

Medical and biological evaluation of the efficiency of heavy metals sorption by food fibers used in meat industry

I.M. Chernukha, N.E. Belyakina, A.V. Ustinova, S.I. Hvylya & A.I. Surnina

GNU the V.M.Gorbatov All-Russian Meat Research Institute, Russia, 109316, Moscow, Talalikhina 26.

E-mail: dpitanie@mail.ru

Abstract

The comparative study of food fibers preparations ("Vitacel" – wheat fiber, beet fibers, calcium alginate, TIPRO 601 – native collagen protein, pork rind) in a chronic biological experiment has shown that none of them had cumulative toxic effect, and possessed a low level of food sensibilization. Calcium alginate, native collagen protein and pork rind help to increase calcium content in bones of laboratory animals. As to the efficiency of removal of lead and cadmium, the native collagen protein and pork rind performed better, than insoluble food fibers. Vitacel and beet fibers are more effective with regards to cadmium, than to lead. Calcium alginate stimulates phagocytosis, improves detoxicating function of kidneys, possesses hypoallergenic effect and prefers to sorb cations of lead than of cadmium. Thus, when the combined effect of heavy metals takes place, it is expedient to use combination of food fibers in optimum proportions.

Introduction

The every day and uncontrolled emissions of great amounts of harmful substances into air and water basin are the cause of the increase of mortality rate and morbidity in all the industrial cities and regions.

In the case of unfavorable effects of the environment the human's organism has an increased requirement in essential nutrients, and first of all, in proteins of animal origin. Meat offers efficient adaptation possibilities and is a source of a complex of indispensable food substances. Besides, it is generally accepted that meat (muscle tissue) is related to little contaminated food products..

One of the efficient ways of correction of the increased amount of heavy metals and other toxic substances in human's organism is enterosorption with food fibers. The additional enrichment with food fibers of a special meat product will increase its removing effect.

The substantiation in the experiments on animals of the more promising for use in meat industry food fibers preparations, assisting in removal of toxic substances from live systems under the conditions of the effects of negative technogenic factors.

Material and methods

The preparations from pork rind (native collagen protein) and the pork rind, being the food fibers of animal origin, were investigated in comparison with the food fibers of plant origin (beet fibers, wheat cellulose, calcium alginate).

Medical and biological evaluation of the effectiveness of food fibers in case of intoxication with lead and cadmium was carried out by conventional experimental methods on the growing white male rats during 30 days in the vivarium of VNIIMP. The feed was mixed with the tested feed supplement at 2 g per 1 animal per day, except the pork rind, which due to 60% moisture content was given at a dose 5 g per animal.

8 groups of animals, 10 to each, were formed. Groups 1 and 2 were given common vivarium diets, group 3 was given beet fibers; group 4 – "Vitacel" (wheat cellulose); groups 5 and 6 – calcium alginate, group 7 - protein preparation from defatted pork rind (TIPRO 601); group 8 – pork rind. To the diets of all the groups (except groups 1 and 5) the solutions of heavy metals salts were added at 1/100 LD50 for rats: cadmium sulfate – 0.6 mg/kg, lead citrate – 1.17 mg/kg [1,2].

The level of heavy metals was determined by inversion-voltampermetric method.

The integral index of chronic intoxication (IPHI) [3] was calculated as the ratio of the weight of the organ to the total weight of the body in %.

The general clinical blood count was carried out in veterinary clinic of MGUPB.

Results and discussion

The gain in live weight of the rats during the experiment was reduced in the following order: calcium alginate (without heavy metals) > calcium alginate, > preparation from pork rind > pork rind > control (without heavy metals > "Vitacel" > control > beet fibers.

The calculated integral index has not revealed cumulative toxic effect in all the tested samples.

Clinical blood count of laboratory animals indicated negative influence of all the preparations on hemopoietic function of rats. The decrease in hemoglobin level can be explained by the capacity of food fibers to bind iron into insoluble complexes and remove them from organism. The largest level of hemoglobin decrease is observed for the preparation "Vitacel".

The analysis of differential blood count of animals has shown an insignificant increase of total amount of leukocytes and lymphocytes in the groups of laboratory animals, eating calcium alginate, the preparation from pork rind and pork rind as compared to the control (group 2), which can be a concomitant symptom of immunological resistance increase of the organism and stimulation by alginates and collagen-containing preparations of phagocytosis and immunity. No juvenile neutrophils were discovered, which confirms the absence of inflammatory process.

The absence of basophilic leukocytes and monocytes in the blood of all the rats indicates a low level of food sensibilization and absence of the immune conflict in the organisms of the experimental animals.

"Vitacel", calcium alginate, preparation from pork rind and pork rind contribute to the increase of ESR (erythrocytes sedimentation rate), i.e. decrease in meat viscosity, which is increased in the case of intoxication.

Table 1. Clinical analysis of blood

Index	Groups of animals						
	2	3	4	5	6	7	8
Erythrocytes $\times 10^2/\text{mcl}$	6,9 $\pm$ 0,72	7,93 $\pm$ 0,57	4,6 $\pm$ 0,1	5,8 $\pm$ 0,75	5,93 $\pm$ 0,86	4,73 $\pm$ 0,93	4,6 $\pm$ 0,82
Hematocrit, %	75,0 $\pm$ 4,56	56,0 $\pm$ 2,0	44,67 $\pm$ 16,28	66,0 $\pm$ 0,0	75,67 $\pm$ 3,5	48,0 $\pm$ 17,4	57,3 $\pm$ 2,3
Hemoglobin, g/dl	18,17 $\pm$ 0,55	16,93 $\pm$ 1,25	12,3 $\pm$ 0,99	16,1 $\pm$ 1,57	14,3 $\pm$ 2,05	14,7 $\pm$ 4,8	14,1 $\pm$ 2,5
Color index. $\bar{6}/3$	0,8 $\pm$ 0,1	0,7 $\pm$ 0,1	0,77 $\pm$ 0,06	0,83 $\pm$ 0,11	0,7 $\pm$ 0,1	-	-
ESR, mm/hour	0,0 $\pm$ 0,0	0,0 $\pm$ 0,0	0,67 $\pm$ 0,1	0,1 $\pm$ 0,0	0,1 $\pm$ 0,0	0,1 $\pm$ 0,0	0,1 $\pm$ 0,0
Leukocytes, $\times 10^5/\text{mcl}$	7,07 $\pm$ 0,4	6,93 $\pm$ 0,83	5,13 $\pm$ 0,58	9,8 $\pm$ 3,57	7,7 $\pm$ 4,76	15,2 $\pm$ 5,8	9,97 $\pm$ 2,2

The investigations of accumulation of heavy metals in organs and tissues of laboratory animals have shown that for groups 1,2,3,4,7,8 cadmium is deposited only in bones, the highest level of deposition is for beet fibers. In other organs and tissues its content was lower than the level of detection, thus one can say about efficiency of these diets for cadmium removal. It should be noted that the control diet already contains cereals with high level of food fibers.

The use of sodium alginate leads to the increase in the level of cadmium in heart, kidneys and especially in liver, and in this case the presence of cadmium was discovered also with the use of the preparation without intoxication, which may suggest about selectivity of calcium alginate with respect to heavy metals, i.e. with simultaneous priming with the salts of lead and cadmium it preferably sorbs lead, which can be explained by larger chemical affinity to carboxyl groups of alginic acid of cations of lead, than of cadmium.

Table 2. Content of cadmium in organs and tissues of laboratory animals

Organs and tissues	Groups of animals							
	1	2	3	4	5	6	7	8
Heart	<0.002	<0.002	<0.002	<0.002	0.0097 $\pm$ 0.00058	0.010 $\pm$ 0.001	<0.002	<0.002
Kidneys	<0.002	<0.002	<0.002	<0.002	0.007 $\pm$ 0.0058	0.015 $\pm$ 0.0015	<0.002	<0.002
Liver	<0.002	<0.002	<0.002	<0.002	0.003 $\pm$ 0.001	0.017 $\pm$ 0.0025	<0.002	<0.002
Muscle tissue	-	<0.002	<0.002	<0.002	<0.002	<0.002	-	-
Bones	0.005 $\pm$ 0.001	0.01 $\pm$ 0.003	0.02 $\pm$ 0.0045	0.011 $\pm$ 0.004	0.01 $\pm$ 0.001	0.01 $\pm$ 0.00152	0.011 $\pm$ 0.004	0.013 $\pm$ 0.001

All the tissues and organs of the group, obtaining beet fibers, accumulated larger amounts of lead, than the control groups, which suggests about lower efficiency of the preparation (table 3). For the animals

consuming “Vitacel” the trend of decrease of lead accumulation in heart and bones was marked. Use of calcium alginate allowed reduce lead level in kidneys by 32%, in heart by 11.6%, which suggests about detoxicating and eliminating function of kidneys.

The use of the preparation from pork rind reduces the level of lead in heart by 79%, in kidneys – by 89%, in liver – by 85%, in bones – by 60%. The use of pork rind reduces the level of lead less effectively: in heart – by 56%, in kidneys – by 23%, in liver – by 36%, in bones – by 9%. The obtained results suggest about greater effectiveness of collagen-containing preparations as compared to insoluble food fibers.

Table 3. Content of lead in organs and tissues of animals

Organs and tissues of animals	Groups of animals							
	1	2	3	4	5	6	7	8
Heart	0.05±0.015	1.18±0.18	1.54±0.23	0.96±0.08	0.0767±0.015	1.043±0.28	0.25±0.015	0.52±0.09
Kidneys	<0.01	1.03±0.02	1.4±0.06	1.03±0.02	0.063±0.021	0.70±0.11	0.11±0.01	0.79±0.12
Liver	<0.01	0.95±0.13	1.8±0.06	1.04±0.07	0.097±0.015	1.35±0.3	0.14±0.036	0.61±0.09
Muscle tissue	-	0.29±0.01	0.44±0.11	0.44±0.06	0.05±0.02	0.31±0.04	-	-
Bones	0.07±0.02	0.98±0.13	1.92±0.14	0.83±0.36	0.11±0.01	1.13±0.24	0.39±0.04	0.89±0.06

To study the influence of food fibers on calcium metabolism during intoxication by heavy metals the investigations of calcium content in bones of laboratory animals were carried out (Table 4).

Table 4. Calcium content in bones of laboratory animals

Sample	Groups of animals					
	1	3	5	6	7	8
Bone	231.7±12,32	204.5±6,1	1164.7±20,00	335.5±26,2	447.2±10,43	296.7±12.34

The investigations have shown that intoxication with heavy metals (for groups 5 and 6) decreases calcium content by 3.5 times, that confirms good reasons for enrichment of diets with calcium during intoxication. Thus, the use of calcium alginate (group 6) led to increase of calcium content in bones as compared to the group, obtaining beet fibers by 1.6 times. The highest calcium content in groups added with heavy metals was found for the preparation made from pork rind, which suggests about capability of collagen-containing preparations to increase digestibility of calcium.

The results of the investigations were used in the development of special products for prophylaxis of obesity, liver and cardio-vascular diseases.

Conclusions

On the basis of the chronic biological test of the preparations of food fibers on laboratory animals the following conclusions can be done:

- absence of cumulative toxic effect and low level of food sensibilization for all the tested preparations of food fibers;
- the preparation from pork rind and pork rind enhance immunity and remove heavy metals more efficiently than the preparations of insoluble food fibers
- calcium alginate enhances immunity, improves detoxicating function of kidneys, possesses hypoallergenic effect and large chemical affinity to cations of lead, than of cadmium;
- “Vitacel” and beet fibers are more efficient with regard to cadmium, than to lead;
- the preparation from pork rind, pork rind and calcium alginate help to increase calcium content in bones of laboratory animals;

References

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