Bulgarian Journal of Agricultural Science, 25 (Suppl. 1) 2019
Agricultural Academy

Content of lead and cadmium in lamb meat and edible organs cooked in different containers

Dimo Penkov*, **Hristo Hristev**

Agricultural University, Plovdiv, 4000 Bulgaria
**Corresponding author:* dimopenkov@gmail.com

Abstract

Penkov, D., & Hristev, H. (2019). Content of lead and cadmium in lamb meat and edible organs cooked in different containers, *Bulgarian Journal of Agricultural. Science, 25*(Suppl. 1), 23–26

The lead (Pb) and cadmium (Cd) contents in meat (from *M. abdominis*), liver and kidneys, thermally processed in 2 different types of containers – metal (German silver) and tin-plated, have been established. Both types of cookware are widely used in food preparation. The authors established higher levels of both elements in all the samples, treated in tin-plated containers. The content of both elements was higher than the Bulgarian maximum permissible levels (MPL). The calculated Clarkes of distribution of both elements were higher in liver cooked in the metal container (for Cd: 0.23 versus 0.13 in the tin-plated container, for Pb: 0.46 versus 0.32, respectively). In meat and kidneys, the Clarkes of distribution were almost equal – 0.09 versus 0.11 and 0.11 versus 0.13, respectively. The authors recommend avoiding the thermal processing of meat in tin-plated containers.

Keywords: lead; cadmium; lamb meat; liver; kidneys; tin-plated containers

Introduction

Lead and cadmium are heavy metals with a potential risk for human health. Their intake (mainly with food) causes serious damage to the organism. For this reason, the European legislation imposes ever stricter restrictions on the content of those elements in food (Commission Directive 2005/87/EC).

Numerous studies on laboratory animals (Sandip et al, 2017; Said et al., 2014; Ali, 2016; Lovasova, et al., 2013; Arnaudova et al., 2008) indicated that those elements are also dangerous as they accumulate in vital organs. That is why protectors are sought to block those elements in the organism of different animals (Kravtsiv et al., 2003; Hannan, et al., 2015 et al.).

The risk of metal intake comes not only from the products but also from their content in the cookware. A large study on the method of thermal processing of tomato and peppers (Kmetov, 2004) indicated that boiling food products in tin-plated cookware seriously increased the risk of additional contamination due to the lead content in the tin mixture.

The aim of the present study was to carry out a comparative investigation of the lead and cadmium content in meat samples and edible lamb offal thermally processed in standard steel and tin-coated containers.

Materials and Methods

In 2017, samples of abdominal muscle (*M. abdominis*), kidneys and liver were collected and fried in a tin-plated container, used by different households in areas with increased technological Clarke. Samples were taken from animals, which dietary regime was followed out from their birth till their consumption stage (Table 1).

Suckled milk was recalculated by twice control milking method, 25±3 days after birth, following the method described by Tyankov et al. (1985).

The amount of feed and water consumed per day was calculated according to the equation: total amount of forage (water) consumed for the whole period by all the

Table 1. Main characteristics of lambs, an object of the experiment

Characteristics	Values	
Age of realization – days	94.05±1.20	
Weight of carcass for realization – kg	11.95±1.0	
Liver weight – kg	0.223±0.01	
Left kidney weight – kg	0.047±0.002	
Consumed milk – average for the whole lifespan by 1 lamb – kg	75	
Consumed drinking water – average for the whole lifespan by 1 lamb – kg	281.5±3.5	
Consumed lucerne hay – average for the whole lifespan by 1 lamb – kg	18.4±0.2	
Consumed energy forage – average for the whole lifespan by 1 lamb – kg	18.93±0.2	
Contents in 1 kg forage	Pb – mg	Cd – mg
Sheep milk	0.025	0.0002
Drinking water	0.002	0.0002
Lucerne hay	2.5	0.22
Energy (grain) forage – 50%:50% wheat:barley	0.08	0.025

lambs divided by the sum of the days of life of all the lambs produced.

After the initial processing of all the animals, the weight of the skinned and cleaned carcass was measured together with the edible o using balances of 5 g accuracy and the liver and kidney weight was measured with balances of 1 g accuracy.

One average sample of all the studied elements of the trophic chain was developed for the analysis. All the samples from forages, muscles, liver and kidneys were tested for the lead and cadmium content, following the method of Jorchrem (1993) by I AAS, type Perkin-Elmer 4100.

Results

Table 2 presents the lead and cadmium content in the studied components. Lead and cadmium contents are higher in all the samples fried in tin-plated cookware. The highest differences in the content of both heavy metals were reported in kidneys – the content of lead was over 3 times higher and of cadmium – more than 2 times higher after processing in tin-plated containers compared to standard metal ones. Although lower in values, the differences in the content of both elements were almost the same for abdominal muscles. The differences in the liver were smaller, which could be explained by the fact that its thermal processing was the shortest.

Table 3 presents two characteristics for the transfer of lead and cadmium along the trophic chain – Bioaccumulation Factor 2 (FB2 – Baykov et al., 2006), representing the ratio of the chemical element content in secondary biological products (animal tissues) and the mean primary organic product (feed and drinking water), as well as Clarke of distribution (CD – Baykov et al., 2005), representing the ratios in

Table 2. Lead and cadmium contents in lamb organs/tissues processed in different containers

Organs/tissues	Thermal treatment in a metal container		Thermal treatment in a tin-plated container	
	Pb – mg/kg	Cd – mg/kg	Pb – mg/kg	Cd – mg/kg
Content in kidney	0.55	0.60	1.70	1.25
Content in liver	0.60	0.20	1.0	0.21
Content in the abdominal muscle	0.15	0.08	0.40	0.16

Table 3. Factor of bioaccumulation (FB2) and Clarke of distribution (CD) in different organs/tissues of the studied lambs, processed in metal and tin-plated containers

Organ/tissue	Element	Thermal treatment in a metal container		Thermal treated in a tin-plated container	
		FB2	CD	FB2	CD
Abdominal muscle	Pb	0.06	0.11	0.16	0.13
	Cd	0.36	0.09	0.73	0.11
Liver	Pb	0.24	0.46	0.40	0.32
	Cd	0.91	0.23	0.95	0.13
Kidney	Pb	0.22	0.11	0.68	0.13
	Cd	2.73	0.09	5.68	0.11

the content of the elements in the studied animal organ/tissue and the mean total content in all the studied organs/tissues.

Studying the Bioaccumulation Factor it becomes obvious that it was higher in all the samples in tin-plated containers. For cadmium, there was a significant difference in kidneys only, whereas the bioaccumulation of lead was more than 2 times higher in liver and muscles. Differences in bioaccumulation of both elements could be only a result of the cookware used because the other components in the eco-technical system were a source of the same amounts of the elements.

The Clarke of distribution showed relatively identical distribution of the elements in the samples obtained from the two methods of thermal processing. That means both elements were surely transferred from the tin-plated cookware to the edible tissues.

Discussion

The sheep milk consumed by lambs is a significant source of lead. The content of the element exceeded the Bulgarian maximum permissible level (MPL) by 25%. The cadmium content was lower than the MPL adopted in Bulgaria (Ordinance No. 31/29.7.2004 of the Ministry of Health). But we assume that the value of that indicator might have been influenced by hand milking, and that the animals and the premises, in which they were reared, were not cleaned on the day of collecting the samples.

Drinking water samples contained 2 times more lead than the latest MPLs reflected in EU Drinking Water Directive 98/83/EC. Besides the natural content of lead in water, the old metal pipes in most plumbing installations also contributed to the increased lead concentrations. The cadmium content was about 2.5 times lower than the permissible level published in the same Directive.

The content of both elements taken by the animals, were much lower in hay and mixed forages compared to the MPL adopted in Bulgaria, which are: cadmium – 1 mg/kg and lead: in cereal feed – 10 mg/kg, in grass forages – 30 mg/kg (Ordinance of the Ministry of Health No. 10/03.04.2009).

When studying the content of the two elements in tissues thermally processed in steel containers, a slight excess of the permissible levels was reported only for cadmium in kidneys. All the other values were below the accepted MPL.

However, the values in the tissues processed in tin-plated cookware were quite different from the above mentioned. Both lead and cadmium contents were higher than the permissible levels in kidneys. The same applied to the content of lead in liver.

Although the concentration of both elements in the abdominal muscles was below the maximum permissible levels, their content exceeded significantly the values reported in the tissues processed in metal cookware. Provided that both elements accumulate in the human body, the risk of disease is significant, even at values lower than the maximum permissible levels. On that basis, we recommend a periodic information campaign among the population on the non-use of tin-plated containers for thermal processing of meat products.

Conclusions

The lead and cadmium content in samples thermally treated in tin-plated containers, exceeded many times the content in samples, treated in standard metal containers. The highest contents of both elements were reported in kidneys, exceeding over 2 times the maximum permissible levels.

The lead content in liver samples treated in tin-plated containers, also exceeded the permissible concentrations.

Although the contents of both elements in the muscle, treated in tin-plated containers were within the permissible levels, the values were 2-3 times higher compared to the samples treated in metal containers.

It is recommended to avoid the use of tin-plated cookware for thermal processing of animal food products for humans.

Biological Accumulation Factor 2 (FB2) showed higher values for both elements in the products cooked in tin-plated containers, while "Clarkes of distribution" showed identical distributions of the elements in tissues, processed in different types of containers.

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