deficiency in children.

II. MATERIALS AND METHODS

In this work, we studied the preparations of iodized milk proteins (the preparation on the basis on whey proteins, the preparation on the basis of milk protein, casein) and iodized salt.

During the experiment the following methods were used:

- iodine content in the products was determined by the voltammetric method;
- medical and biological assessment of the finished meat products was performed by experimental methods in the experiments on laboratory animals;
- general clinical investigation of the blood samples from the experimental animals was carried out using the automatic veterinary hematological analyzer (Austria) with the reagent kits from Diatron;
- biochemical investigation of the animal blood was performed using the semi-automatic biochemical analyzer BioChem SA (HTI, USA) with the reagent kits from High Technology (USA).

In order to ensure the targeted level of iodine (40 μg/100 g of a product), the application rate of the preparations for cooked sausages was:

- the preparation on the basis on whey proteins: 1.3 g/100kg;
- the preparation on the basis of milk protein, casein: 0.4 g/100kg;
- iodized salt: 640 g/100kg.

III. RESULTS AND DISCUSSION

The experiments on studying iodine loss before and after cooking, and during storage of sausages were carried out (Table 1).

At the end of the shelf-life of cooked sausages for child nutrition, iodine loss was 50% upon iodized salt supplementation (sample 3), 15% upon supplementation with the preparation on the basis of milk protein, casein (sample 2), and 5% upon supplementation with the preparation on the basis of whey proteins (sample 1).

Table 1 Iodine content in cooked sausage

Storage duration	Indicator, mass fraction, μg/100g of a product			Iodine loss, %		
	Sample			Sample		
	1	2	3	1	2	3
Before cooking	19.59 ±0.78	32.70 ±1.31	27.85 ±1.11	-	-	-
Finished product	19.68 ±0.78	31.65 ±1.27	17.85 ±0.71	-	3.2	35.9
Sausage during storage, days						
10	19.60 ±0.78	28.05 ±1.03	17.35 ±0.69	-	14.2	37.7
20	18.66 ±0.74	27.8± 1.11	13.7± 13.7	5.0	15.0	50.1

In order to examine the possibility of toxic effects development when using the enriched products and substantiate the effectiveness of the iodine-containing preparations, the experiments on animals were carried out.

Four groups of animals (rats) were formed for conducting the experiment:

group 1 - a standard diet of the vivarium;

group 2 - cooked sausage with the preparation on the basis of milk protein, casein;

group 3 - cooked sausage with the preparation on the basis of whey proteins;

group 4 - cooked sausage with iodized salt.

Throughout the experiment, the rats from groups 2-4 received the iodine-enriched diet. The cooked sausages containing the preparations under investigation at the rate of 15 g/ 100 g of animal weight were added to feed.

After two days, the animals were weighed; the live weight gain was measured. Animal clinical status and behavior, the condition of neuromuscular functions, hair condition, feed and water consumption were recorded. A special attention was paid to the development of the signs of toxicosis.

Duration of the experiment on detection of the possible toxic effects was 25 days. Then, the intermediate slaughter of a subgroup of animals in each group was performed.

The intermediate (25 days) slaughter and final slaughter were performed using carbon dioxide. The blood was taken from the cardiac ventricles of

the stunned animals for general clinical and biochemical examination.

The visceral organs (heart, kidney, liver, spleen, thymus and thyroid gland) were examined by a weighing method. No manifestations of inflammatory pathological processes in the visceral organs of the animals were observed. The spleen of the animals, which diet contained the cooked sausages with the preparation on the basis of milk protein, casein, was slightly decreased in size; the kidney, liver, heart and thyroid gland were within the normal limits. In the rats fed the products with iodized salt, the liver enlargement was observed. The visceral organs of the animals, in which diets the products enriched with the preparation on the basis on whey proteins were added, did not change and corresponded to the values of the control group of animals.

During biochemical examination of the experimental animal blood, no evident changes in the indicators were observed suggesting non-toxicity of the examined iodine-containing cooked sausages.

Thus, it was shown that the tested product did not have any toxic effects on an animal body. The largest weight gains were observed in the rats consumed the meat product with the preparation on the basis on whey proteins during 25 days.

From the 26th day, the simulation of the hypothyroidism (iodine deficiency) induced by daily intragastric administration of mercazolilum (50 mg/kg of body weight) was performed on the remaining animals during 25 days.

When studying biochemical indices of the animal blood from group 1 by the end of the experiment on the hypothyroidism simulation, a reduction in total protein owing to the albumin fraction, bilirubin, creatinine, cholesterol, enzymes aspartate aminotransferase (AST) and alanine aminotransferase (ALT), and an increase in urea, gamma-glutamyl transferase (GGT) and glucose were observed, suggesting the excretory system (kidney and liver) dysfunction.

In the animals from group 2, which received the sausages with the preparation on the basis of milk protein, casein, an increase in total bilirubin, urea, GGT, cholesterol, glucose (up to 50%) and a reduction in alkaline phosphatase and lactate dehydrogenase (LDH) were observed. In the animals consumed the meat product with the preparation on the basis on whey proteins, creatinine, urea, GGT increased (20 to 70%), while the concentrations of LDH, total bilirubin, alkaline phosphatase and glucose decreased (15 to 47 %).

The animals from group 4 fed the sausages with iodized salt showed an increase in LDH and a reduction in alkaline phosphatase and cholesterol (up to 30%).

It is important to note that the concentrations of triglycerides, ALT and AST reduced in all groups. The minimal concentrations of triglycerides were found in group 4 (reduced by 72.6), AST and ALT in group 2 (by 47.7 and 65.1 %, respectively).

It was shown that in the animals consumed the meat products with iodized salt an increase in triglycerides was more significant (2-2.5 times) on the background of an increase in total cholesterol (25-50%).

In the rats fed the meat product with the preparation on the basis on whey proteins prior to disease simulation, the amount of cholesterol reduced by 5-12% and the indices of triglycerides increased by 35% to 84.5%, which can be explained by acceleration of lipid metabolism.

At a pathoanatomical examination of the animals from group 1, an increase in the weight of spleen by 53%, kidney by 11%, liver by 20.5% and thyroid gland by 31.7% was observed on the 25th day of disease simulation.

In this connection, it can be concluded that the antithyroid preparation mercazolilum causes obvious destructive-degenerative changes in the organs associated with the immune and excretory systems of a body, which is indirectly confirmed by the results of the hematological and biochemical studies of the animal blood.

In the experimental groups of animals consumed the iodine-containing meat products, the trend towards an increase in the visceral organ weight persisted (Table 2).

By the end of the experiment, the spleen, kidney, liver and thyroid gland enlarged up to 43.7%, 30%, 9%, and 42%, respectively, in the rats received the meat products with the preparation on the basis of milk protein, casein; while in the animals consumed the meat products with the preparation on the basis of whey proteins, these values increased up to 38%, 19%, 11.3% and 35%, respectively.

In the animals received iodized salt in the composition of the meat products before disease

simulation, the spleen, kidney, liver and thyroid gland enlarged up to 47%, 14%, 13% and 38%, respectively, at the end of the experiment.

The study of the hormonal state showed that in the animals from group 2 received the sausage with the preparation on the basis of milk protein, casein, the concentration of T_3 did not change significantly, the concentration of T_4 reduced by 56.6%.

The animals from group 3 received the products with the preparation on the basis of whey proteins showed the negative dynamics regarding hormone T_4 (about 40.8%), the T_3 concentration virtually did not change. In the animals from group 4 consumed the product with iodized salt, the T_3 concentration reliably increased by 64.6%, and the T_4 concentration reduced by 47.3%.

Table 2 Integral indicator of chronic intoxication

Group	Weight of visceral organs, g				
	spleen	kidney	liver	heart	thyroid gland
25th day of experiment (feeding the experimental meat products)					
1	0.42±0.13	0.86 ±0.11	9.06 ±0.13	1.01 ±0.12	0.28 ±0.15
2	0.43±0.2	0.75 ±0.07	8.97 ±0.18	1.02 ±0.14	0.31 ±0.06
3	0.44±0.03	0.7 ±0.06	9.26 ±0.21	1.00 ±0.12	0.28 ±0.02
4	0.45±0.1	0.75 ±0.11	10.1 ±0.3	0.87 ±0.07	0.27 ±0.03
25th day of simulation					
1	0.88±0.06	0.97 ±0.3	11.39 ±0.38	0.95 ±0.09	0.41 ±0.0 3
2	0.69±0.1	1.01 ±0.1	10.26 ±0.76	1.09 ±0.14	0.5 ±0.05
3	0.69±0.16	0.9 ±0.11	10.28 ±0.75	0.95 ±0.09	0.40 ±0.08
4	0.85±0.07	0.87 ±0.11	11.27 ±0.31	0.96 ±0.02	0.43 ±0.08

IV. CONCLUSION

The biological investigations showed the absence of the toxic effects on the organism of the laboratory animals consumed the meat products enriched with the iodine-containing preparations: iodized milk proteins and iodized salt. The possibility to correct experimental iodine deficiency with the preparations on the basis of milk proteins incorporated into the cooked sausage composition was substantiated.

With that, the highest effectiveness was observed when using the preparation on the basis of whey proteins. Use of iodized salt is ineffective because of the significant iodine losses during sausage production and storage. In addition, its use has the least protective effect in conditions of iodine deficiency.

REFERENCES

1. Dedov, I.I., Sviridenko, I. Yu. (2001). Strategy of elimination of iodine deficiency diseases in the Russian Federation. Problems of Endocrinology 47, No 6: 3-12.
2. Dedov, I.I., Melnichenko, G.A., Troshina, E.A. et al. (2006). Iodine deficiency – the threat to the development and health of Russian children (national report). M: UNICEF.
3. Zummermann, M.V. (2012). Effect of iodine deficiency in pregnancy and in infancy. Pediatric and Infant Epidemiology 26 (Annex 1): 108-117.
4. Iodine deficiency diseases in children and adolescents: diagnostics, treatment and prevention. (2005). Scientific-Practical Program. The International Foundation for Maternal and Child Health Protection, M.
5. WHO Guidelines on food fortification with micronutrients (2011) who.int/mediacentre/events/2015/eb136/ru/
6. Shahtarin, V.V., Tsyb, A.F., Roziev, R.A. (2005). Effectiveness of iodcasein for iodine deficiency prevention. Medical Scientific and Educational-Methodological Journal 27: 91-101 .
7. Ustinova, A.V., Lubina, N.V., Soldatova, N.E., Timoshenko, N.V. (2005) Iodine supplemented meat products for nutrition of preschool and school- age children// All about meat 1.
8. Ustinova, A.V., Soldatova, N.E. (2002). Competitive cooked sausage products for children. Meat Industry 3:20-22.
9. Derevitskaya, O.K., Ustinova, A.V., Soldatova, N.E., Schiptsov, V.N. (2012). Prospective technology of enriched ready-to-eat meat products for child nutrition. Meat Industry 11: 46-50.