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REGULAR ARTICLE

OBSERVING OF RADIOACTIVE CAESIUM ^{137}Cs VALUE IN BEEF MEAT (CZECH PIED CATTLE) IN LESS-FAVOURED AREAS OF THE CZECH REPUBLIC

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ABSTRACT

Value of radiocaesium ^{137}Cs as one of Risk Factors in beef meat is very important for human health. Beef meat (*m. longissimus lumborum et thoracis*) from Czech Pied cattle in two less-favoured areas located more then 500 meters above sea level (Bohemian Forest Bohemian and Moravian Highland) was dependent on Sex (decrease by female, increase by male, $P<1.10^{-6}$) and on area ($P<1.10^{-6}$). Value of radiocaesium ^{137}Cs in beef meat ($\bar{x}$ = 0,42 Bq.kg^{-1}; s_x = 0,28) was less then food standard (600 Bq.kg^{-1}). This observed result are responding to finding another authors and could be used for next more detailed research in optimal utilization of Czech Pied cattle in less-favoured areas.

Keywords: Radiocaesium; ^{137}Cs; beef meat; Czech Pied cattle; LFA

INTRODUCTION

Radioactivity is a physical phenomenon in which radiation is emitted into the surrounding. This radiation is not directly perceived by the senses of living organisms or man,

but at higher doses it negatively affects their health. Crucial to the degree of negative impact is the absorbed radiation dose.

Current Status

Radioactive substances are among the most serious contaminants of food and feed. The intensity of radiation commonly occurring in nature is not dangerous to living organisms and are bind tightly to clay in soil. Radioactivity (A) is defined

$$\mathbf{A = \lambda.n = \lambda.n_0.e^{-\lambda t} = A_0.e^{-\lambda t}}$$

where λ is the decay constant (characterizes the expected rate of decay of the radionuclide),

$\mathbf{n_0}$ original number of nuclei,

$\mathbf{A_0}$ activity in the initial time.

Activity (decay rate) decreases with time. The unit is the becquerel (Bq).

Among the most important radionuclides belong radioactive caesium (Cs), strontium (Sr), plutonium (Pu), yttrium (Y), lanthanum (La), plutonium (Pu), iodine (I) and others. Observed radiocaesium ^{137}Cs is β^-, and γ emitter with a half-life of 30 years. It is detected by gamma-spectroscopy, as well as to irradiation in radiotherapy, in defectoscopy and a number of measurement and technical applications.

Maximum levels of radioactive contamination of feed additives and premixes expressed by the sum of the mass activities of caesium ^{134}Cs and ^{137}Cs. Maximal limit of radioactive contamination of complete feeds for calves (2500 $Bq.kg^{-1}$) is expressed by the sum activities ^{134}Cs and ^{137}Cs and for other feed is at 5000 $Bq.kg^{-1}$. These values apply to feed intended for direct feeding to animals (Vyhláška Ministerstva zemědělství ze dne 11. prosince 2000, MZe ČR). Food standard is at 600 $Bq.kg^{-1}$ and is valid throughout the European Union.

The issue of monitoring radiocaesium ^{137}Cs was especially widespread after the accident at Chernobyl in Ukraine in 1986, when its observation gave a number of scientific papers. They descriped its value in the population of deer in southern Germany (**Kiefer et al. 1996**), Denmark (**Strandberg and Knudsen, 1994**), central Sweden (**Karlen et al. 1991**), Ireland (**McGee et al. 1995**) and roe deer and wild boars in Croatia (**Vilic et al., 2005**). The studies demonstrated association of the season (**Karlen et al., 1991**) and the type of grazing animals. A higher value of radiocaesium ^{137}Cs in meat of wild animals has been detected in monitored

areas during the autumn and especially by increased intake of mushrooms, which also showed increased level of fungual spores in the faeces (**Strandberg and Knudsen, 1994, Kiefer et al., 1996**). **Absalom et al. (2001)**.

The concentration of radiocaesium ^{137}Cs in relation to sex and age have been established (**Eisenbund, 1987**). While viewing the values of radiocaesium ^{137}Cs in rumen, kidneys and faeces - it was found that the value is the lowest in the rumen and the same value in kidneys and faeces (**McGee et al., 1995**). The value of radiocaesium ^{137}Cs in grazing, depending on the season was dealt with **Howard (1993)**, **Gillet and Crout (2000)** and **Ziblod et al. (2001)**. Value of radiocaesium ^{137}Cs in mushrooms, blueberries, roe deer and wild boars in the Czech Republic followed the study by **Švadlenková et al. (1996)**, who has also used it as the basis for a model of an accident for a nuclear power plant Temelín. **Kalač (2001)** pointed out the value of natural and radioactive isotopes in mushrooms growing wild and artificially propagated. **White et al. (2003)** dealt with the storage of radiocaesium ^{137}Cs in plants and their choice in order to minimize the transfer of Cs into the food chain. **Bulgakov (2009)** devoted to exploring the storage in the soil.

MATERIAL AND METHODS

For researching were chosen two locations. Farm Rodínov near Kamenice nad Lipou lies in the district of Pelhřimov in Czech-Moravian Highlands (Farm 1) and farm Zubčice is located in the district of Český Krumlov in the Bohemian Forest (Farm 2). Both areas meet the required parameters - the position of 500 meters above sea level, the location in South County and Highland County, breeds with a high percentage of Czech Pied cattle, a large proportion of the grazing except winter period. Beef meat samples were obtained fom December 2006 to December 2009.

Total of 148 breed Czech Pied cattle (103 cows, 45 bulls) were included in the observations. Of these, 96 pieces from farm Rodínov in the district of Pelhřimov and 52 pieces from the farm Zubčice in the district of Český Krumlov (Table 1).

Table 1 Number of animals and their distribution by sex and age in each area

	Rodínov (Farm 1)	Zubčice (Farm 2)
Cow	60	43
Young bull[1]	18	0
Bull	18	9

[1]to the 15th month of age

The distribution of the calendar year in the season is as follows:

- Season 1 - June to November
- Season 2 - December to May.

On the farm Rodínov in Kamenice nad Lipou the pasture *ad libitum* was the most used option during the test period except winter months. Ration was supplemented with corn and grass silage and the grain (compound feed production PKS 1) in the amount of 0,5 kg per day and animal, water was supplied *ad libitum*. In the period from April to late October the cattle were placed on pasture. In winter, cattle were stabled in the barn with loose housing. Ration contained corn silage (57%), a mixture silage (38,5%), meadow hay (1,5%), oats (3%), PKS 1 - wheat (20%), barley (20%), soya (20%), rape (25%), oats (11%), salt, minerals and vitamins (4%).

Cattle on the farm Zubčice (district Český Krumlov) used also the maximum extent grazing in summer (from mid-April to late October) *ad libitum*, supplemented with grass silage and the grain (PPP 2) equal to 0,5 kg per day and animal, water was supplied *ad libitum*. Cattle were placed overnight in a covered shelter. In winter, the animals were placed in the barn with loose housing. Ration consisted of corn silage (48%), lucerne silage (48%), meadow hay (2.7%), oats (1.3%) and PKS 2 - wheat (37%), barley (31%) soybeans (28%), minerals and vitamins (4%). Rations were calculated on a 600 kg live weight of cattle and was added in amount of 0,5 kg per day and animal.

Samples of beef muscle (*m. longissimus lumborum et thoracis* - MLLT) from the 15 to 20 vertebrae of 1 kg of the carcasses of animals removed 45 to 48 hours after slaughter, vacuum packed in watertight bags of polypropylene and frozen within 12 hours at a temperature of -18 ° C. Radiocaesium ^{137}Cs was determined by gamma-spectroscopic coaxial germanium detector (HPGe - high purity germanium detector), relative efficiency of at least 60 % FWHM : 1,9 on the level of 1332 keV (60Co), EtherNIM-analysator and Gamma Vision-32 software. Sample surface of meat with fat (1 kg weight, cooled to +3 ° C to +5 ° C) put into the measuring metal capsule (Marinelli vessels). After a hermetical encasement, the Marinelli vessel was placed in a lead housing with a detector and during the measurement time 240 000 s for the desired sensitivity of 0,1 $Bq.kg^{-1}$ (MDA) was obtained value of radiocaesium ^{137}Cs (measured in State Veterinary Institute in Prague, Department of Chemistry, which is accredited by Czech Institute for Accreditation o.p.s. No. 1176.1).
The results of determination of radiocaesium ^{137}Cs were compiled in STATISTICA CZ 6.1 (Statsoft CR). To monitor the impact of gender (Sex), environment (Farm) and season

(Season) on the value of radiocaesium ^{137}Cs in MLLT was used a t-test, according to an independent evaluation groups and ANOVA, Gaussian (normal) distribution. Samples did not exceed the value of MDA were not included in this research.

RESULTS AND DISCUSSION

The aim was to determine the degree of influence of selected factors – territory, season and sex - on the radiocaesium ^{137}Cs value in meat of Czech Pied cattle breed in selected less-favoured areas (LFA) in the Czech Republic. Based on the value of the radiocaesium ^{137}Cs assess the possibility of using the Czech Pied cattle breed in LFAs above 500 m with regard to the degree of contamination with radiocaesium ^{137}Cs.

We studied the influence of many factors (Farm, Season, Sex) on the value of radiocaesium ^{137}Cs (^{137}Cs) and weight of carcasses. ^{137}Cs is contaminating the organism of animals and consequently the human body by number of ways. Especially a food, which is at the disposal of radiocaesium ^{137}Cs very sensitive **(Gillet et al., 2001, Beresford et al., 1996)**. It is therefore very important to know the values that radioactive substances reach in nature and animals. **Gillet and Crout (2000)** pointed out some shortcomings in the monitoring of ^{137}Cs, and processing of results (especially statistical).

Farm

We investigated the influence of territory (Farm 1, n = 96; Farm 2, n = 55) for the value of ^{137}Cs (Fig 1, Table 2). The value based on ^{137}Cs territory (Fig 1) shows that on the significance level of $P < 1.10^{-6}$ in the Farm 1 there is a lower value of ^{137}Cs in MLLT of observed animals than in Farm 2.

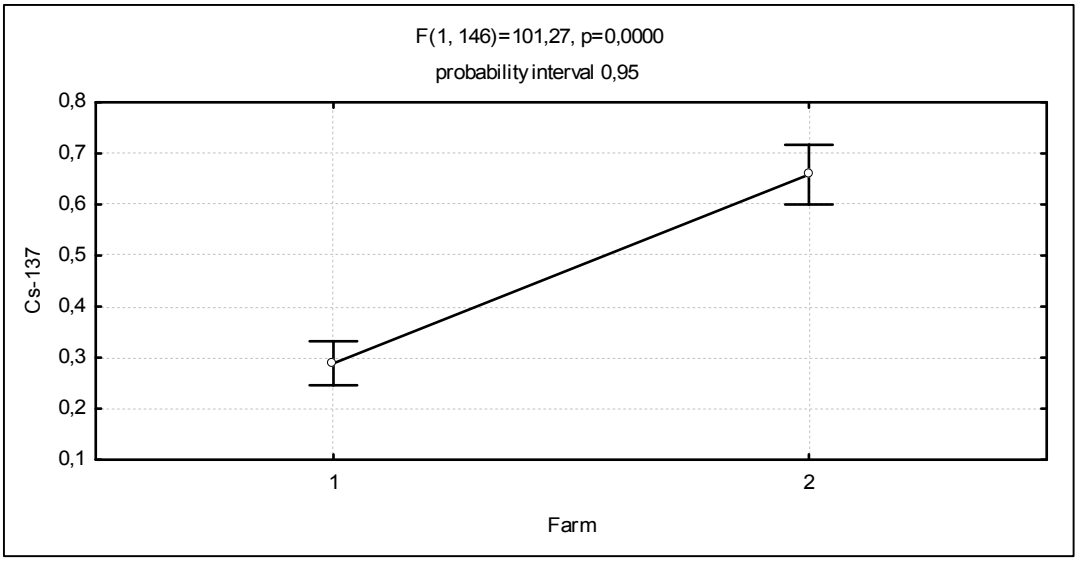

Figure 1 Influence of territory (Farm1 - Kamenice n / Lipou; Farm 2 - Zubčice) on ^{137}Cs value in Beef Meat (*m. longissimus lumborum et thoracis*) ($P<1.10^{-6}$)

The value of ^{137}Cs contributed to activity from the environment (pasture), in which cattle are moved to pasture **(Absalom et al. 1995, Kiefer et al., 1996, Paller et al., 2008).** Other factors such as soil composition and adhesion **(Crout et al., 1993)** types and numbers of mushrooms in pastures **(Strandberg and Knudsen, 1994; Zibold et al., 2001)** were not on this research considered. The differences in soil composition and the difference in the affected areas, especially after the fallout of nuclear power plant accident at Chernobyl in Ukraine in 1986 were not related **(http://www.suro.cz/cz/publikace/cernobyl/pruzkum_pud_1986.pdf, Downloaded on 20th 6th 2011)**.

The monitoring results showed that meat from animals reared in the Bohemian Forest (Farm 2) contained more than twice the amount of ^{137}Cs than the meat of animals reared in the Czech-Moravian Highlands (Farm 1). These results match the findings, which published the National Radiation Protection Institute based on survey of 1986 **(http://www.suro.cz/cz/publikace/cernobyl/pruzkum_pud_1986.pdf, downloaded on 20th 6th 2011)**. Higher value of ^{137}Cs in MLLT is observed in animals kept in Farm 2. The slopes of researched territories were on the windward side and were with greater fallout of this radioactive contaminated cloud from Chernobyl.

We researched also on the relationship between the value of ^{137}Cs and weight of carcasses. When we made the comparisons with regard to the territory (Table 2) it showed, that with increasing weight of carcasses also grew a value of ^{137}Cs.

Table 2 Summary statistics volumes of territory[1] (value of Cs-137 and carcass weight)

	Farm1		Farm2	
	Rad. Cs-137 ($Bq.kg^{-1}$)	Carcass weight (kg)	Rad. Cs-137 ($Bq.kg^{-1}$)	Carcass weight (kg)
Median	0,27 ≤ MDA =	296,95	0,57	329,30
Minimum	0,xx	180,10	0,34	242,60
Maximum	0,72	404,70	1,30	436,10
Standard Deviation	0,19	50,97	0,25	46,91
n (pcs.)	96	96	55	55

[1]territory: Farm1 Kamenice n/Lipou
Farm2 Zubčice

Season

The ^{137}Cs value depending on the season (Fig 2, Table 3) is apparent that the significance level of ($P<1.10^{-6}$) is the period from June to November (Season 1) in the incidence of samples higher than in the period from December to May (Season 2).

In Season 1 period (June to November) were the animals the maximum time on pasture (*ad libitum*) and they were sent for slaughter only when strictly necessary. This is illustrated by the number of samples from this period (n = 34). Ration was supplemented with grass silage only and compound feed production (PKS) in the amount of 0,5 kg per day and animal (PKS 1 - Farm Rodínov, PKS 2 - Farm Zubčice). The composition of soil and grass on which cattle grazed, has not been investigated. The results of the radiocaesium ^{137}Cs value depending on the season (Season 1, Season 2) confirmed the conclusions, as identified by **Karlen et al. (1991)**. In the period where was higher intake of grazing increased the value of ^{137}Cs in MLLT and there were also greater differences between the observed value of the values of ^{137}Cs. In contrast, in the period Season 2 when the animals were in a stable and ration consisted of silage, hay and grain, the values of the value of ^{137}Cs were at about 40 % lower then the values of the Season 1. During Season 2 the herds were observed and selected. The selected pieces were sent to slaughter (n = 114). This choice was done only for economic reasons.

When the animals were on pasture (Season 1) showed that at the higher intake of fresh forage increased value of ^{137}Cs. ^{137}Cs was also detected by heavier carcass weight (Table 3).

Table 3 Summary statistics volumes of Season[1] (value of Cs-137 and carcass weight)

	Season1		Season2	
	Rad. Cs-137 ($Bq.kg^{-1}$)	Carcass weight (kg)	Rad. Cs-137 ($Bq.kg^{-1}$)	Carcass weight (kg)
Median	0,50	315,40	0,37	308,20
Minimum	0,19	182,70	≤ MDA= 0,xx	180,10
Maximum	1,30	429,20	0,96	436,10
Standard Deviation	0,33	64,92	0,24	50,61
n (pcs.)	34	34	114	114

[3]Season: Season1 June to November
Season2 December to May

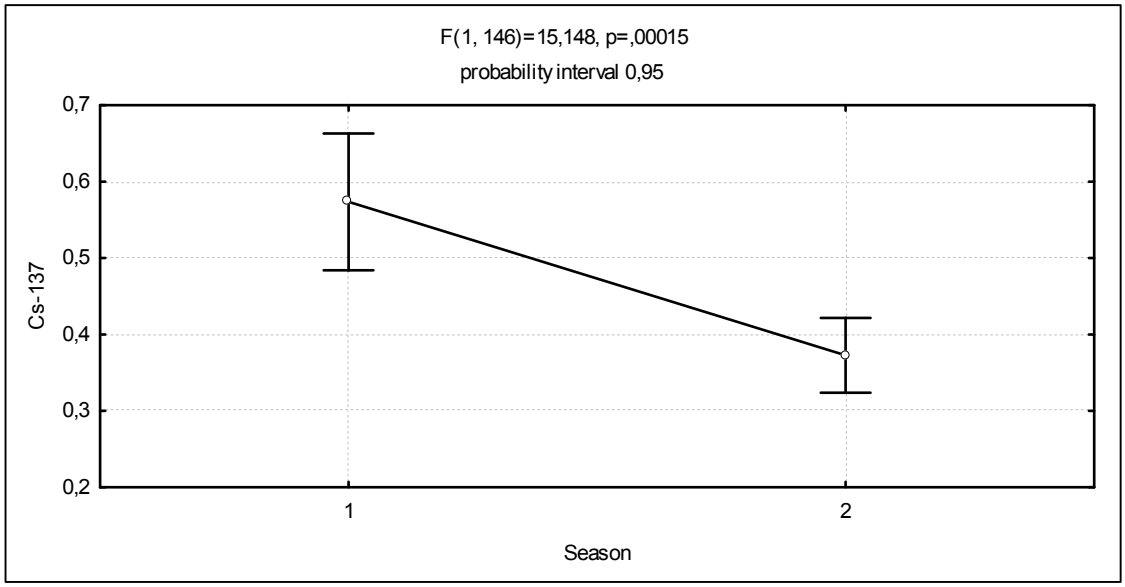

Figure 2 Influence of Season (Season 1 - June to November; Season 2 – December to May) on ^{137}Cs value in Beef Meat (*m. longissimus lumborum et thoracis*) ($P<1.10^{-6}$)

Sex

The impact of gender on the value of ^{137}Cs was divided into a set of cows and bulls. Effect of Sex (Fig 3) on the value of ^{137}Cs was not statistically significant ($P>0,04$). This finding correlates with the conclusions researched by **McGee et al. (1995)**.

The values of ^{137}Cs measured in MLLT were by bulls (Sex2) significantly higher as by cows (Sex1). The value of ^{137}Cs in MLLT of bulls and cows did not much differ from each other **(Beresford et al., 2007, Crout et al., 1996)**.

Table 4 Summary statistics volumes of Sex[1] (value of Cs-137 and carcass weight)

	Sex1		Sex2	
	Rad. Cs-137 (Bq.kg^{-1})	Carcass Weight (kg)	Rad. Cs-137 (Bq.kg^{-1})	Carcass Weight (kg)
Median	0,45	291,10	0,54	355,30
Minimum	0,00	180,10	0,41	285,00
Maximum	1,30	436,10	0,79	404,70
Standard Deviation	0,27	57,75	0,1	32,22
n (pcs.)	103	103	27	27

[2]Sex: Sex1 cow >24 months
Sex2 bull 15 to 24 months

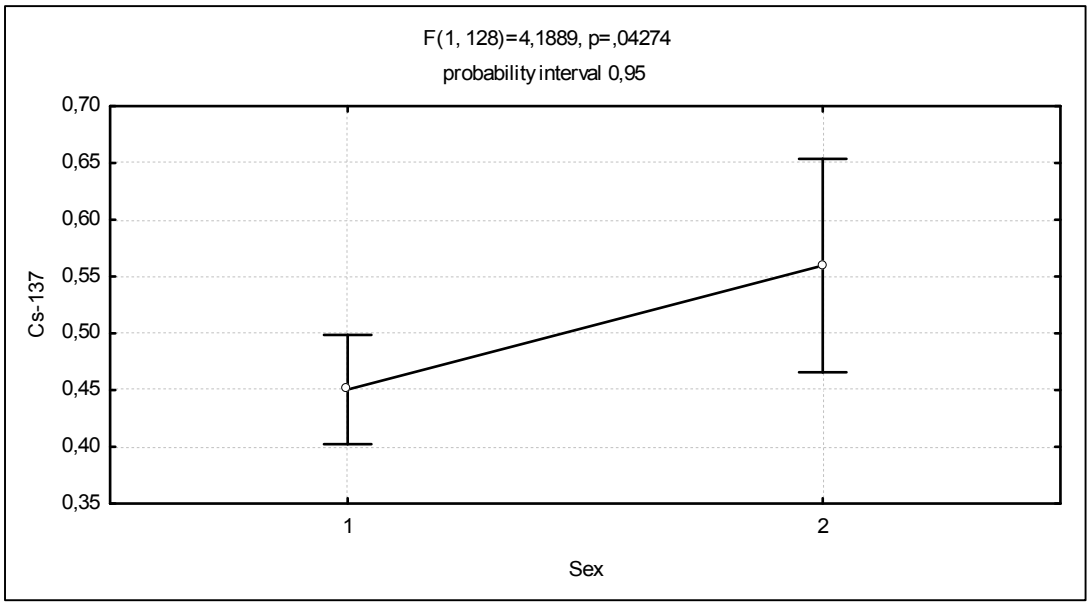

Figure 3 Influence of Sex (1 - Cow, 2 - Bull) on ^{137}Cs value in Beef Meat (*m. longissimus lumborum et thoracis*) (P>0,04)

Noteworthy is the highest value of ^{137}Cs which has been achieved in the bulls meat, although they were slaughtered at the age of 15 to 24 months as cows. As shown in Fig 3, it is possible to believe that the ^{137}Cs in meat of cattle stores in increased level after a

certain age. To confirm this assumption will need to get more results mainly from a group of young bulls.

As shown in Fig 3 the value of ^{137}Cs in cows meat were significantly lower as the value of ^{137}Cs in bulls meat. This findings agree with conclusions, that excreting of ^{137}Cs by females is faster as by male

CONCLUSION

The value of radiocaesium ^{137}Cs in *m. longissimus lumborum et thoracis* by all tested cows and bulls ($\bar{x}$ = 0,42 Bq.kg^{-1}; s_x = 0,28) was less then food standard (600 Bq.kg^{-1}). Findings of the value of ^{137}Cs depending on the territory, season and sex confirmed the findings of the authors who have dealt with this issue before. We can conclude that the value of radiocaesium ^{137}Cs in muscle (*m. longissimus lumborum et thoracis*) of Czech Pied cattle in LFAs situated higher as an altitude of 500 meter above sea level is not a health risk for consumers of beef meat from these herds. Given the small number of young bull samples were these excluded from comparsion by sex. For obtaining relevant results were important get more samples from both territories.

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