Influence of Concentration of Manganese in Food and Water on Their Representation in Tissues of Bullocks in Fattening Stage

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Abstract

In the course of the first half of 2006 the contents of manganese was controlled in water, meadow's hay, complete feed mixture (PKS), with aim of determining of influence on its contents in the muscle tissue, liver and kidneys in fattening bullocks.

The water and feed samples were taken quarterly. Ten samples of samples for each of: water, hay, PKS, muscle tissue, liver and kidney (on slaughtering the bullocks) were totally treated. Apart from water, the samples for analysis were prepared from ashes (by means of burning at 550^{o}C), and in all samples the contents of manganese was determined by means of atomic absorption spectro-photometry (AAS).

The average quantity of manganese in water was 0.016 mg/L, with variation interval 0.002-0.070 mg/L, in hay 76.007 mg/L with variation interval 32.079- 100.159 mg/L, in PKS 42.637 mg/kg with variation interval 8.84-54.618 mg/kg, in muscle tissue 0.338 mg/kg with variation interval 0.173-0.523 mg/kg, in liver 2.371 mg/kg with variation interval 1.811-2.859 mg/kg in kidney 1.117 mg/kg with variation interval 0.899-1.303 mg/kg.

As in tested materials (except for water), in the matrix there are other elements in a big quantity (Cu, Zn, Fe, K, Na, Mg i Na), we considered it to be important to find out their influence on determination of Mn applying AAS methods. That is why in all tested materials, an average percentage of potential was determined. The level of interferences of Cu, Zn, Fe, K, Na, Mg and Na, during determining of Mn by means of AAS method, was tested by means preparation of synthetic solutions of interferences with Mn on three levels (low – I; medium – II and high – III).

Our researches showed that the bullocks, through hay and PKS, gained the sufficient quantity of manganese. The biggest quantity of manganese, in case of bullocks' tissues are concerned, was found in bullocks' livers.

Keywords: manganese, water, complete feed mixture, muscle tissue, liver, kidney, interferences

Introduction

As a difference from other microelements, there are not so many data about Mn referring the chemical form or combinations in which it is occurring in animal organism. With the exception of arginase in liver, for which it was found out to contain Mn as an essential component [3], it is not an isolated meta-enzyme containing protein in molecule with exactly determined quantity of Mn. However, Mn in vitro activates numerous enzyme systems, in most cases together with other bivalent ions, especially with manganese. The fact is that Mn is concentrated in mitochondria, induces us to make a conclusion that it is included in partial regulation of oxidative phosphorylation. Manganese is not concentrated in any specific organ or tissue, but it has been confirmed that its concentration in bones, liver, kidneys and pancreas is higher (1-3 mg/kg of fresh tissue) than in skeleton muscles (0.1-0.2 mg/kg).

The animals needs for Mn depend on animal specie as well as on the quantity of Ca and P contained in single feeding. Estimating the needs for Mn is made difficult by the insufficient knowledge about the availability of Mn (in fowl food the quantity available is estimated to be at the level of 5%), so it is considered that, for the fattening bullocks, it is necessary that the single feeding should contain 10 mg/kg Mn [3]. The quantity of Mn in hay directly depends on its contents in soil, so there are regions where the deficit of Mn contents is expressed in hay for its lack of contents in soil. The most frequent method now applied when determining Mn in biological material is AAS method [2]. There are not so many data in bibliography for the disturbances in interference caused by other present elements when determining Mn by applying AAS method. That was the reason that, besides determining of the contents of this element in water PKS for bullocks and bullocks tissues, to start the determining of disturbances caused by other elements (Cu, Zn, Fe, K, Na, Mg i Na) when determining Mn.

Materials and Methods

This paper shows the determining of the contents of Mn in water, meadow hay, complete feed mixtures (PKS) intended for fattening bullocks of home breed (Simmental) and on slaughtering in the muscle tissue, liver and kidneys. By the analysis 10 samples of all tested materials each were comprised.

The samples of water, hay and PKS for analyses have been taken since January 2006, quarterly, while the tissues were taken on slaughtering the bullocks. The samples of water for analysis were prepared by means of canning (by means of nitrate acid) on the farm, and then they were concentrated in the laboratory. Hay samples were homogenized, chopped and then burned on the electric ring, then fired in the firing furnace at 550^{o}C. The rest after the firing process was solved in HCl (1:1) and then moved to already measured vessels of 50 mL [16].
PKS samples were homogenized in the homogenization mill "Cyclotec", burned on the electric ring and then fired in the firing furnace at 550^{o}C. Ashes were solved in HCl (1:1), while determining of Mn in all materials was performed by means of AAS method (Perkin Elmer 3300) [2].

Beside the contents of Mn, in the quoted samples the average contents of Cu, Zn, Fe, K, Na, Mg and Na was found as interferences when determining Mn.
Synthetic solutions of Mn with interferences were prepared on three levels of concentrations. Manganese was present in concentration 1.0 mg/L (I level); 1.5 mg/L (II level) and 2.0 mg/L (III level).

The average concentration of interferences Cu in water amounted to 0.047 ± 0.02 mg/L, in concentrated feed 7.695 ± 1.17 mg/kg, in muscle tissue 3.13 ± 0.56 mg/kg, in liver 71.68 ± 38.33 mg/kg and in kidney 6.64 ± 0.28 mg/kg.

The average concentration of Zn in water amounted to 0.260± 0.286 mg/L, in concentrated food 32.18 ± 8.79 mg/kg, in muscle tissue 44.30 ± 10.26 mg/kg, in liver of fattening bullocks 42.38± 28.01 mg/kg and in kidney 15.32 ± 1.60 mg/kg.

The average concentration of interferences Fe in water amounted to 1.92 ± 1.48 mg/L, in concentrated food 137.43 ± 18.07 mg/kg, in muscle tissue 38.87 ± 16.42 mg/kg, in liver 67.60 ± 1310 mg/kg and in kidney 78.83 ± 20.63 mg/kg.

The average concentration of interferences K in water amounted to 2.37 ± 1.06 mg/L, in concentrated feed 11 283.07 ± 556.06 mg/kg, in muscle tissue 5 712.6 ± 393.39 mg/kg, in liver 5 597.31 ± 625.25 mg/kg and in kidney 5 688.09 ± 431.41 mg/kg.

The average concentration of interferences Na in water amounted to 2.81 ± 1.57 mg/L., in concentrated feed 1 344.00 ± 41.63 mg/kg, in muscle tissue 464.05 ± 44.91 mg/kg, in liver 557.58 ± 89.39 mg/kg and in kidney 774.24 ± 100.83 mg/kg.

The average concentration of interferences Ca in water amounted to 12.98 ± 4.92 mg/L, in concentrated feed 9 623.14 ± 218.87 mg/kg, in muscle tissue 729.07 ± 106.23 mg/kg, in liver 534.04 ±788.87 mg/kg and in kidney 252.44 ± 41.17 mg/kg.

Based on these results three levels of interferences were determined (low, medium and high).

So, during determining procedure of Mn the first (I) level of interferences was: 1.0 mg/L Zn; 3.0 mg/L Cu; 5.0 mg/L Na; 10.0 mg/L Fe; 10.0 mg/L Mg; 20 mg/kg Ca; 20.0 mg/L K.

The second level (II) of interferences during determining procedure of Mn was: 5.0 mg/L Zn; 10.0 mg/L Cu; 20.0 mg/L Fe, Mg and Na; 100.0 mg/L K and Ca.

The third level (III) of interferences during determining procedure of Mn was formed by: 10.0 mg/L Zn; 20.0 mg/L Cu; 50.0 mg/L Mg and Fe; 40 mg/L Na; 500.0 mg/L Ca and K.

Results and Discussion

The results of our research work referring to the contents of Mn in water, hay, PKS for bullocks, in muscle tissue, liver and kidneys, are shown in Tables (Tables 1 and 2)

The average contents of Mn in water by which the bullocks were watered amounted to 1.57 x 10^{-2} mg/L with variation interval of 0.002- 0.070 mg/L, which is considerably lower than MDK for potable water [11].

As the bullocks farm is provided with water from alluviums of the river Ibar, as well as the town of Kraljevo, these results on the contents of Mn in water show that the quantity of Mn in the water of river Ibar almost unchanged as referred to the researches from 1987, '88 and '89. [5].

The values below referring the contents of Mn were determined in accumulation Vrutci (in average 0.007 and 0.012 mg/L, with variation interval 0.000 – 0.075 mg/L) [8].

According to our results, the hay in the Kraljevo region contains Mn in the average quantity of 76.01 mg/kg of air dried hay, with variation interval 32.08- 100.16 mg/kg. Our results have a little higher values than the results which were found by Ševković and associates (1989) [14, 15] during testing of the contents of Cu, Zn, Mn and Fe in hay in the Kraljevo region and Pozega. They informed that the contents of Mn in hay meadow from the Kraljevo region is within the limits of 44.54- 87.22 mg/kg, while from the region of Požega from 68.42- 143.95 mg/kg. In the Kraljevo region – in the village of Vitkovac [6] it was found that the average contents of Mn was 88.47 mg/kg, while at the same time the hay from the village Lađevci contained 45.97 mg/kg of Manganese. Hay-grass from the region of Dragačevo [7] contained 166.67 mg/kg Mn, and from Pešter 87.39 mg/kg. These data confirm the fact that the quantity of Mn is dependable on its quantity in soil and is considerably different depending on the location where the grass hay was collected.

PKS for bullocks averagely contained 12.64 mg/kg of Mn with variation interval of 8.84- 54.62 mg/kg. Average contents of Mn is lower than the needs of fattening bullocks prescribed by the Rules on Quality and other Requirements for Animal Feed ("Official Gazette of SRJ" No: 20/2000, 38/2001) [12] in amount of 20 mg/kg. The bullock needs for Mn are very hard to estimate for the ignorance about Mn availability.

Results about the contents of Mn in tissues (Table 2) shows that Mn, in the biggest quantity, is concentrated in liver (averagely 2.37 mg/kg, in kidney 1.18 mg/kg and in meat 0.34 mg/kg. Determined quantity of Mn in liver is approximate to the quantity found by Rogovski (1981) [13] in amount of 0.26mg/100g. Similar results referring the contents of Mn in bullock liver were found by Marija Vukašinović and I. Rajić (1989) [4], by determining, depending on the season of the year, 1.38 do 2.63 mg/kg Mn.

Table 1. Average contents of Mn in water (mg/L), hay and PKS (mg/kg)

n=10	Water	Hay	PKS
X	1.57 x10^{-2}	76.01	12.64
Sd	1.97x10^{-2}	22.21	12.84
Cv	125.15	29.22	30.18
Iv	0.002-0.070	32.08-100.16	8.84-54.62

Table 2. Average contents of Mn in tissue fattening bullocks (mg/kg)

n=10	Liver	Kidney	Meat
X	2.37	1.12	0.34
Sd	0.32	0.13	9.70x10^{-2}
Cv	13.69	11.95	28.68
Iv	1.81-2.86	0.90-1.30	0.17-0.52

The average value of contents of Mn in the liver of fattening bullocks that was found in this research work is above the contents in liver of bullocks which were the subject of judging about the contents of micro-elements in the tissues of cows and bullocks (lungs, liver, kidneys, and three kinds of different muscles) [10]. Considerably higher contents of manganese were determined by the quoted authors in livers of cows (51.20 mg/kg), while the liver of bullocks contained less manganese than the quantity determined in this paper (0,97 mg/kg of manganese).

The contents of manganese in kidneys of the bullocks in our experiment is above the contents found in cows and bullocks in the mentioned study and it amounts to averagely 1.12 mg/kg, while the kidneys of cows in Bulgaria had a contents of 0.63, and bullocks 0.38 mg/kg.

Obtained results for the contents of manganese in muscle tissue of bullocks in our experiment is close to the quantity which was confirmed in the muscles for steak, while in all other muscles of cows and bullocks which were the subject of the mentioned study the lower rates of manganese contents were obtained.

Interferences when determining Mn

In the atomic absorption spectroscopy there occur different disturbances which can considerably influence on the exactness of the obtained results. According to different authors they can differently be divided, but most often are: physical, chemical, spectral etc. [1].

In this particular paper the quantity of Mn related to interference elements is relatively high, so the disturbances by the present interfering should be neglected, during its determination.

Interferences are obtained by calculation of medium value from 9 aspirations of the prepared synthetic solutions of Mn with interferents.

Table 3. Interferences which induce Zn, Cu, Fe, Mg, K, Na and Ca when determining Mn

Interferents	I	II	III
Mn, mg/L	%	%	%
1.0	+3.30	+3.93	+9.01
1.5	+1.95	+2.38	+4.11
2.0	+1.65	+2.00	+2.02

From Table 3, one can see that fixed interferences for concentration of Mn of 2.0 mg/l within the limits acceptable for this kind of determination (up to 2%, it is considered to be permissible deviation). Somewhat above acceptable deviation the interferences were determined when the concentration of Mn being 1.0 mg/L, while the interferents present on the I and II levels, and the Mn 1.5 mg/L, while the interferents present on the II level. The biggest deviation due to the presence of interferents was determined when the concentration of Mn amounted to 1.0 mg/L, and interferents present in the highest concentration (III level) in amount of 9.01%, while that amount is somewhat lower for concentration of Mn of 1.5 mg/L along the presence of interferents at the highest level in amount of 4.11%.

Having in mind that during the determination of Mn (as per Beer's Law) the linear dependability of concentration and absorbance only up to 2.0 mg/L Mn, it is necessary for its concentration in the samples of biological material, by means diluting the samples, to lower to 2.00 mg/L. Simultaneously, the concentration of interferents is lowered (most frequently 5 or 10 times), so very rarely are there the highest level (III nivo) of interferents in the solutions. It induces one to make the conclusion that Mn in biological material can directly be determined by applying AAS method, without previous extraction

Conclusions

Based on the obtained results the following conclusions can be derived:

1. Bullocks, through water, averagely gained Mn in the quantity that does not exceed MDK.
2. The average quantity of Mn gained by bullocks through PKS is below the quantity determined by valid regulations. Considerably high contents of Mn were contained hay consumed by bullocks.
3. Mn is concentrated in highest quantity in liver of the fattening bullocks. The quantity of Mn in bullocks' meat amounted 0.34 mg/kg, in kidney 1.12 mg/kg and in liver 2.37 mg/kg.
4. Determined interferences during determining Mn are within the limits of acceptable values when its concentration is 2.0 mg/L, and interferents present in all three levels. Only in case of concentration of Mn 1.0 mg/L in the presence of interferents on the III level the interferences above the acceptable values were determined.
5. Manganese can be determined in biological material directly, without the previous extraction.

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