การศึกษาเปรียบเทียบระดับของแคดเมียมในไตของปศุสัตว์จากอำเภอแม่สอด จังหวัดตาก กับตัวอย่างจากปริมณฑลของกรุงเทพฯ

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บทคัดย่อ

แคดเมียมจัดเป็นโลหะหนักที่มีความเป็นพิษ ซึ่งการปนเปื้อนในสิ่งแวดล้อมสามารถส่งผ่านมาตามห่วงโซ่อาหารสู่มนุษย์ ในการศึกษาครั้งนี้จึงมีวัตถุประสงค์เพื่อประเมินระดับการตกค้างของแคดเมียมในไตของปศุสัตว์ 2 ชนิด คือ วัวเนื้อและสุกรที่รวบรวมจากอำเภอแม่สอด จังหวัดตาก ซึ่งเป็นพื้นที่ที่พบปัญหาการปนเปื้อน เปรียบเทียบกับตัวอย่างที่ได้จากบริเวณปริมณฑลของกรุงเทพฯ และพื้นที่ใกล้เคียง ผลการศึกษาตรวจพบระดับของแคดเมียมในตัวอย่างจากแม่สอด ดังนี้ ไตวัวเนื้อ, geomean: 0.91 ± 0.43 mg/kg, range: 0.19 – 19.60 mg/kg, n=53; ไตสุกร, geomean: 0.73 ± 0.67 mg/kg, range: 0.09 - 40.14 mg/kg, n=112 ในขณะที่ตัวอย่างจากบริเวณกรุงเทพฯ พบค่าการตกค้างในระดับที่น้อยกว่า ดังนี้ ไตวัวเนื้อ, geomean: 0.14 ± 0.11 mg/kg, range: 0.02 – 2.38 mg/kg, n=27; ไตสุกร, geomean: 0.56 ± 0.44 mg/kg, range: 0.01 – 20.21 mg/kg, n=102 ทั้งนี้หากพิจารณาจากเกณฑ์ความปลอดภัยทางด้านอาหารซึ่งกำหนดให้มีการตกค้างของแคดเมียมในไตปศุสัตว์ได้ไม่เกิน 1 mg/kg แล้วจะพบว่าตัวอย่างไตวัวเนื้อจากแม่สอดประมาณ 50% จัดอยู่ในกลุ่มที่ไม่ปลอดภัยต่อผู้บริโภค โดยมีจำนวนมากกว่าตัวอย่างจากบริเวณกรุงเทพฯ ซึ่งพบอยู่ที่ระดับ 7% ส่วนกรณีของไตสุกรนั้นมีข้อน่าสังเกตว่าทั้ง 2 พื้นที่ที่ทำการศึกษาพบสัดส่วนของจำนวนตัวอย่างที่มีการตกค้างของแคดเมียมเกินกว่าค่าที่กำหนดไว้ในระดับที่ใกล้เคียงกัน คือ แม่สอด 27% และบริเวณกรุงเทพฯ 29% จึงอาจกล่าวโดยรวมได้ว่าการพบการปนเปื้อนของแคดเมียมในระดับที่ไม่ปลอดภัยและพบในสัดส่วนที่ค่อนข้างสูงในตัวอย่างทั้งในและนอกพื้นที่ปนเปื้อน อาจส่งผลให้ผู้บริโภคโดยเฉพาะกลุ่มที่นิยมการบริโภคเครื่องในสัตว์ มีโอกาสเสี่ยงต่อการได้รับแคดเมียมเข้าสู่ร่างกายในปริมาณสูง อย่างไรก็ตามควรมีการสุ่มตรวจตัวอย่างในพื้นที่อื่นๆ เพิ่มเติม รวมถึงการส่งเสริมให้มีมาตรการเฝ้าระวัง พร้อมกับการรณรงค์ให้ความรู้แก่ผู้บริโภคอย่างสม่ำเสมอในการหลีกเลี่ยงอาหารกลุ่มเสี่ยง อันจะเป็นการช่วยสร้างความเชื่อมั่นด้านความปลอดภัยของอาหารกลุ่มที่เป็นผลิตภัณฑ์จากสัตว์ และช่วยลดความเสี่ยงต่อการได้รับแคดเมียมผ่านทางอาหารเหล่านั้น

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Comparative Evaluation of Cadmium Contents in Livestock's Kidney from Measot District, Tak Province and the SW Vicinity of Bangkok.

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ABSTRACT

Cadmium (Cd), a toxic metal, is considered as an environmental and industrial pollutant. The risk of Cd exposure in non-smoking population is constantly increasing through its contamination via the food chain. In the present study, Cd contents in kidney samples of beef and pig collected from 2 locations: 1) a Cd polluted region of Maesot, Tak and 2) SW vicinity of Bangkok were evaluated. The results revealed that samples from Maesot had broader ranges of Cd levels both in bovine kidneys (geomean: 0.91 ± 0.43 mg/kg, range: 0.19 – 19.60 mg/kg, n=53) and pig kidneys (geomean: 0.73 ± 0.67 mg/kg, range: 0.09 - 40.14 mg/kg, n=112), compared to those from SW vicinity of Bangkok (geomean: 0.14 ± 0.11 mg/kg, range: 0.02 – 2.38 mg/kg, n=27, for bovine kidneys; and geomean: 0.56 ± 0.44 mg/kg, range: 0.01 – 20.21 mg/kg, n=102, for pig kidneys). Based on the maximum limit for Cd in kidney (1 mg/kg), the results also indicated a significantly higher ratio of unsafe beef kidneys from Maesot. Interestingly, although the highest level of Cd detected in pig kidneys from Maesot was twice higher, the percentage of unsafe products was comparable between the 2 locations. As such levels of contamination render these animal products the potential risk to consumer, it is suggested that monitoring of Cd level in livestock organs should be regularly conducted and not be limited to the polluted areas. Consumer education and the routine removal of the high-risk products from the food chain would also help reduce human Cd intake.

Keywords: cadmium, kidney, beef cattle, pig, Bangkok, Tak

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Introduction

Cadmium (Cd), a nonessential trace mineral, is a highly toxic metal that occurs widely in nature as a contaminant of zinc. It is present as an industrial pollutant, a food contaminant and as one of the major constituents of cigarette smoke. Cd has been proved toxic to many organs including cardiovascular system, immune system, liver, lung, kidney, brain and bone. It can also interfere reproductive function and has been classified as a category I carcinogen (human carcinogen), mutagen and a teratogen.[1-3]

The incidence of Cd-polluted environment has been reported in many regions around the world during the past 50 years.[4-6] Recently, the case of Cd pollution near the zinc-mineralized area in Mae Sot district, Tak province, Thailand has been described. Investigation of Cd levels in soil samples revealed several magnitudes higher than the Thai background soil Cd levels and European Economic Community Maximum Permissible levels.[7, 8] Due to the high mobility of this metal in soil-plant systems, Cd can be readily transferred through the food chain and can be found in virtually all foods.[8-11] As evidence of this, for example, rice samples from the polluted fields were found to be contaminated with Cd at the levels ranging from 0.1 to 4.4 mg/kg, whilst the average Thai background rice Cd concentrations was 0.043 mg/kg.[8, 9] Since food is generally the main Cd source in non-smoking population and the limits are considered to have very small margins of safety, it is not then surprised that the adverse health impact of Cd on exposed local populations of Mae Sot district have been confirmed.[12-15]

With regard to foods from animal origin, kidney is the first organ to reach the limit of fitness for human consumption.[16] In addition, many Thais habitually consume offal, in which domestic information concerning Cd concentration appears limited. The aim of this study therefore was to investigate the presence of Cd in kidney samples from two livestock species, beef cattle and pig, collected from Maesot district, Tak province, where it has been considered a potentially Cd polluted area, and the southwest (SW) vicinity of Bangkok (BKK), treated as a reference site. Cadmium contents and levels compared between the two locations were determined. It is anticipated that the knowledge of Cd levels in livestock species would be valuable for risk estimation of Cd carrying over to human as the final consumer.

Materials and Method

Study sites

The present study was conducted in Mae Sot district, considered a zinc mineralized area in Tak Province, Thailand, of which earlier reports revealed average Cd concentrations in water ranged from ND (not detectable) to 5 µg/l during dry and rainy season, and total Cd levels in surface sediments and soils ranged from 64 to 1458 mg/kg.[10, 11] Meanwhile, the southwest (SW) vicinity of Bangkok (BKK) was treated as a reference site where incidence of Cd pollution has not been reported.

Samples collection

Kidney samples from 53 beef cattle raised in Maesot area were collected either at the abattoirs or the local market. The 112 pig kidneys were obtained from Maesot market, of which were further classified into 2 categories: supermarket (n=57) and local market (n=55) types. The ‘supermarket’ type of Maesot pig kidneys was defined as samples from a major local producer, while those of 'local market' type were samples from several small-scale holders in the area.

In the area of SW vicinity of BKK, bovine kidneys (n=27) from locally raised animals were collected. Meanwhile, of 102 pig kidney samples, 46 samples were obtained from two major-chained supermarkets of which animals' origins were considerably diverse but mostly from lower central part of Thailand. The other 56 samples of a local market type were from small-scale producers in SW vicinity of BKK.

Collection of samples at Maesot and SW vicinity of BKK was conducted on a monthly basis during Nov. 2007 to May 2008. The cranial half of each kidney sample was packed separately in plastic bag and kept frozen at -20°C until analysis. The lag time between each collection and analysis was approximately 1 week.

Analytical method

Approximately 1 g subsamples were excised from semi-thawed tissues and digested in 5 ml concentrated nitric acid and 1 ml hydrogen peroxide in a microwave digestion system (Milestone, Ethos Plus). Digested samples were allowed to cool, then transferred to volumetric flask and diluted to 25 ml with ultrapure water. The sample solutions were analyzed for Cd by inductively coupled plasma mass spectrometry (ICP-MS; Agilent-7500CX). Samples with Cd levels >14 ppm were re-analyzed and confirmed with ICP-OES (Perkin-Elmer The Optima 4300DV). The analytical process was conducted under a strict quality assurance. Precision and accuracy of Cd determination was evaluated, using the Standard Reference Material treated in the same system. Analytical recoveries were also evaluated using spiked samples (n=5-8 for each batch of analysis), and ranging from 92%-97%. The limit of detection (LOD) and limit of quality (LOQ) were 0.002 and 0.004 mg/kg, respectively.

Statistical analysis

Data were reported as mean ± sem, and 'n' being the number of animals from which samples were obtained. Statistical analysis was performed with SPSS (PASW Statistics 17.0). Comparison between locations was carried out by binomial test. The level of significance was set at 5%.

Result

Table 1 summarized Cd levels in kidneys from beef cattle and pigs collected from Maesot compared to those in samples from SW vicinity of BKK. It was noted that the 51% of beef kidneys from Maesot contained Cd greater than the permitted levels (maximum limits, MLs: 1 mg/kg), compared to 7% positive samples collected from SW vicinity of BKK. Regarding pig kidneys, samples from both locations had relatively broad range in Cd levels, of which the highest level found in Maesot sample was twice higher than that of the sample from SW of BKK. It is noteworthy, however, that the ratio of positive pig kidneys was comparable between the 2 locations.

When further examined the origin of high Cd contaminated pig kidneys samples, the results were tabulated in Table 2 and revealed that the samples from Maesot local market had the higher ratio of unsafe kidneys than the samples obtained from supermarket. On the contrary in the SW of BKK, the percentage of positive samples was slightly higher in samples of supermarket type than those from the local market type. It was also noted that 92% of positive samples from BKK supermarket were advertised under the quality assurance production. Concerning the sample with the highest Cd level in this study (Maesot: 40.14 mg/kg and SW of BKK: 20.21 mg/kg), the record showed that each was the sample classified under the local market type.

Discussion

Although Cd contamination can be detected in almost all animal products, offal particularly kidney and liver from grazing ruminant and other mammals are regarded as high-risk products due to their ability to accumulate high Cd levels, which in turn present major sources of Cd being transferred to human. Cadmium intake is log-normally distributed and a small portion of the population might have an intake that is much higher than the average population. A fraction of population, including those who inhibitat in the polluted areas and those regularly consume offal, could be considered as a high-risk group because offal would contribute significantly to their average daily Cd intake.[17]

Since 1998, a region where water has been naturally supplied by Mae Tao creek in Maesot district, Tak province, Thailand, has been suggested as the potentially high Cd polluted area.[7-11] The cattle, mainly fed on local grown fodder and pasture, could be considered the primary livestock species exposed to Cd contamination. As evidence of this, 51% of bovine kidneys from Maesot area, compared to 7% of those collected from SW vicinity of BKK, contained Cd at the levels regarded unsafe. Moreover, the highest level of Cd contamination in Maesot sample was approximately 10 times greater than the level detected in bovine sample from SW of BKK. Since beef cattle are normally grazing, animals reared in Cd contaminated areas are likely at greater risk of Cd exposure. This tendency has been shared by several studies and thus it has been suggested that the degree of exposure observed in these animals could, at some extent, be an indicator reflecting the degree of contamination in the environment, but also a possible increment in human Cd exposure.[18-20]

On the contrary and noteworthy, the ratios of positive pig kidneys were comparable between the 2 locations. Nonetheless, the highest level of Cd identified in kidney sample collected from Maesot was twice higher than that detected in the sample from SW of BKK. These findings were in agreement with the previous investigation that the markedly high Cd levels were found in kidneys, but not meat, of the pigs obtained from the Maesot area.[21] It is then likely that the strikingly high Cd contamination in pig kidneys could be a result from multiple point sources, in which the local environmental Cd exposure may partly involve but has less impact than the bovine species. Although the source(s) of contamination were not clear, previous reports revealed that a premix containing Cd-contaminated zinc salt could be a major source of Cd at extremely high levels.[21, 22] Additionally, non-identified individual factors, genetic and environmental, may also have the effect on Cd levels in pig kidney.[23] These lines of evidence would possibly explain the relatively high Cd accumulation in pig kidneys and the high percentage of unsafe products identified outside the contaminated region.

Due to the limited domestic information concerning levels of Cd residue in livestock kidney, data of Cd contamination in the bovine kidney from industrialized areas among countries were presented in Table 3 in order to evaluate relative consumer risk of high level exposure via this offal product. Our data in the present study were in the lower range of those recently reported in China and Jamaica.[27, 28]

Meanwhile, the reported levels of Cd in pig kidneys from other countries, based on the available information thus far, were in the ranges of 0.3-10 mg/kg.[23, 29-31] Hence, our present investigation revealing such a high level of Cd in pig kidneys and high ratios of positive samples at both study locations suggests that these products would likely pose Thais, particularly the offal consumers, at greater risk. Interestingly, it is well established that Cd intakes differ widely in different countries. While the provisional tolerance for Cd intake in humans has been set at 57-71 µg/day, the mean values of 177, 72 and 15 µg/day were estimated in Thailand, the US and the UK, respectively.[16, 32] It is noteworthy that the average consumption of Cd reveals only part of the population. Certain groups of consumer including those habitually consume offal could further experience 'an extreme daily exposure' as suggested by the Cd levels reported in this study.

Based on the information concerning renal Cd contents in 2 livestock species, it is concluded that the samples from a polluted area accumulated higher Cd levels and at several magnitudes exceeding the permitted levels. The unsafe products however could be detected at both study locations and could potentially pose risk to the consumer. In addition, renal Cd contents in different livestock species might implicate the different point sources of Cd exposure in animals, prompting the need for further study in order to characterize those point sources, particularly in the pig production.

The FAO/WHO guidelines state that it is the national authorities' responsibility to assure that the food products do not contain toxic chemical substances at the levels susceptible to affect the health status of the consumer. Therefore, a continuous surveillance system of contaminants in food is essential for consumer protection and facilitates international trade.[33] In the case of Cd-contaminated food of animal origin, the regular monitoring program in close cooperation with veterinary inspection should be implemented and the high-risk products should be removed from the food chain. Moreover, consumer education on food-derived Cd-related toxicity should also be strengthening since effective and safe regimens for reversal of cadmium accumulation in the body has not yet been available. Self-protection by avoiding cadmium intake would be an effective measure.

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Table 1 Cadmium levels (mg/kg) in kidneys of beef cattle and pigs collected from Maesot, Tak and SW vicinity of Bangkok

	n	Geomean ± sem	Range	% Positive samples (Cd>1 mg/kg)
Maesot, Tak				
Beef cattle	53	0.91 ± 0.43	0.19 - 19.60	50.94
Pig	112	0.73 ± 0.67	0.09 - 40.14	26.79
SW vicinity of Bangkok				
Beef cattle	27	0.14 ± 0.11	0.02 - 2.38	7.41
Pig	102	0.56 ± 0.44	0.01 - 20.21	29.41

Table 2 Cadmium levels (mg/kg) in pig kidneys collected from Maesot, Tak and SW vicinity of Bangkok, classified by the market type

	n	Geomean ± sem	Range	% Positive samples (Cd>1 mg/kg)
Maesot, Tak				
Supermarket	57	0.57 ± 0.93	0.09 - 33.26	22.81
Local market	55	0.89 ± 0.97	0.11 - 40.14	30.91
SW vicinity of Bangkok				
Supermarket	46	0.56 ± 0.58	0.01 - 15.76	30.43
Local market	56	0.56 ± 0.65	0.14 - 20.21	28.57

Table 3 Comparative cadmium levels in kidney samples among reports.

	Cadmium levels (mg/kg)	References
Average	0.39	Spain[24]
Range	0.11 - 1.35	(n=56)
Average	0.57	Kazakhstan[25]
Range	0.13 - 1.06	(n=140)
Average	1.48	Poland[26]
Range	0.35 - 3.52	(n=19)
Average	7.92	Jamaica[27]
Range	0.01 - 117.00	(n=100)
Average	6.64	China[28]
Range	2.15 - 38.30	(n=75)
Average	0.91	Thailand (n=53)
Range	0.20 - 19.60	(present study)