

Investigation The Effect of Different Levels of Dry Sugar Beet Pulp mixed Concentrate Feeds on Cadmium Levels in Rabbit Slaughter Products

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ABSTRACT

Commercial concentrated feeds are traditionally a major component of rabbit diets which contain Cadmium element in quantities above generally accepted level. This toxic trace element can accumulate in meat, kidneys, liver, bones and spleen of rabbits. Consumption of such meat and by-products will contribute to the accumulation of Cadmium in the human body, which may lead to a number of pathological changes. In this study, 100 young rabbits-analogues of silver breed were selected, and divided into 5 groups, 20 rabbits in each group: the 1st group was the control group, the 2nd, 3rd, 4th and 5th were experimental with total 60 days duration period. Results showed the smallest content of Cadmium in slaughter products was observed in the rabbits at 5th experimental group. In conclusion, the course of the experiment, it has been established that supplementation into the rabbit's mixed fodder of dry sugar beet pulp contributes to reducing the level of Cadmium accumulation in slaughter products. It has also been noted that most of Cadmium is excreted with feces, that is, it is not absorbed into the bloodstream and does not have a negative effect on the body of the rabbit.

Keywords: Cadmium, dry sugar beet pulp, slaughter products, rabbits, mixed fodder

Kadmiyum İlaveli Konsantre Yemlere Farklı Düzeylerde Kuru Şeker Pancarı Posası Katılmasının Tavşanların Kesim Ürünlerinde Kadmiyum Seviyelerine Etkisinin Araştırılması

ÖZ

Ticari konsantre yemler genellikle kabul edilen seviyenin üzerinde kadmiyum elementini içeren tavşan diyetlerinin ana bileşenidir. Bu toksik iz element, tavşanların etlerine, böbreklerde, karaciğerde, kemiklerde ve dalaklarında birikebilir. Bu tür et ve yan ürünlerinin tüketimi, insan vücudunda kadmiyum birikimine katkıda bulunabilir ve bu durum bir takım patolojik değişikliklere neden olabilir. Bu çalışmada, 100 adet gümüş ırkın analogu genç tavşan kullanılmıştır. Tavşanlar, her birinde 20 adet olmak üzere 5 gruba ayrılmıştır. Gruplar 1 kontrol ve 4 deneme grubu olacak şekilde düzenlenmiştir. Araştırma 60 gün boyunca sürdürülmüştür. Sonuçlar, 5. deneme grubundaki tavşanlarda, kesim sonrası elde edilen karkasta ve bazı iç organlarda en az düzeyde kadmiyum içeriğinin tespit edildiğini göstermiştir. Sonuç olarak, deneme boyunca, 0.04 mg/kg düzeyindeki kadmiyum katkılı rasyonlara artan düzeylerde kuru şeker pancarı ilavesinin, karkas ve bazı iç organlarda kadmiyum seviyesinin azaltılmasına katkıda bulunduğu tespit edilmiştir. Ayrıca kadmiyumun çoğunun dışkı ile atıldığı, yani kan dolaşımına emilmediği ve tavşanın vücudu üzerinde olumsuz bir etkiye sahip olmadığı da kaydedilmiştir.

Anahtar Kelimeler: Kadmiyum, kuru şeker pancarı posası, kesim ürünleri, tavşan, karma yem

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INTRODUCTION

Cadmium (Cd) is a highly persistent environmental toxicant that exhibits higher rates of soil-to-plant transfer than other toxic heavy metals, such as lead (Pb) and mercury (Hg), making Cd a food-chain contaminant of great concern. Further, Cd oxide (CdO), which is a highly bioavailable form of Cd, is present in cigarette smoke and polluted air, contributing to elevated Cd concentrations in blood, urine, and tissues of smokers, compared with non-smokers of similar age and gender (McLaughlin et al., 1999). For several decades, the problem of reducing the content of heavy metals, in particular Cadmium, in the environment is an acute problem in the world (Wu et al., 2016). The toxicity of this chemical element has been proved by numerous studies (Carson et al., 2018). Cadmium primarily affects the kidneys (Johri et al., 2010), respiratory and cardiovascular systems, and spermatogenesis (Rahimzadeh et al., 2017). Bones undergo less noticeable changes, although under the action of elevated doses of Cadmium, they become brittle and fragile (Chen et al., 2011). Additionally, carcinogenic effects of Cadmium on human body have been proven in recent studies (Adams et al., 2014; Eriksen et al., 2015). So it is very important not to allow the accumulation of heavy metals, in human diet prevent its accumulation in the human body. The major sources of Cadmium in the human body are food, water and air (Nordberg, 2004).

The idea of using of sugar beet pulp as a sorbent of heavy metals is not new. A number of studies prove the effectiveness of sugar beet pulp in such applications as water purification (Pehlivan et al., 2008). The results of a number of studies have also confirmed the detoxifying effect of pectin on poisoning with Lead (Khotimchenko et al., 2007). There are reports of a decrease in the level of heavy metals in chicken broiler meat after the feeding with citrus pectin (TemiraeV et al., 2017).

Previously, we have published the results of studies conducted on pigs that showed that the use of beets, apple and sugar beet pulp in pig's feeding contributes to the decrease of heavy metals accumulation in their slaughter products (Dyachenko et al., 2015, 2017).

Since pork is less used for feeding of children and sick people belonging to the most vulnerable populations, our experiments were aimed at investigating the effects of different levels of beet pulp in mixed fodder on the accumulation of heavy metals in young rabbits grown for meat.

MATERIALS and METHODS

The current study was performed at the Experimental Animal Research farm of Bila Tserkva National

Agrarian University Ukraine after the approval of the Local Ethics Committee of the Faculty of Veterinary Medicine under approval No: 00001/01; dated: 30/05/2016.

Experimental design and management

To conduct scientific and economic experiment, 100 young rabbits-analogues of silver breed were selected, and divided into 5 groups, 20 rabbits in each group: the 1st group was the control group, the 2nd, 3rd, 4th and 5th were experimental ones (Table1). During the comparative period, within 15 days, rabbits were fed with a full-fodder feed № 1, in which the dry beet pulp was absent. In the main period, the animals in the control group were got feeding of this mixed fodder, and the rabbits of the 2nd - 5th experimental groups got the mixed fodder where the share of barley was replaced with dry beet pulp according to the Table 2. The chemical composition and nutrition of the complete feed corresponded to the established requirements (Maertes at all. 2004).

Data Collection and Analyses

In the course of the experiment, the rabbits were kept individually in cages equipped with bunker feeders. Mixed fodders were used in the form of solid granules with a diameter of 5 mm. Animals of all groups had free access to food and water during 24 hours. The slaughter was carried out in accordance with the relevant animal protection regulations during the slaughter procedure (European Communities, 2009). The content of Cadmium in mixed fodders, excrements and rabbit slaughter products was determined using an atomic adsorption spectrophotometer.

Statistics

The model assumptions of normality and homogeneity of variance were examined by Shapiro-Wilk and Levene tests, respectively. The statistical analysis was performed with MedCalc software (MedCalc Software bvba, Ostend, Belgium, version 17.5). One-way ANOVA was used for group comparison followed by Tukey-Kramer for post-hoc. All data were expressed as mean \pm SEM. The significance level was considered as $p < 0.05$.

RESULTS

The main purpose of dry beet pulp as a sorbent of heavy metals was to reduce the level of fasciation of Cadmium in the body of rabbits. The results of the balance study showed that at the same level of consumption of Cadmium in all experimental groups, the majority of this trace element was excreted with feces and lesser with urine (Table 3).

The inclusion of dry beet pulp into the mixed fodder not only improved the growth of rabbits, but also reduced the flow of Cadmium into the products of their slaughter. At the mass fraction of dry pulp in the mixed fodder of 3% the Cadmium fixation in the rabbit's bodies of the 2nd experimental group decreased by 3.43% compared to the control one. With the 12% mass fraction of dry pulp in the feed (the 5th experimental group) the quantity of Cadmium in the body of rabbits decreased to 8.68%, which is 9.31% less than control group (Table 4).

During the main experimental period the animals in test groups, according to the average daily increments, dominated their peers from the 1st control group (Fig. 1 and Fig. 2). According to Fig.1 in the first group, highest assimilation of Cadmium in the body of rabbits, % of consumed however, in other groups it decrease drastically. According to Fig. 2, in the 3rd experimental group, highest average daily increments (g) in the rabbits were observed as compared to other experimental and control group.

Table 1. *In vivo* experiment schedule.

| Group | Feeding terms and conditions | |
|------------------------|---|--|
| | Comparative (preparatory) period (15 days) | Main period (60 days) |
| 1 – control group | Mixed fodder (MF) 1 | MF 1 (Cadmium content 0.04 mg/kg) ¹ |
| 2 – experimental group | MF 1 | MF 2 (Cadmium content 0.04 mg/kg) ¹ |
| 3 – experimental group | MF 1 | MF 3 (Cadmium content 0.04 mg/kg) ¹ |
| 4 – experimental group | MF 1 | MF 4 (Cadmium content 0.04 mg/kg) ¹ |
| 5 – experimental group | MF 1 | MF 5 (Cadmium content 0.04 mg/kg) ¹ |

¹Natural content in feed

Table 2. Composition of the Concentrated Feeds, %

| Item | MF No 1 | MF No 2 | MF No 3 | MF No 4 | MF No 5 |
|----------------------------|---------|---------|---------|---------|---------|
| Barley grain | 19 | 16 | 13 | 10 | 7 |
| Corn, grain | 10 | 10 | 10 | 10 | 10 |
| Wheat, grain | 18 | 18 | 18 | 18 | 18 |
| Soybean meal | 10 | 10 | 10 | 10 | 10 |
| Alfalfa hay flour | 30 | 30 | 30 | 30 | 30 |
| Dry sugar beet pulp | - | 3 | 6 | 9 | 12 |
| Meat and bone meal | 5 | 5 | 5 | 5 | 5 |
| Salt (NaCl) | 5 | 5 | 5 | 5 | 5 |
| Chalk (CaCO ₃) | 1 | 1 | 1 | 1 | 1 |
| Premix Axelarat | 2 | 2 | 2 | 2 | 2 |
| Total | 100 | 100 | 100 | 100 | 100 |

Table 3. Balance of Cadmium in the body of young rabbits, μg , $\bar{0} \pm s_{\bar{0}}$ (n=3)

| Item | Group | | | | |
|--------------------------|--------------|-------------------|-------------------|-------------------|-------------------|
| | Control 1 | Experimental 2 | Experimental 3 | Experimental 4 | Experimental 5 |
| Consumed with feed | 6.00±0.304 | 5.94±0.173 | 6.15±0.131 | 5.92±0.130 | 5.88±0.148 |
| Consumed with water | 0.15±0.004 | 0.14±0.005 | 0.16±0.001 | 0.15±0.002 | 0.14±0.005 |
| Secreted with excrements | 2.67±0.145 | 2.90±0.153 | 3.47±0.088* | 3.47±0.067* | 3.43±0.088* |
| Secreted with urine | 2.37±0.033 | 2.30±0.058 | 2.07±0.088 | 2.00±0.116 | 2.07±0.088 |
| Assimilated | 1.11±0.132 | 0.88±0.054 | 0.77±0.053 | 0.60±0.064* | 0.52±0.045* |

* P < 0.05

Table 4. Cadmium content in young rabbit slaughter products, μg , $\bar{0} \pm s_{\bar{0}}$ (n=3)

| Item | Group | | | | |
|--------|------------------|--------------------|--------------------|---------------------|---------------------|
| | Control | Experimental | Experimental | Experimental | Experimental |
| | 1 | 2 | 3 | 4 | 5 |
| Kidney | 181.7 \pm 4.06 | 164.7 \pm 3.93* | 147.0 \pm 4.16** | 143.0 \pm 4.04** | 127.0 \pm 3.79*** |
| Bones | 153.3 \pm 2.73 | 136.3 \pm 2.03** | 126.3 \pm 2.33** | 113.3 \pm 2.03*** | 109.3 \pm 2.33*** |
| Liver | 106.3 \pm 2.91 | 89.3 \pm 2.33* | 85.0 \pm 2.31** | 75.7 \pm 2.03** | 65.3 \pm 1.76*** |
| Meat | 28.7 \pm 0.88 | 24.7 \pm 0.88* | 22.3 \pm 0.88** | 20.7 \pm 0.88** | 19.3 \pm 1.20** |

* P <0.05; ** P <0.01; *** P <0.001 as compared with the control group.

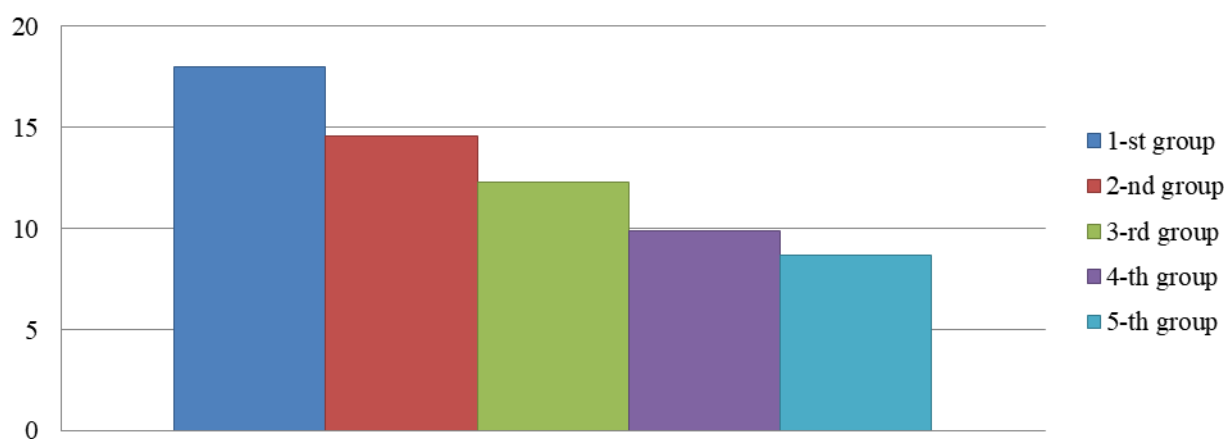


Figure 1. Assimilation of Cadmium in the body of rabbits, % of consumed

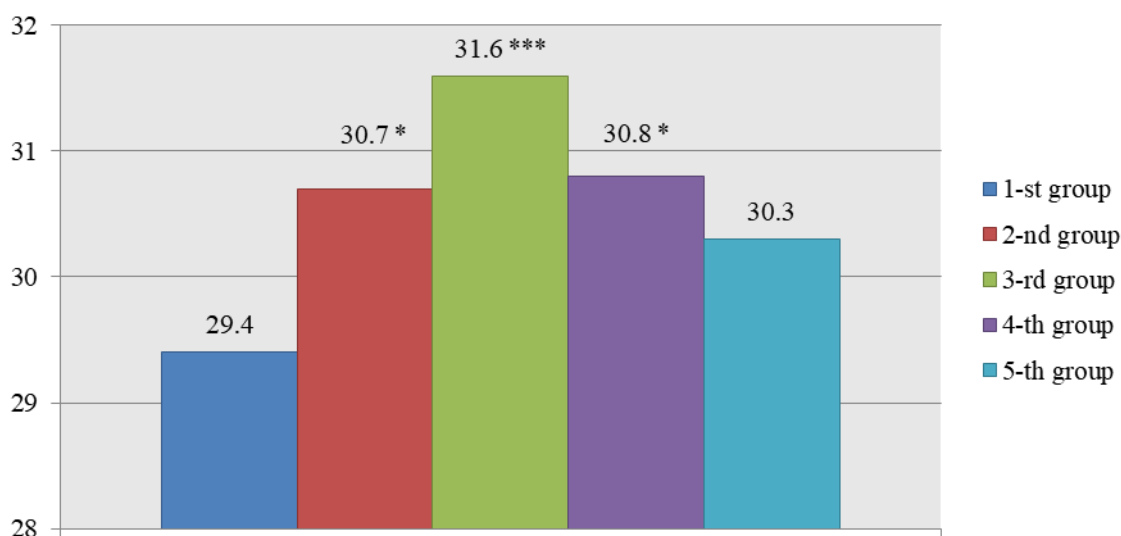


Figure 2. Average daily increments of the rabbits during the experiment, g

DISCUSSION

Main adsorption of Cadmium occurred in the gastrointestinal tract. Reduced level of Cadmium fixation contributed not only to the reduction of the accumulation of this element in the body, but also to decrease its negative influence on individual organs

and tissues of rabbits. Animal and *in vitro* studies suggest that the absorption of Cd in the gastrointestinal tract is mediated by several transporter systems, which may include divalent metal transporter1, DMT1 (Garrick et al. 2003). Absorption rates for dietary Cd are influenced by the intake levels and body content of vital metals and elements.

Higher dietary zinc intake levels were associated with lower Cd body burden, as assessed by urinary Cd excretion levels (Vance, et al., 2015).

The data of the Cadmium accumulation level in the body of experimental rabbits. As it can be seen, with the increase of the proportion of dry beet pulp in the mixed fodder, the level of Cadmium consumption in the body of rabbits decreased. Moreover, the amount of Cadmium fixation in the rabbit organism was inversely proportional to the content of dry pulp in the feed. The majority of reported dietary Cd intake estimates are within the FAO/WHO tolerable level of 58µg/day for a 70-kg person, with an exception for certain locations in Japan, where intake exceeded the FAO/WHO safe intake guideline (Ikeda, et al., 2015). In particular, the increase of the dry beet pulp mass fraction in the mixed fodder up to 3% resulted in the increase of the average daily increment of the rabbit's body weight, while the rabbits of the 2nd experimental group, compared with control one, increased body weight by 4.4%. With 6% of mass fraction of dry pulp in mixed fodder, the average daily increment of the rabbits' body weight of the 3rd experimental group was the highest - 31.6 g, which is higher than in the control group by 7.5%. The average daily increments, the mass of the rabbit's body of the 4th and 5th experimental groups, with the mass fraction of dry pulp in the mixed fodder 9 and 12%, exceeded the control group, by 4.8 and 3.1% respectively. The best rabbits' productivity was noted in the rabbits of the 3rd experimental group with the 6% mass fraction of dry pulp in mixed fodder. The body content of Cd assessed by urinary and/or blood Cd levels showed an inverse association with body mass index (BMI), central obesity, and risks of weight gain, and obesity in both children and adults. These have consistently been observed across populations, including the U.S., Belgium, Canada, Korea, and China. In a Chinese study, urinary Cd levels that were equivalent to or greater than 2.95 µg/g creatinine were associated with a reduced risk of being overweight (Nie et al., 2016).

The introduction of dry beet pulp into the fodder of rabbits of the 2nd experimental group in an amount of 3% by weight contributed to a decrease of the Cadmium content in the kidneys, liver, bones and meat, respectively, by 9.4%; 16.0; 11.1 and 13.9% compared to the rabbits of the control group. The increase in the mass fraction of dry beet pulp in the mixed fodder of rabbits of the 3rd experimental group up to 6% resulted in a decrease in the Cadmium content in meat by 22.3%, liver by 20%, in kidneys by 19.1%, in bones by 17.6% relatively to benchmarks. A significant decrease in the level of Cadmium in slaughter products was noted in the animals of the 4th experimental group. Thus, they outperformed the control analogues with Cadmium in the kidneys, liver, bones and meat, respectively, by

21.3%; 28.8; 26.1 and 27.9%. The introduction of the 12% of dry pulp into the mixed fodder of rabbits in the 5th experimental group reduced the Cadmium content in meat by 33% compared to the control animals. However, Cadmium content in the kidneys decreased by 30%, in the liver - by 39%, in bones - by 29%. In the Swedish study, a half of total kidney Cd content (10 µg/g kidney cortex) was estimated to come from food consumption, and the other half was attributed to cigarette smoking. The majority of subjects with high kidney Cd levels (>50 µg/g) were women (Elinder, et al., 1976).

In conclusion, the addition of dry beet pulp into the mixed fodder for rabbits, which are grown for meat, in an amount from 3 to 12% by weight, reduced the absorption of Cadmium in their bodies and reduced its content in slaughter products (kidney, liver, bone, meat), that increased their quality and environmental safety. In conclusion, the course of the experiment, it has been established that supplementation into the rabbit's mixed fodder of dry beet pulp contributes to reducing the level of Cadmium accumulation in slaughter products.

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Conflict of Interest: The authors declare that they have no conflict of interest.

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