Transfer of ^{40}K and ^{137}Cs from diet into meat of ruminants: analogy or not?

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SUMMARY

The study of transfer coefficients and concentration ratios of ^{40}K and ^{137}Cs was performed in order to investigate the bioavailability and potential analogy relationships of observed radionuclides in the chain of animal production of ruminants.

Sampling of material was performed at small individual farms situated inside the three regional livestock areas in Bosnia and Herzegovina.

Transfer coefficients and concentration ratios of ^{40}K and ^{137}Cs were calculated for beef and sheep meat. Obtained results were in accordance with literature data with average transfer coefficient values for ^{40}K and ^{137}Cs in beef of 0.017 and 0.058 d kg-1, respectively; whilst the same values for the sheep meat were higher (0.104 and 0.341). Average values for concentration ratios of ^{40}K and ^{137}Cs were equilibrated between the species (beef: 0.125 and 0.418; sheep meat: 0.136 and 0.443).

Obtained results indicated on the hidden analogy between observed radionuclides, covered by the homeostatic control of potassium in ruminants. The study confirmed the use of potasssium compounds for reduction of radiocesium contamination in ruminants.

Key words: *ruminants, ^{137}Cs and ^{40}K analogy, transfer to meat*

INTRODUCTION

Migration of radionuclides through the food chain of ruminants is especially important parameter for radio ecological predictions in conditions of radiological emergencies. Regarding the fact of significant contribution of milk and meat to the total diet of all population categories, knowledge about transfer and distribution of radionuclides through the food chain of ruminants is necessary for adequate radiation protection of animal production which lead to the adequate radiation protection of population in emergency situations.

Mobility of radionuclides in food chain is quantified by transfer factor (transfer from soil to plant) and transfer coefficient (transfer from total daily diet to specific animal product). Expression "transfer coefficient" was introduced in middle 1970s (Ward et al. 1965) for ratio between activity concentration of particular radionuclide in animal product and its activity concentration in total daily diet. Transfer coefficient represents, therefore, the share of the radionuclide activity in daily diet distributed into kilogram or litre of the particular animal product or tissue in equilibrium conditions. In general, transfer factors and transfer coefficients should be recognized as measure of radionuclide bioavailability.

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From the livestock production standpoint, the most important amongst the main radioactive contaminants is artificial radionuclide ^{137}Cs. Long half-life as well as similarity with potassium, make this radionuclide capable to be ubiquitous distributed in different animal products for long period of time.

Analogy and competitive relation between K and Cs is well documented for the soil to plant transfer (Menzel et al. 1954; Nishita et al. 1961; Korobova et al. 2007) while the evidences of the similar competitive relation in higher organisms were under the question (Howard et al. 2009). Having in mind that aplication of potassium compounds for the purpose of protection during the internal contamination of higher organisms had been recomended in the previous decades (Severa and Bar, 1991), the use of potassium compounds for mentioned purpose shoud be reconsidered.

Regarding the homeostatic control, it is well known that the behavior of the analogues of essential elements depends on the concentration of their essential elements (Varga et al. 2009). Choi et al. (2008) reported that increased potassium concentration in soil above the limit did not lead to more effective reduction of radiocesium transport into cabbage.

It is well known that basic principle of potassium homeostasis in higher organisms is based on the changes in renal excretion of potassium in response to variations in intake. Complexity of the potassium metabolism in higher organisms was well explained by Sattler and Fecteau (2014) and Sweeney (1999) who divided metabolically available potassium into external and internal potassium balance. External potassium balance was further divided into input (intake) and output (renal excretion) whilst internal balance was described by potassium distribution between intra and extracellular body compartments which is influenced by many factors (Schneider et al. 2016). As a result of mentioned complexity, distribution of the total body potassium content is divided between several compartments with approximately 80 % of body potassium distributed in human muscle, whilst the rest is unequal divided between other compartments. Such distribution of potassium makes it hard investigation of potential analogy relationships between potassium and other elements like ^{137}Cs.

Distribution and fate of body potassium content during the slaughtering has not completelly elucidated and therefore, behavior of similar element ^{137}Cs has also quite unknown. The other factors with significant impact on ^{137}Cs levels in meat were diet composition and bioavailability of ^{137}Cs.

Presence of such relationships should lead to combined competitive/uncompetitive relationships between analogues depending of the concentration of the essential analogue as well as nutritional requirements of the biological object.

Mentioned facts makes the correlation analysis as useful tool for explaining behavior of analogues in environment as well as in human or animal organisms. Starting with the hypothesis of chemical and metabolic analogy between the potassium and cesium, the competitive relations with negative correlation amongst their transfer coefficents should be expected. In contrary, absence of analogy and competitive relationships should produce the positive correlation between transfer coefficients of these two radonuclides. Having regard the majority of factors influencing the relations between these elements, statistically significant negative or positive correlation between their concentration in certain compartments (muscle, body liquids) should not be evident, taking into consideration the variability of potassium distribution between different body compartments.

The comparative study of the transfer coefficients of ^{137}Cs and ^{40}K for the meat of ruminants was conducted in order to get the information about transfer and relations between these two radionuclides through the cycle of animal production in several agricultural areas of Bosnia and Herzegovina as well as for comparing of obtained results with the values proposed in the IAEA publication (IAEA 2010) regarding the transfer of radionuclides.

MATERIAL AND METHODS

Research was performed during the period 2010 – 2014 at 3 locations: Kakanj, Hadzici and Livno in Central and South-Western part of Bosnia and Herzegovina. These parts of Bosnia and Herzegovina are representative agricultural areas with extensive livestock production.

Samples of hay and grass, beef and sheep meat were sampling from the households who were breeding cows and sheeps in surroundings of towns Kakanj, Hadzici and Livno. Composition of the diet was almost identical and consisted of the hay and pasture (85-90 %) which animals were consuming continuously (winter-hay, summer–grass). Hay was prepared of the grass from the large grasslands that were using also for the pasture. Other diet components were not observed in the study regarding the fact that contribution of other components to daily ^{137}Cs intake was assessed as negligible. Described feeding practice was common in individual breeding and ensured the equilibrium between intake and excretion of ingested radionuclides. The activity concentrations of ^{40}K and ^{137}Cs calculated on the dry matter basis represented reliable parameter for daily intake assessment (summer - winter diet).

In order to reach the detectable levels of ^{137}Cs in observed samples, dry ashing procedure were performed in muffle furnace. Samples were burning in furnaces at temperature of 3900 C.

Preparing the samples for dry ashing procedure was performed according the procedures described in IAEA (1989).

The measurements were performed at coaxial HPGe detector ("ORTEC", p-type, Model "GEM 30P4") with relative efficiency 30 % and resolution 1.85 keV at 1.33 MeV. The detector was placed in the lead shield with 10 cm thickness of the walls.

Activity concentration of the ^{137}Cs in the ash was calculated from its energy at 662 keV and recalculated on the fresh (meat) or dry (grass, hay) weight of samples. The levels of ^{40}K in observed samples were calculated from its energy at 1461 keV. Measuring time was 50 000 or 80000 seconds, depending of the levels of ^{137}Cs in observed samples.

Transfer coefficients were calculated according the expresion:

TC (d kg-1) = activity concentration in animal product (Bq kg-1) / activity concentration in daily diet.

Activity concentration of ^{137}Cs in samples of hay were calculated on dry matter basis in order of equilibrating obtained values with nutrition requirements expressed in kg of dry matter. Quantification of the daily dietary intake expressed in kg of dry matter (DM) was 7.2 kg DM for cattle and 1.3 kg for sheep according to values recommended in IAEA (2009).

Concentration ratios, as alternate approach in quantifing of radionuclide transfer into animal products, was calculated as equilibrium ratio between ^{137}Cs activity concentration in meat Bq kg-1 (fresh weight) divided by its activity in Bq kg-1 (dry weight) of hay.

Statistical analyses of results were performed by use of Microsoft Excel 2013 statistics. Basic statistical parameters as well as Pearson's and Spearman's corelation coefficients were used for determination of relationships between ^{40}K and ^{137}Cs.

RESULTS AND DISCUSION

The results are presented in tables (Table 1 and Table 2) and graphs (Graphs 1-6).

Obtained results showed good agreement with the values presented in the IAEA publication (2010). Generally, obtained mean TC values of ^{137}Cs for the ruminants (0.058 for the beef and 0.34 for the sheep meat) were slightly higher but still under the range of recommended values while the mean TC values of ^{40}K for the beef (0.017) were in accordance with the results of Sheppard et. al (2009).

Statistical analysis of the results showed significantly lower variability for TC of ^{40}K which resulted in one order of magnitude lower SD values compared with the same values for ^{137}Cs, despite the fact that levels of ^{40}K in diet varied significantly higher (Table 1 and Table 2). Also, mean TC values of ^{40}K were equilibrated between localities whilst TC values of ^{137}Cs varied in wide range (Graphs 1,2). The finding was indicated on the fact of strong homeostatic control of essential ^{40}K contrary to its analogue ^{137}Cs.

On the other hand, it seemed that metabolism of the ^{137}Cs, in great extends, depended of metabolism

Table 1 Transfer coefficients and concentration ratios of ^{40}K and ^{137}Cs for beef with parameters requested for their calculation

Locality	Diet (Bq kg^{-1} DM)		Meat (Bq kg^{-1} FM)		Transfer coefficient		Concentration ratio	
	^{40}K	^{137}Cs	^{40}K	^{137}Cs	^{40}K	^{137}Cs	^{40}K	^{137}Cs
K	521.6	0.34	60.2	0.20	0.016	0.082	0.115	0.588
K	518.1	0.46	57.7	0.10	0.015	0.030	0.111	0.217
K	461.2	1.00	69.1	0.90	0.021	0.125	0.150	0.900
K	525.3	0.23	86.0	0.20	0.023	0.120	0.164	0.870
K	693.7	0.80	91.9	0.50	0.018	0.087	0.132	0.625
H	965.0	4.10	75.4	0.30	0.010	0.010	0.078	0.073
H	713.7	1.60	71.3	0.40	0.014	0.035	0.100	0.250
H	411.8	4.80	66.2	0.60	0.022	0.017	0.161	0.125
H	436.9	1.60	67.1	0.50	0.021	0.043	0.154	0.312
H	996.5	0.60	80.0	0.40	0.011	0.093	0.080	0.666
L	518.8	5.30	70.2	1.80	0.019	0.047	0.135	0.340
L	656.0	2.80	80.5	0.60	0.017	0.030	0.122	0.214
L	746.9	2.00	96.9	0.90	0.018	0.062	0.130	0.450
L	597.1	2.30	74.1	0.50	0.017	0.030	0.124	0.217
Mean	625.9	2.00	74.8	0.60	0.017	0.058	0.125	0.418
SD	182.7	1.70	11.3	0.40	0.004	0.034	0.026	0.260
MIn	411.8	0.20	57.7	0.10	0.011	0.010	0.078	0.073
Max	996.5	5.30	96.9	1.80	0.023	0.125	0.164	0.900

Table 2 Transfer coefficients and concentration ratios of ^{40}K and ^{137}Cs for sheep meat with parameters requested for their calculation

Locality	Diet (Bq kg^{-1} DM)		Meat (Bq kg^{-1} FM)		Transfer coefficient		Concentration ratio	
	^{40}K	^{137}Cs	^{40}K	^{137}Cs	^{40}K	^{137}Cs	^{40}K	^{137}Cs
K	461.2	1.00	65.2	0.12	0.109	0.092	0.141	0.120
K	521.6	0.34	77.2	0.05	0.114	0.128	0.148	0.166
K	518.1	0.46	68.9	0.09	0.102	0.138	0.133	0.180
K	525.3	0.23	81.4	0.10	0.119	0.385	0.155	0.500
K	693.7	0.80	85.1	0.08	0.094	0.077	0.123	0.100
H	965.0	4.10	94.7	1.20	0.075	0.225	0.098	0.293
H	713.7	1.60	79.6	0.80	0.086	0.385	0.112	0.500
H	411.8	4.80	60.2	0.40	0.112	0.064	0.146	0.083
H	436.9	1.60	64.4	0.60	0.113	0.288	0.147	0.375
L	518.8	5.30	87.5	3.20	0.130	0.464	0.169	0.604
L	656.0	2.80	87.8	2.90	0.103	0.797	0.134	1.036
L	746.9	2.00	95.9	1.60	0.099	0.615	0.128	0.800
L	597.1	2.30	82.6	2.10	0.106	0.702	0.141	0.913
L	576.8	3.50	78.1	1.90	0.104	0.418	0.135	0.543
Mean	595.9	2.2	79.4	1.10	0.104	0.341	0.136	0.443
SD	148.4	1.7	12.1	1.10	0.014	0.24	0.017	0.312
MIn	411.8	0.2	60.2	0.05	0.075	0.064	0.098	0.083
Max	965.0	5.3	95.9	3.20	0.130	0.797	0.169	1.036

of potassium in animal organism (Relman 1956), Some authors reported the correlation between potassium content in diet and biological half-life of ^{137}Cs in muscle (Mc Neal et al.1961; Sato et al. 1997) which indicated high dependence of ^{137}Cs behavior toward to the presence of ^{40}K. The other factors with significant impact on ^{137}Cs levels in meat were diet composition and bioavailability of ^{137}Cs. As result of simultaneous impact of mentioned three important factors,, the high variability of TC values for ^{137}Cs were reported in previous research (IAEA, 2010; IAEA, 2009, Shepard et al., 2010), as well as in presented study.

Results showed in Table 1 and Table 2, therefore, pointed on the stabile homeostatic control of ^{40}K which kept the levels of potassium under physiological limits while the levels of ^{137}Cs were varied in dependance of its levels in the diet and geografical origin. That was in accordance with conclusions of Fukuda et al (2013).

Finding of the opposite trends of transfer parameters (TC and CR values) for ^{137}Cs between beef and sheep meat at investigated areas (Graph1 and Graph 2) pointed out at possible quantitative differences in gastrointestinal absorption and metabolism of ^{137}Cs among observed two species. That was in accordance with available literature sources which reported quantitative differences between transfer parameters among the cattle and sheep (IAEA 2010).

Obtained CR values showed more equilibrated average values for ^{137}Cs between species (0.42 for the beef and 0.44 for the sheep meat) while some differences were recorded between the localities. Values for ^{40}K were almost identical at all three localities. Generally, equilibration of the results between CR values was obtained due to excluding the impact of daily intake on CR values. These finding made CR approach more appropriate for the field experiments in order to avoid high variability of calculated results (IAEA, 2010).

Having regard to the hypothesis explained in the introduction of the paper, correlation analysis of results was used to investigate relationships between the potential analogues, ^{40}K and ^{137}Cs.

Correlation analysis of the integral results for the beef showed expected negative or positive correlation coefficients between the parameters included in calculation of TC and CR values. Exception was the low positive correlation recorded among ^{40}K activity concentrations in beef and its TC and CR values, which was indicated the presence of the homeostatic control of potassium.

Positive Pearson's correlation coefficient was recorded between TC values of ^{40}K and ^{137}Cs with higher values (r =0.48) for integral results of sheep meat compared with the same for beef (r =0.25). Such finding pointed on the absence of analogy between ^{40}K and ^{137}Cs in ruminants which was in accordance with statement of lack of evidences about analogy relationsheeps between observed radionuclides in animal organisms under normal potassium intake (Howard et al. 2009).

Low negative Pearson's correlation coefficient for integral results was recorded between ^{40}K activity concentration in diet and TC values of ^{137}Cs for beef (r = -0.05), whilst the significant positive correlation was obtained for the same values in sheep (r=0.59). Contrary to the previous results, these findings pointed on

the possible presence of analogy relationship in cattle whilst there was no evidence of similar relationship in sheep.

Low negative Pearson's correlation coefficient was also obtained among ^{40}K activity concentrations in diet and ^{137}Cs ativities in beef (r =-0.182). These findings together with low negative correlation recorded among ^{40}K levels in diet and TC and CR values of ^{137}Cs pointed out on the presence of low competitive relationship among observed radionuclides during their transfer from diet into beef.

Similar results were obtained for integral results for the sheep meat, with exemption of recorded low positive correlations between ^{40}K activities in diet and levels of ^{137}Cs in meat as well as for TC and CR values for^{137}Cs. There was also low negative correlation recorded between ^{40}K activity concentration in sheep meat and calculated TC and CR values for ^{40}K (R= -0.352). Regarding the fact that calculated value mathematically should be positive, such finding was pointed out the impact of homeostatic control on the levels of potassium in sheep meat. Obtained results also indicated on the possible quantitative differences in metabolism of ^{137}Cs between these two animal species.

Some of the results, also, indirectly indicated the possible higher nutritional requirements for potassium in sheep compared with cattle. The main reason for seemingly higher potassium requirements in sheep was the use of additional diet components in catlle diet contrary to sheep diet. Suplementation of the diet with aditional potassium content from diet components that were not observed in the study, made that potassium requirements for cattle seamed to be lower than for sheep.

In order to get informations about impact of potassium content in diet on relation among ^{40}K and ^{137}Cs, obtained results were divided in two groups and analysed by Spearman's correlation analysis. The first group of results for the beef was consisted of results with lower ^{40}K activity concentrations in range 411.8 – 521.6 Bq kg-1 DM which corresponded to values of 13.3 - 16.8 g /kg of DM whilst the second one had higher levels of ^{40}K in range 597.1 - 996.5 Bq kg-1 of DM (19.3-32.2 g / kg of DM). The first group of sheeps had the same ^{40}K activity concentration as first group for beef and second group contained the levels of ^{40}K between 576.8 and 965 5 Bq kg-1 of DM (18.6 - 31.1 g / kg of DM). Results of the correlation analyses are presented in Graphs 3-6.

The findings presented in the Figures 3-6 confirmed hypothesis about combined presence and absence of analogy between observed elements, primarily depending of the levels of potassium in diet.

Spearman's correlation analyses showed negative coefficient between activity concentrations of ^{40}K in diet and ^{137}Cs in meat for both groups and species, as evidence of competitive relation between analogues during their distribution into meat. The finding was approved the use of dietary potassium suplements in order to reduce the radiocesium contamination of meat in ruminants. Correlation coeficients between ^{40}K in diet and its TC values showed tipical negative correlation for the beef as evidence of potassium homeostaic control in beef, while the the same results for the first group of sheep were positive, which indicated on the potassium deficitary diet. Second group of sheep had expected negative coefficient as a result of higher levels of potassium in diet. Third correlation (^{40}K diet/TC ^{137}Cs) for beef showed the expected low negative correlation for the first group as a result of lower potassium content in diet and positive correlation for the second group with

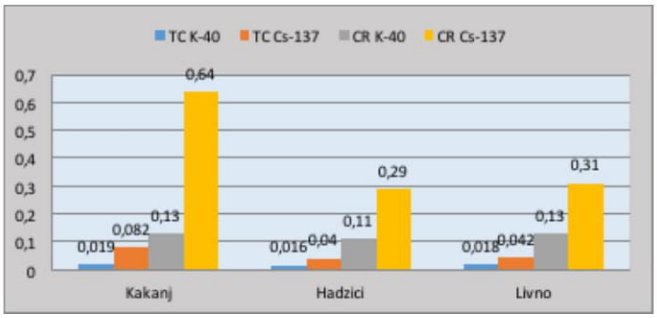

Figure 1 Transfer Coefficients (TC) and Concentration Ratios (CR) of ^{40}K and ^{137}Cs in beef at observed localities

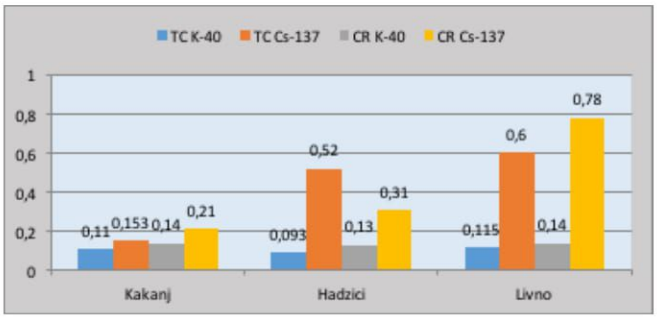

Figure 2 Transfer Coefficients (TC) and Concentration Ratios (CR) of ^{40}K and ^{137}Cs in sheep meat at observed localities

high potassium content in diet. That was probably due to the presence of homeostatic inhibition of potassium distribution into muscle at higher ^{40}K levels in diet which caused the increased distribution of its analogue, ^{137}Cs. The same results for the sheep meat showed opposite trend with positive correlation for the first group and negative correlation for the second group as a result of analogy relationships between ^{40}K and ^{137}Cs.

Correlation coefficients between ^{137}Cs activity con-

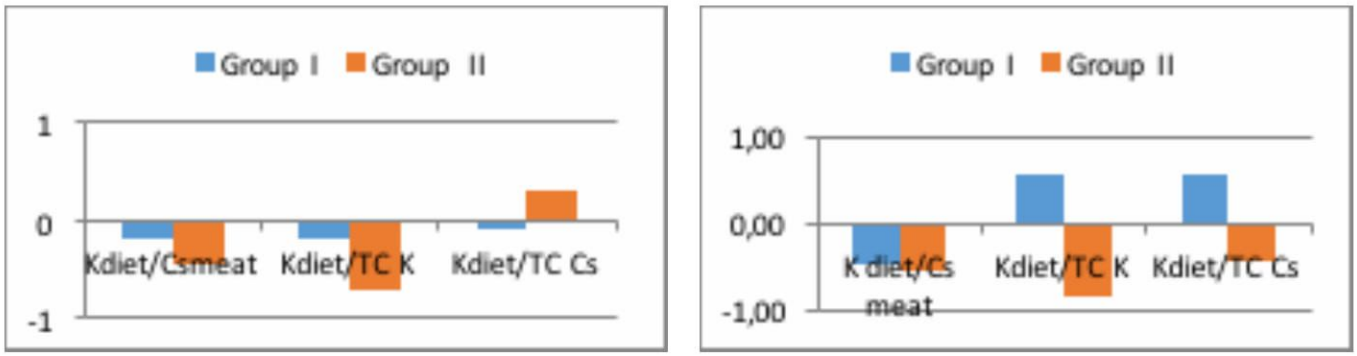

Figure 3 and Figure 4: Spearman's correlation coefficients between ^{40}K activity concentration in diet and: ^{137}Cs levels in meat; TC of ^{40}K and TC of ^{137}Cs (left- cattle, right-sheep)

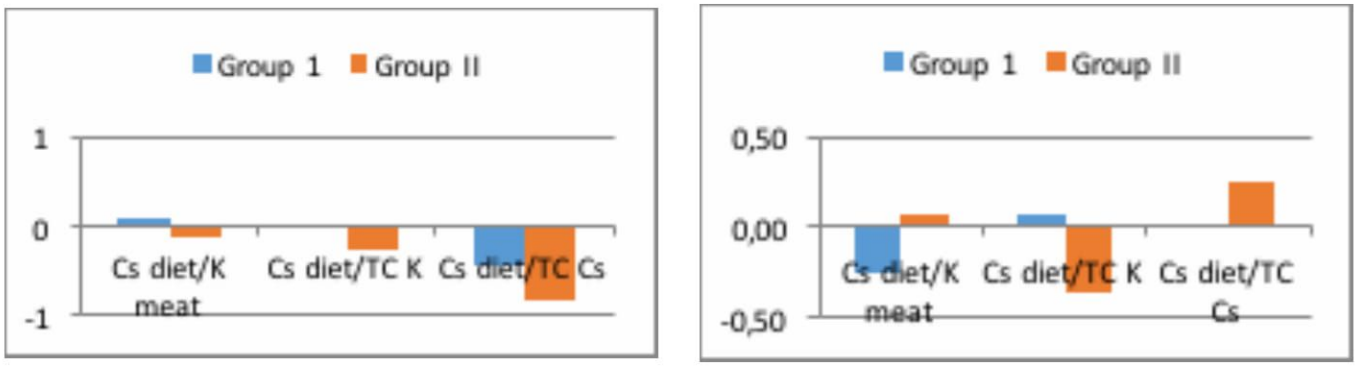

Figure 5 and Figure 6: Spearman's correlation coefficients between ^{137}Cs activity concentration in diet and: ^{40}K levels in meat; TC of ^{40}K and TC of ^{137}Cs (left- cattle, right-sheep)

centrations in diet and ^{40}K levels in meat also showed opposite results between the species. Beef had low positive correlation for the first group with lower levels of potassium in diet and consequent slightlu higher transfer of both ^{40}K and ^{137}Cs into meat, whilst the second group showed the negative correlation coefficient as a result of inhibiting impact of higher levels of potassium in diet on ^{40}K transfer into meat. Opossite trend was recorded in sheep with high negative correlation coefficient for the first group (r^s=-0.25) as a result of the fact that lower potassium content in diet caused the higher ^{137}Cs and lower ^{40}K distribution from diet into meat, whilst the second group showed staitistically insignificant positive correlation coefficient.

Correlation coefficients recorded for relationships between ^{137}Cs levels in diet and TC of ^{40}K showed the negative feedback for diets with higher potassium concentrations (second groups of both species). The finding was a consequence of previously explained homeostatic control of potassium at higher levles of potassium in diet, who inhibited potassium transfer and decreased the TC ^{40}K values of second observed groups. The first groups showed opposite but statistically insignificant results.

The relation between intake of ^{137}Cs and its transfer coefficient showed expected negative correlation coefficients for both cattle groups while the recorded value for the sheep was positive for the second group probably as result of homeostatic control of potassim which was, on the other hand, stimulated transfer of ^{137}Cs into meat.

CONCLUSIONS

Results of the study confirmed the hidden analogy between the ^{40}K and ^{137}Cs. The analogy between observed elements in ruminants is probably covered by the complexicity of potassium metabolism and its distribution between intra and extra celular body compartments. Despite the majority of statistically insignificant results, obtained values indicated the strong dependance among ^{137}Cs distribution in the body and potassium concentration in diet. It seems that metabolisms of observed elements in ruminants follow the same pattern recorded in plants which stimulate ^{137}Cs absorption from soil in conditions of low and high potassium concentration in soil. The similar pattern was recorded in this study related to diets with low and high potassium content.

Results of the study confirmed the use of potassium compounds in the case of radiocesium contamination for ruminants with low intake of potassium through the diet. The care should be taken to prevent overdose in order to avoid negative side effects as well as increased transfer of ^{137}Cs into meat.

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Transfer ^{40}k i ^{137}cs iz obroka u meso preživača: analogija ili ne?

SAŽETAK

Istraživanje transfer koeficijenata i koncentracijskih odnosa ^{40}K (Kalij-40 – puni naziv radionuklida) i ^{137}Cs (puni naziv radionuklida Cezij-137) je izvedeno u cillju proučavanja biološke iskoristlivosti i potencijalnih analognih odnosa promatranih radionuklida u lancu animalne proizvodnje preživača.

Materijal je uzorkovan na malim privatnim farmama smještenim unutar tri regionalna stočarska područja u Bosni i Hercegovini.

Transfer koeficijenti i koncentracijski odnosi ^{40}K i ^{137}Cs izračunati su za govedinu i ovčje meso. Dobiveni rezultati bili su u suglasnosti s literaturnim podacima s prosječnim vrijednostima transfer koeficijenata za ^{40}K i ^{137}Cs u govedini od 0,017 i 0,058 za svaki od promatranih radionuklida, dok su iste vrijednosti za ovčje meso bile više (0,104 i 0,341). Prosječne vrijednosti koncentracijskih odnosa ^{40}K i ^{137}Cs su bile ujednačene između observiranih vrsta mesa (govedina: 0,125 i 0,418; ovčje meso: 0.136 i 0.443).

Dobiveni rezultati su ukazali na skrivenu analogiju između promatranih radionuklida, prekrivenu homeostatskom kontrolom kalija u preživača. Istraživanje je potvrdilo upotrebu kalijevih preparata za redukciju kontaminacije radiocezijem kod preživača.

Ključne riječi: *preživači, analogija ^{137}Cs i ^{40}K, transfer u meso*

Analogie in der Übertragung von ^{40}k und ^{137}cs aus der Nahrung ins Fleisch der Wiederkäuer

ZUSAMMENFASSUNG

Es wurde eine Untersuchung der Übertragungskoeffizienten und des Konzentrationsverhältnisses von ^{40}K und ^{137}Cs durchgeführt, um die Bioverfügbarkeit und die potentiellen analogen Verhältnisse zwischen den untersuchten Radionukliden in der Kette der Wiederkäueraufzucht zu erforschen.

Die Proben wurden in kleineren einzelnen Landbetrieben in drei regionalen Viehzuchtgebieten in Bosnien und Herzegowina genommen.

Die Übertragungskoeffizienten und die Konzentrationsverhältnisse von ^{40}K und ^{137}Cs wurden bei Rind- und Schafsfleisch ermittelt. Die Ergebnisse entsprachen den Angaben aus der Literatur, wobei der durchschnittliche Übertragungskoeffizient von ^{40}K bei Rindfleisch 0,017 und von ^{137}Cs 0,058 betrug, während die durchschnittlichen Werte des Übertragungskoeffizienten von ^{40}K und ^{137}Cs bei Schafsfleisch etwas höher waren (0,104 und 0,341). Die durchschnittlichen Werte des Konzentrationsverhältnisses von ^{40}K und ^{137}Cs waren bei beiden Fleischsorten ausgeglichen (Rindfleisch 0,125 und 0,418; Schafsfleisch: 0,136 und 0,443).

Die gewonnenen Ergebnisse weisen auf eine verdeckte Analogie zwischen den untersuchten Radionukliden hin, die aufgrund der homöostatischen Kaliumkontrolle bei Wiederkäuern verdeckt ist. Die Untersuchung gerechtfertigte den Einsatz von Kaliumverbindungen zur Reduzierung der Kontaminierung durch Radiocäsium bei Wiederkäuern.

Schlüsselwörter: *Wiederkäuer, Analogie ^{137}Cs und ^{40}K, Übertragung auf Fleisch*

Analogía de la transferencia del ^{40}K y del ^{137}Cs de la comida a la carne de los rumiantes

RESUMEN

Fue hecha la investigación del coeficiente de transferencia y cociente de la concentración de los ^{40}K i ^{137}Cs con el fin de investigar la biodisponibilidad y potenciales relaciones analógicas entre los radionucleidos investigados en la cadena de cría de los rumiantes. La toma de muestras de los materiales fue hecha en pequeñas granjas individuales en tres regiones de la cría del ganado en Bosnia y Hercegovina. El coeficiente de transmisión y los cocientes de concentración de los ^{40}K y ^{137}Cs fueron contados para la carne bovina y carne ovina. Los resultados obtenidos fueron de acuerdo con los datos de la literatura, donde el valor medio del coeficiente de transmisión en la carne bovina para el 40K fue 0,017, y para el ^{137}Cs 0,058, mientras en la carne ovina el valor medio del coeficiente de transmisión para el ^{40}K y ^{137}Cs fue un poco más alto (0,104 i 0,341). El valor medio del cociente de concentración de los ^{40}K y ^{137}Cs entre las especies fue uniformes (carne bovina: 0,125 i 0,418; carne ovina: 0,136 y 0,443). Los resultados obtenidos indican una analogía escondida entre la investigación de los radionucleidos, encubierta por el control homeostático del potasio en los rumiantes. La investigación confirmó la justificación del uso de los compuestos de potasio para la reducción de la contaminación en los rumiantes.

Palabras claves: *rumiantes, analogía ^{137}Cs i ^{40}K, transferencia a la carne*

Analogia nella trasmissione di ^{40}K e ^{137}Cs dal cibo alla carne dei ruminanti

SUNTO

La ricerca sui coefficienti di trasmissione e sul rapporto di concentrazione di ^{40}K e ^{137}Cs è stata effettuata allo scopo di analizzare la biodisponibilità e i potenziali rapporti analogici dei radionuclidi esaminati nella catena dell'allevamento dei ruminanti.

La campionatura dei materiali è stata eseguita in singole piccole aziende zootecniche collocate all'interno di tre aree regionali d'allevamento della Bosnia e Erzegovina.

Il calcolo dei coefficienti di trasmissione e dei rapporti di concentrazione di ^{40}K e ^{137}Cs ha riguardato la carne bovina e quella ovina. La ricerca in questione ha dato risultati in linea con i dati contenuti nella letteratura di riferimento, laddove, riguardo alla carne bovina, s'è registrato un valore medio del coefficiente di trasmissione per il radionuclide ^{40}K di 0,017, mentre per il radionuclide ^{137}Cs è stato registrato un valore medio di 0,058. Per quanto riguarda, invece, la carne ovina, sono stati registrati valori medi del coefficiente di trasmissione per ^{40}K e ^{137}Cs leggermente superiori (0,104 e 0,341). Circa il rapporto di concentrazione di ^{40}K e ^{137}Cs tra specie, sono stati registrati valori medi pressoché identici (carne bovina: 0,125 e 0,418; carne ovina: 0,136 e 0,443).

I risultati ottenuti rimandano a un'analogia occulta tra i radionuclidi esaminati, nascosta dal controllo omeostatico del potassio nei ruminanti. La ricerca ha confermato la giustificabilità dell'uso di composti potassici per ridurre la contaminazione da radiocesio nei ruminanti.

Parole chiave: *ruminanti, analogia ^{137}Cs e ^{40}K, trasmissione alla carne*