Annual Research & Review in Biology
4(8): 1260-1267, 2014

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Levels of Selected Heavy Metals in Fresh Meat from Cattle, Sheep, Chicken and Camel Produced in Algeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author BB made toxicological analysis, wrote the first draft of the manuscript and managed the literature searches. Author BE collect samples and prepare the extract in laboratory. Author ZR wrote the protocol and managed the analyses of the study. All authors read and approved the final manuscript.

Original Research Article

Received 11th October 2013
Accepted 21st December 2013
Published 2nd January 2014

ABSTRACT

Aims: Levels of selected heavy metals iron, copper, zinc, lead, cadmium and mercury were determined in fresh meat from cattle, sheep, chicken and camel produced in Algeria.
Methodology: We are using atomic absorption spectrophotometry in some different samples of beef (n=120), sheep (n=120), chicken (n=120) and camel (n=120) of fresh meat collected in two areas north and south from Algeria.
Results: The order of the levels of the trace elements obtained was iron >zinc >copper> lead >cadmium >mercury. The highest concentration of iron and lead were found in the chicken meat (246.83µg/g, 8.80µg/g respectively) while camel's meat maintained the lowest values of most studied metals except values of lead (3.21µg/g) and zinc (4.17µg/g) in southern area.
Samples from the north area are more contaminated due to massive industrialization and agricultural practices.
Conclusion: The concentrations of all essential elements in the selected products were high and often exceeded legal limits set by health authorities.

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Keywords: Metal; meat; contamination; food analysis.

1. INTRODUCTION

A toxic metal is defined as that metal, which is neither essential nor has beneficial effect, on the contrary, it displays severe toxicological symptoms at low levels. With increasing industrialization, more and more metals are entering into the environment. These metals stay permanently because they cannot be degraded in the environment. They enter into the food material and from there they ultimately make their passage into the tissue [1].

Meat is a very important human food; therefore, it may potentially accumulate toxic minerals and represents one of the sources of heavy metals for humans [2]. Meat represents the main source of protein in the diet of Algerian consumers at 45 kg/year/person MADR [3].

Meat is a very rich and convenient source of nutrient, including microelements. The chemical composition of meat depends on both the kind and degree of the feeding animal. Metals in general can be classified as toxic (cadmium, mercury) and essential (cobalt, copper, zinc, iron) [1].

The risk associated with the exposure to heavy metals present in food product has aroused widespread concern in human health [2]. An improvement in the food production and processing technology has increased the chances of contamination of food with various environmental pollutants, especially heavy metals. Ingestion of these contaminants by animals causes deposition of residues in meat.

Toxic elements can be very harmful even at low concentration when ingested over a long time period due to their ability to accumulate in human and animal body [4].

The present study was carried out in view of the scarcity of information about heavy metals Fe, Cu, Zn, Pb, Cd and Hg in fresh meat from four animals: beef, sheep, chicken and camel produced in Algeria and collected from two areas.

2. MATERIALS AND METHODS

2.1 Sample Collection

During the year 2012, a total of 480 samples of fresh meat samples (n=480) were collected from four animal species: beef (biceps femoris muscle), sheep (shoulder), chicken (pectoral muscle) and camel (biceps femoris muscle). The samples were collected randomly at slaughterhouses and butchery from two sampling areas in Algeria: northern area (Mitidja, Dahra, Kabylie) and southern area (Saoura, Mzab) (Table 1).

All collected samples were stored in clean polyethylene bags according to their type and freighted to laboratory for preparation and treatment.

Table 1. Distribution of samples

Samples	North		South	
	Butchery (40)	**Slaughterhouse (24)**	**Butchery (20)**	**Slaughterhouse (10)**
Cattle	30	30	30	30
Sheep	30	30	30	30
Chicken	30	30	30	30
Camel	30	30	30	30
Total	120	120	120	120

2.2 Samples Treatment and Analysis

The collected samples were washed with distilled water to remove any contaminant particles. The samples were cut to small pieces using clean scalpel. Samples were dried in an oven at 100ºC.

After drying, the samples were ground into a fine powder using a ceramic pestle and mortar and stored in polyethylene bags till used for acid digestion.

Acid mixture (10 mL, 70% high purity HNO_3 and 65% $HCLO_4$, 4:1 v/v) was added to the beaker containing 2g dry sample according to [5].

The mixture was then digested at 80℃ till the tran sparent solution was achieved. After cooling, the digested samples were filtered using Whatman 042 filter paper and the filtrate was diluted to 50mL with deionized water obtained from a NANO pure II water purification system.

Determination of the heavy metals (Fe, Cu, Zn, Cd and Pb) in the filtrate was achieved by an atomic absorption spectrophotometer (Shimadzu Model 6800 with graphite furnace Model GFA 7000 made in Japan).

2.3 Statistical Analysis

Data collected were presented as mean and standard deviation and were subjected to one-way analysis of variance (ANOVA) ($p<0.05$) to assess whether heavy metals varied significantly between animals. All statistical calculations were performed with SPSS 21.0; Inc., Chicago, IL, USA for Windows.

3. RESULTS AND DISCUSSION

The concentration of Fe, Cu, Zn, Pb, Cd and Hg in the studied four fresh meat species: chicken, beef, sheep and camel are given in Table 2.

Table 2. Heavy metals concentrations (µg/g dry weight) of studied fresh meat

		n	North	n	South
Fe	Chicken	10	246.83±6.26[a]	10	186.33±6.79[a]
	Beef	10	84.22±2.99[b]	10	68.72±2.59[b]
	Sheep	10	70.36±1.01[c]	10	70.24±0.90[c]
	Camel	10	75.03±2.74[d]	10	70.98±4.43[d]
Cu	Chicken	10	2.30±0.08[a]	10	2.31±0.09[a]
	Beef	10	12.37±0.18[b]	10	9.59±0.32[b]
	Sheep	10	2.56±0.09[c]	10	3.84±0.13[c]
	Camel	10	2.82±0.10[d]	10	2.20±0.11[d]
Zn	Chicken	10	27.93±0.69[a]	10	36.93±1.06[a]
	Beef	10	36.99±1.92[b]	10	78.15±4.80[b]
	Sheep	10	39.64±1.86[c]	10	147.82±3.81[c]
	Camel	10	23.51±0.66[d]	10	40.17±2.62[d]
Pb	Chicken	10	8.80±0.23[a]	10	8.18±1.12[a]
	Beef	10	7.76±0.03[b]	10	5.85±0.03[b]
	Sheep	10	3.49±0.07[c]	10	3.57±0.13[c]
	Camel	10	2.01±0.05[d]	10	3.21±0.04[d]
Cd	Chicken	10	1.39±0.03[a]	10	1.49±0.13[a]
	Beef	10	1.56±0.12[b]	10	1.71±0.14[b]
	Sheep	10	1.39±0.09[c]	10	1.31±0.04[c]
	Camel	10	0.91±0.01[d]	10	0.83±0.07[d]
Hg	Chicken	10	0.015±0.05[a]	10	0.009±0.01[a]
	Beef	10	0.051±0.07[b]	10	0.032±0.07[b]
	Sheep	10	0.027±0.06[c]	10	0.020±0.04[c]
	Camel	10	0.032±0.03[d]	10	0.024±0.01[d]

Values are means ± 1.96 $\frac{\sigma}{\sqrt{n}}$ *(n = 10; for all distributions)*

Within column, mean with different letters are statistically significant p<0.05

In recent years, much attention has been given to contamination of food products by heavy metals [6]. Moreover, Mn, Cu, Zn, Fe, Cd, Hg and Pb concentrations have been determined in liver, kidney and muscle meat of ducks, chickens, rabbits and sheep slaughtered in Poland [7].

Mineral and heavy metal contents of retail meat were also determined [8].

The level of heavy metals in meat from different animals depends on factors such as environmental conditions, type of pasture and industrialization development [9,10,11].

The order of the levels of the trace elements obtained from the different meat species in two are as was Fe>Zn >Cu>Pb>Cd >Hg.

The levels of iron in meat ranged between 68.72µg/g dry weight and 246.83dry weight µg/g. Chicken meat contained significantly more Iron (p<0.05) than meat from other species (Table 2).

These results are in concordance with that obtained by Demirbas [9] in Turkey. It was noticed that Fe contents in the meats (chicken and camel) were significantly (p<0.05) higher when compared to those in the other meat.

Iron deficiency causes anemia and meat is the source of this metal. However when their intake is excessively elevated the essential metal can produce toxic effects [12].

Iron in all studied samples fell within the recommended tolerable levels [13].

Copper contents of samples ranged between 2.20µg/g and 12.37µg/g for meat. Camel meat from southern area had the lowest Cu concentration while beef meat from northern area recorded the highest value. Although, copper is essential for good health; very high intakes can cause health problems such as liver and kidney damage, the sheep is more sensitive to copper toxicity [14].

Determination of the Cu content in food is also an important subject with respect to human consumption [15,2].

In this study, all samples contained lower amount of Cu, than these limits, and there was no significant difference between the paired samples studied.

The provisional tolerable weekly intakes (PTWI) copper for fresh meat has been proposed as 14mg/week/ person [16]. The copper concentrations obtained from this study were lower than those recorded by [17].

Zinc is another important element in our diet, but the excess may be harmful and the PTWI zinc for meat is 700mg/week/person [16].

The minimum and maximum levels (ML) ($p<0.05$) of Zn were respectively estimated at 23.51µg/g (camel meat in northern area) and 147.82µg/g (sheep meat in southern area) and none of the samples exceeded the recommended limit.

According to Bartik and Piscac [18] normal concentrations of zinc in meat samples was 35-45mg/day, so it appears that most investigated samples in the present study contained high levels of zinc.

However, our result for zinc was similar to those recorded by Salisbury and Chan [19]. These authors stated that zinc concentrations in meat and special organs such as kidney and liver ranges from 23 to 147.2 ppm.

The monitoring of lead concentration in meat is important for human health [20]. Lead is known to induce reduced cognitive development and intellectual performance in children and increase blood pressure and cardiovascular diseases in adults [21].

The average amount of this metal was between 2.01µg/g (camel meat) and 8.80µg/g (chicken meat) and there was no significant difference between the Pb content of samples obtained from different meat. These values were higher than the maximum lead level allowed by FAO [2] for fresh meat i.e. 0.5µg/g [2].

Chicken (northern area) contains higher contents while camel's meat (northern area) represents the lowest contents.
Cadmium may accumulate in the human body and cause some diseases.

The levels of cadmium in all analyzed samples ranged from 0.83µg/g to1.71 µg/g, Camel meat has the lowest Cd concentration while beef meat recorded the highest value. These values appeared higher than the maximum cadmium level allowed by FAO [2] for fresh meat i.e. 0.5µg/g [2].

Cd concentrations in meat depend on the concentrations of Cd in the animal feed [22-24]. The hazardous effect was more visible at higher bioaccumulation of heavy metals during vegetative growth stage [24].

Vos et al. [20] stated that Cd may accumulate in the human body and may induce kidney dysfunction, skeletal damage and reproductive deficiencies.

Most of the samples analyzed in our study present health risk considering Cd contents.

Mercury may induce neurological changes and some diseases [25]. Mercury contents of samples ranged between 0.009µg/g and 0.051µg/g. Chicken from the southern area contained the lowest Hg concentration, while beef meat from the northern area had the highest value. Hg data showed in significant variation between all studied samples.

Hg concentrations obtained from this study were lower than the allowed mercury limit of 1.0 µg/g [13].

The high metal content found in the Algerian meat products may be caused by pollution and the environment itself, more probably by secondary contamination caused by agricultural practices and livestock feed, as well. Contamination is transferred to animals through direct sewage water and industrial effluent. Contamination of meat can also be caused by vehicle emission and from dirty slaughter places.

4. CONCLUSION

Generally, chicken and beef meat were found to have the highest significant levels of metals and sheep and camel meat the lowest levels.

Therefore, the monitoring of these products is important with respect to toxic elements affecting human health.

Most estimated metal indicated health risk as values are higher than the allowed tolerable levels cited by internationals committees.

Based on the above results, it can therefore be concluded that metals bioaccumulation in the meat species studied did not exceeds the permissible limits set for heavy metals by FAO and WHO except lead and cadmium.

ACKNOWLEDGEMENTS

The authors are highly grateful to the high financial support from the laboratory of national Office of Livestock Feed that provided necessary assistance.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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