

NICKEL LEVELS OF LIVER FROM TEN DIFFERENT PIG GENETIC LINES PRODUCED IN VOJVODINA

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Original scientific paper

Abstract: The content of nickel was investigated in the liver of sixty-nine pigs from ten different genetic lines, produced in Vojvodina. Nickel was determined by the flame atomic absorption spectrometry after mineralization by dry ashing. The difference in the nickel content among different genetic lines of pigs was not significant ($P > 0.05$) in the analyzed liver tissues. Nickel levels ranged from 13.02 to 68.21 $\mu\text{g}/100\text{g}$ with a general average of 26.73 $\mu\text{g}/100\text{g}$. Average nickel content, found in this study, is in agreement with the contents observed in pig liver in other countries.

Key words: nickel, liver, pigs

Introduction

Meat quality is the sum of all sensory, nutritive, hygienic-toxicological and technological factors of meat. The nutritive factors of meat quality comprise proteins and their composition, fats and their composition, vitamins, minerals, utilization, digestibility and biological value (Hofmann, 1990; Honikel, 1999).

Red meat (beef, veal, pork and lamb) contains high biological value protein and important micronutrients including iron, zinc and vitamin B12, all of which are essential for good health throughout life (Higgs, 2000; Williamson et al., 2005; Lombardi-Boccia et al., 2005; McAfee et al., 2010). Also, meat contains useful amounts of copper, magnesium, cobalt, phosphorus, chromium and nickel (Higgs, 2000).

In most food products, the nickel content is less than 0.5 mg/kg fresh weight. Cacao products and nuts may, however, contain as much as 10 and 3 mg/kg, respectively (IARC, 1990). According to Solomons et al. (1982), dry beans, cacao products, baking soda, and some nuts contain high levels of nickel ($>2.0 \mu\text{g}/\text{g}$); wheat and wheat products, shellfish, processed meats and many vegetables

contain intermediate levels (0.2-2.0 µg/g); and whole and dried milk, fresh fruits, meat and eggs contain low levels of nickel (<0.2 µg/g).

Nickel is widely distributed in animal tissues in concentrations generally between 0.01 and 0.2 mg/kg (wet weight) when dietary nickel is not excessive (<25 mg/kg). Nickel does not accumulate with age in any organ, but, as with other mineral elements, overcoming homeostatic mechanisms by the addition of soluble nickel salts to drinking water or diet elevates tissue and blood nickel concentrations (NRCNA, 2005).

Nickel is present in a number of enzymes in plants and microorganisms. In humans, nickel influences iron absorption and metabolism, and may be an essential component of the haemopoietic process. COMA (Committee on Medical Aspects of Food and Nutrition Policy) and FDA (US Food and Drug Administration) were unable to set recommended amounts for nickel intake. Based on extrapolation from animal data, the hypothetical human requirement for nickel would be 16 to 25 µg/1000 kcal or about 75 µg of elemental nickel per day (Solomons et al., 1982). Nickel deficiency has not been observed in humans (EVM, 2003).

On the other hand, acute nickel exposure is associated with a variety of clinical symptoms and signs which include gastrointestinal disturbances, visual disturbance, headache, giddiness, wheezing and cough. Approximately 7-10% of the population (predominately women) are affected by nickel allergic dermatitis (EVM, 2003).

The lowest reported oral dose associated with acute effects in humans was 0.05 mg/kg bw (1.2 mg in a 60 kg adult) (EVM, 2003). Total diet studies indicate a total average oral intake of 200–300 µg/day (WHO, 1991). Early estimates of daily nickel consumption in the USA ranged from 300 to 600 µg (Schroeder et al., 1962). Recovery studies indicate an absorption rate of less than 15% from the gastrointestinal tract (Sunderman et al., 1989). Dietary intake of nickel in food is not expected to result in harmful effects (EVM, 2003).

The Autonomous Province of Vojvodina is a region where the number of animals of the porcine species and the production of pork meat are of high economic importance. Most studies have focused on the proximate compositions, vitamins and other essential nutrients. In the present investigation we determined the content of nickel in liver obtained from two pure and eight crossbred pigs used nowadays in Vojvodina for pork production.

Materials and Methods

Animals, sampling and preparing. The pigs used in the present study were produced in a pig (cross)breeding programme provided by nucleus and multiplication farms in Vojvodina (GGP-GP traditional pyramid structure of genetic programme) (Visscher et al., 2000). In this breeding programme five pig

purebreds were used. The Large White (LW) and Landrace (L) were used as female lines and Duroc (D), Hampshire (H) and Pietrain (P), were used as male lines. An investigation was performed on sixty-nine pigs (castrates males and females) from ten different genetic lines (two purebred and eight crossbred pigs): [LW, $n = 8$; L, $n = 7$; LWxL, $n = 7$; LxLW, $n = 6$; Dx(LWxL), $n = 7$; Dx(LxLW), $n = 6$; (DxP)x(LWxL), $n = 8$; (DxP)x(LxLW), $n = 7$; (HxP)x(LWxL), $n = 6$; (HxP)x(LxLW), $n = 7$].

The pigs were randomly selected at an individual live weight between 95 and 110 kg and about six months old. One pig from each genetic line was taken at every six months from the same farm.

All the pigs were slaughtered in the two biggest Vojvodian slaughterhouses according to routine procedure. Carcasses and offal (liver) were conventionally chilled for 24 h in a chiller at 2-4°C. The samples for chemical analysis taken after the homogenization of the whole liver, were vacuum packaged in polyethylene bags and stored at -40°C until analysis.

Analytical methods and quality control. The nickel (Ni) content of the liver was determined after dry ashing mineralization according to the following procedure (*Gorsuch, 1970; Tomović et al., 2011*): a twenty-gram sample was weighed into a porcelain crucible and dried in a laboratory oven at 105°C for 3 h. After drying the sample was charred on a hot plate and then incinerated in a muffle furnace at 450°C overnight (16 h). When a suitable ash was obtained it was moistened with little water, treated with 10 ml of hydrochloric acid/deionized water (1:1, v/v) and evaporated to dryness. Finally, the ash was redissolved with 10 ml of hydrochloric acid/deionized water (1:9, v/v), transferred into a 25 ml volumetric flask and diluted to volume with deionized water.

Nickel was measured in the ash solution by flame atomic absorption spectroscopy according to the manufacturer's instructions (*Varian, 1989*).

A strict analytical quality control programme was employed during the study. The quality control of the analytical measurements for Ni was performed using the standard reference material (SRM): SMRD 2000 (Matrix meat reference material, National Food Administration, Uppsala, Sweden). For the determination of the Ni content the SRM samples were spiked with three different concentrations of this element. The results of the analytical quality control programme are presented in Table 1. In every series of samples, 2 blanks and 2 samples of standard reference material were included. All analyses were performed in duplicate.

Table 1. The results of the analytical quality control programme ($n = 8$) used in the determination of the nickel in pig liver

Ni	Recovery (%)	Limit of detection ($\mu\text{g}/100\text{g}$)
	103.2	12.5

Statistical analysis. All data are presented as mean, standard deviation (SD) and range. The analysis of variance (one-way ANOVA) was used to test the hypothesis about differences between more mean values. The software package STATISTICA 8.0 was used (*StatSoft, Inc., 2008*) for analysis.

Results and Discussion

The average content, standard deviation and range for the Ni in the investigated samples of the liver tissue of ten different genetic lines of pigs are presented in Table 2.

The order of the genetic lines of pigs according to nickel content in the liver samples (Table 2) in $\mu\text{g}/100\text{ g}$ was: LWxL < Dx(LWxL) < (HxP)x(LWxL) < (DxP)x(LxLW) < LxLW < Dx(LxLW) < (HxP)x(LxLW) < (DxP)x(LWxL) < L LW. The content of nickel found in the present study did not differ significantly ($F = 1.244$; $P = 0.292$) among the liver tissue belonging to different genetic lines of pigs (Table 2). On the other hand, animals belonging to the same genetic line, from the same farm, raised under the same conditions, given the same feed, and slaughtered at the same age had Ni content in the liver that could differ up to four times (Tables 2). The lowest, average and highest nickel content in the liver was 13.02 [genetic line of pigs: Dx(LxLW)], 26.73 and 68.21 [genetic line of pigs: (HxP)x(LxLW)] $\mu\text{g}/100\text{ g}$, respectively. According to *Greenfield and Southgate (2003)*, biological material exhibits natural variations in the amounts of nutrients contained and the limits of natural nutrient variation are not defined.

The nickel levels obtained in pig liver in this study parallel those reported in the literature: Finland (< 20 $\mu\text{g}/100\text{g}$, *Nuurtamo et al., 1980*), Sweden (11 $\mu\text{g}/100\text{g}$, *Jorhem et al., 1989*), Denmark (17 $\mu\text{g}/100\text{g}$, ranged from 14 to 139 $\mu\text{g}/100\text{g}$, *Larsen et al., 2002*) and Spain (9 $\mu\text{g}/100\text{g}$, ranged from not detected to 31 $\mu\text{g}/100\text{g}$, *Lopez-Alonso et al., 2007*). Not much data are available for nickel content of pig liver in many countries.

Table 2. Nickel content ($\mu\text{g}/100\text{g}$) of the liver from the pigs in Vojvodina

Genetic line of pigs	Mean \pm SD	Range
LW ($n = 8$)	35.71 \pm 14.23	20.80–58.54
L ($n = 7$)	35.43 \pm 15.08	13.91–55.00
LWxL ($n = 7$)	18.12 \pm 4.94	14.59–27.72
LxLW ($n = 6$)	25.96 \pm 4.93	19.77–31.61
Dx(LWxL) ($n = 7$)	20.37 \pm 5.88	13.41–27.05
Dx(LxLW) ($n = 6$)	26.18 \pm 11.72	13.02–38.28
(DxP)x(LWxL) ($n = 8$)	28.92 \pm 12.57	18.32–53.11
(DxP)x(LxLW) ($n = 7$)	23.81 \pm 10.37	13.28–43.77
(HxP)x(LWxL) ($n = 6$)	23.68 \pm 13.11	13.97–45.62
(HxP)x(LxLW) ($n = 7$)	28.44 \pm 21.62	14.63–68.21
All animals ($n = 69$)	26.73 \pm 12.83	13.02–68.21

Conclusion

The results of the present investigation show that the content of nickel determined in the liver of pigs was not influenced by the genetic lines. Compared with developed countries, the nickel content in the liver tissue of pigs from Vojvodina parallel those reported in the literature. In addition, the obtained nickel composition could be used to provide regular nutrient compositional data of the pork meat in Serbia.

Acknowledgment

These results are part of the project No 114-451-2091/2011 (Improvement of meat quality from indigenous and modern pig breeds produced in Vojvodina for the production of traditional dry fermented sausages and dry cured meat products), which is financially supported by the Provincial Secretariat for Science and Technological Development, Autonomous Province of Vojvodina, Republic of Serbia.

Sadržaj nikla u jetri deset različitih genotipova svinja odgajanih u Vojvodini

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Rezime

U ovom radu određen je sadržaj nikla u jetri ($n = 69$) deset različitih genotipova svinja odgajanih u Vojvodini. Sadržaj nikla je određen plamenom atomskom apsorpcionom spektrofotometrijom nakon "suvog spaljivanja" uzoraka. Sadržaj nikla u tkivu jetre nije se značajno razlikovao ($P > 0.05$) između različitih genotipova svinja. Određeni sadržaj nikla bio je u granicama od 13,02 do 68,21 $\mu\text{g}/100\text{g}$, sa prosečnim sadržajem od 26,73 $\mu\text{g}/100\text{g}$. Prosečni sadržaj nikla, određen u ovom ispitivanju, odgovara sadržaju nikla utvrđenom u jetri svinja odgajanih u drugim zemljama.

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Received 30 June 2011; accepted for publication 15 August 2011