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Appraisal of Some Heavy Metals in Organ Meat from Non-industrialized Areas of Faisalabad, Pakistan

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Abstract: The aim of this investigation was to determine the current situation and distribution of heavy metals; cadmium (Cd), lead (Pb) and nickel (Ni) in organ meat of buffalo and goat reared in non-industrialized rural areas of district Faisalabad, Pakistan. Meat samples were subjected to wet digestion and analyzed by atomic absorption spectrophotometer. There was a significant difference ($P<0.05$) in the concentration of Ni, Pb and Cd in organ meat of buffalo and goat. Mean concentration of Cd, Pb and Ni in meat samples of buffalo was 0.04, 0.29, 1.58 µg/g and of goat was 0.09, 1.28, 1.43 µg/g, respectively. The distribution and concentration of metals varied in different organs of both species. Mean Pb concentration in goat organ meat was higher than the permissible limits set internationally. Mean Ni concentration was higher in meat of both species. Mean of Cd concentration in meat samples of both species were below the permissible limits. The results of the current investigation indicated polluted environment even in non-industrialized areas with different types of heavy metals approached to environment through various sources.

Key words: Heavy Metals · Organ Meat · Buffalo Goat · Non-Industrialized Areas · Faisalabad

INTRODUCTION

Meat is essential for growth and maintenance of good health and mainly composed of proteins, fat, carbohydrate and some important essential elements. The need for mineral compounds depends on age, physiological state and feed intake as well as on living conditions [1]. Direct exposure, polluted water and crops grown on irrigated sewerage water and industrial effluents are the sources of metal contamination to animals and humans [2]. Among various environmental pollutants, heavy metals are directly related to human health. Heavy metals have density more than 5g/cm3, atomic weight 63.546 to 200.590 [3] and a specific gravity greater than 4.0 [4]. Living organisms usually need some of heavy metals up to certain limits, while excess accumulation leads to severe harmful effects [3, 5]. Increasing industrialization facilitates entering of metals into the environment. These metals persist permanently as they cannot be degraded in the environment. Heavy metals enter into the food chain, make their passage into the tissues and often have direct toxic effects [1]. Lead, cadmium, mercury and arsenic are among the main toxic metals which accumulate in food chain [6]. Contamination of meat and other edible tissues with hazardous metals is a matter of concern for humans. Heavy metals are toxic in nature and even at relatively lower concentrations can cause adverse effects [7, 8]. Processing of meat [8, 9] and rearing of livestock in proximity to polluted surroundings are key factors for their pollution in meat [10, 11].

Open literature documented the bioaccumulation and toxicity of heavy metals residues in animal tissue as hazardous potential [12-14]. Heavy metals contamination in meat is due to eating of spoiled feed by animals and also due to rearing of animals near heavy metal contaminated area [15-17]. Instances of heavy metals contamination in meat products during processing have also been reported [8, 9]. Similarly, the distribution and localization of some heavy metals in the tissues of some calf organs indicated higher levels of trace metals in livers, kidneys and small intestines [18]. The local community likes organ meat of animals including liver, kidney, heart

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etc. and used in different traditional recipes. Considering this point, present study aimed to evaluate the level and distribution of heavy metals (Cd, Pb, Ni) in organ meat of animals reared in non-industrialized areas of district Faisalabad, Pakistan.

MATERIALS AND METHODS

Collection of Organ Meat Samples: Fresh organ meat (lungs, livers, kidneys, hearts; 50 each) of buffalo and goat were purchased from the local meat shops located in non-industrialized rural areas of Faisalabad, Pakistan. It was insured that slaughtered animals were reared in these areas and not brought from unknown localities. Removal of fat from the collected samples was exercised prior to meat collection. The collected samples were kept frozen (-4°C) until further processed for elemental analysis.

Reagents and Standard Solutions: Calibrated standards were prepared by using the commercially available stock solution (Applichem®). All the glass apparatus used throughout the process of analytical work were immersed in 8N HNO_3 overnight and finally rinsed with several changes of de-ionized water, air dried and stored.

Pre-treatment of Samples: The collected samples were decomposed by wet digestion method [19]. Accurately weighed meat samples (1gm) were placed in digestion flasks and concentrated nitric acid (10 ml) was added. The digestion flasks were heated (60-70 °C) on a hot plate for 20 minutes. After cooling, 5 ml of $HCLO_4$ was added and heated vigorously till the white fumes appeared and mixture volume reduced to 2-3 ml. The content of the flask was filtered into a 50 ml volumetric flask and diluted up to the desired volume by adding de-ionized water. The blank solution was also prepared in the similar acid matrix.

Analysis of Heavy Metals: Heavy metals (Cd, Pb, Ni) in digested meat samples were analyzed using atomic absorption spectrophotometer (Hitachi Polarized Zeeman AAS, Z-8200, Japan) following the conditions described in AOAC [20]. The instrumental operating conditions for the analysis of heavy metals are summarized in Table 1.

Data Analysis: The collected data is presented as mean and standard deviation and subjected to one-way analysis of variance (ANOVA). All statistical calculations were performed with SPSS 9.0 for Windows.

RESULTS

Cadmium: Cadmium level was highest in liver (0.08 µg/g) and kidneys (0.14 µg/g) whereas non-detectable in heart of both species (Table 2). Variation in the distribution of Cd in different organs of both species was significant ($P<0.05$). Mean Cd concentration was higher (0.09 µg/g) in goat than buffalo (0.04 µg/g) organ meat.

Lead: The mean concentration of Pb varied significantly ($P<0.05$) in organ meat of buffalo (0.29 µg/g) and goat (1.28 µg/g). Pb level was highest (0.54 µg/g) and lowest (0.18 µg/g) in buffalo kidneys and heart respectively (Table 2). Its concentration in heart, liver and lungs was non-significant ($P>0.05$) whereas, it was significant ($P<0.05$) in kidneys. In case of goat organ meat, it was maximum (2.67 µg/g) in liver and minimum (0.44 µg/g) in heart with a significant ($P<0.05$) variation in the examined organs.

Nickel: Nickel concentration in organ meat of buffalo and goat has been depicted in Table 2. In buffalo organ, highest concentration of Ni was found in lungs (2.49 µg/g) and lowest in heart (0.90 µg/g). Concentration of Ni varied significantly ($P<0.05$) between lungs and kidneys whereas; it was non-significant ($P>0.05$) in heart and liver.

Table 1: Operational conditions of atomic absorption spectrophotometer for the analysis of heavy metals

Parameters	Cd	Pb	Ni
Wavelength (nm)	228.8	283.3	232.0
Slit Width (nm)	1.3	1.3	0.2
Lamp Current (mA)	7.5	7.5	10
Burner Head	Standard type	Standard type	Standard type
Flame	Air-C_2H_2	Air-C_2H_2	Air-C_2H_2
Burner Height (mm)	5.0	7.5	7.5
Oxidant gas pressure (Flow rate) (kpa)	160	160	160
Fuel gas pressure (Flow rate) (kpa)	6	7	7

Table 2: Concentration of heavy metals (µg/g) in different organs of buffalo and goat

		Concentration	
Elements	Organs	Buffaloes	Goats
Cadmium	Heart	0.00±0.00^{f}	0.00±0.00^{f}
	Liver	0.08±0.00^{c}	0.08±0.00^{c}
	Lungs	0.05±0.00^{d}	0.12±0.00^{b}
	Kidney	0.04±0.00^{e}	0.14±0.00^{a}
	Mean	0.04±0.00^{B}	0.09±0.01^{A}
Lead	Heart	0.18±0.00^{f}	0.44±0.00^{e}
	Liver	0.22±0.00^{f}	2.67±0.03^{a}
	Lungs	0.22±0.00^{f}	0.89±0.01^{c}
	Kidney	0.54±0.00^{d}	1.11±0.01^{b}
	Mean	0.29±0.04^{B}	1.28±0.25^{A}
Nickel	Heart	0.90±0.01^{d}	0.97±0.01^{d}
	Liver	0.97±0.01^{d}	1.95±0.02^{b}
	Lungs	2.49±0.03^{a}	1.40±0.02^{c}
	Kidney	1.98±0.02^{b}	1.40±0.02^{c}
	Mean	1.58±0.20^{A}	1.43±0.10^{B}

Mean of individual elements sharing similar letter in a row or in a column are statistically non-significant (P>0.05). Small letters represent comparison among interaction means and capital letters for overall means.

Highest concentration of Ni was observed in liver (1.95 µg/g) and lowest (0.97 µg/g) in heart of goat. Deposition of Ni was significant (P<0.05) in heart and liver whereas non-significant (P>0.05) in lungs and kidneys.

DISCUSSION

None of the organs of both species exceeded the permissible limit of 1 ppm recommended by FAO/WHO [21]. Highest Cd concentration was observed in goat kidneys that were also below the permissible limit. The relatively higher level of Cd in kidneys than in liver may be due to detoxification function of this organ where the metal is accumulated [22, 23]. Some previous studies conducted in the province of Punjab, Pakistan also reported under permissible Cd levels. Mariam *et al*. [24] reported under permissible limit of Cd in liver of animals at Lahore. Similarly, under permissible levels of Cd was also reported by Aslam [11] in liver, lungs and kidneys of goat at Faisalabad. In Egypt, Khalafalla *et al*. [25] also reported this trend of Cd accumulation in liver and kidneys of cattle. In contrast, higher levels of Cd have been recorded by Kramer *et al*. [26], Antoniou *et al*. [27], Jorhem *et al*. [28], Niemi *et al.*[29], Aranha [22], Roga-Franc *et al.*[30] and Lopez-Alonso *et al.*[31]. Akan *et al*. [32] reported 0.22, 0.17 and 0.44, 0.39 mg/g Cd in liver and kidneys of cow and goat. This reported high level of cadmium may be due to species, seasonal variation, feeding and rearing of livestock on contaminated land causing high accumulation of this metal in different organs and tissues.

Lead concentration in goat organs was higher than the permissible limit of one ppm set internationally. This higher trend was supported by the results of Sabir *et al*. [16] that indicated higher Pb concentration in mutton (< 2 ppm) and beef (up to 3 ppm). Mariam *et al*. [24] found higher levels of Pb than permissible limit of one ppm [33] in liver (2.18; 4.25 ppm) and kidneys (2.02; 3.85 ppm) of beef and mutton. Much high levels 7.72 and 14.38 mg/kg of Pb in lungs and kidneys of cattle and goat has been reported by Aslam [11] in Faisalabad, Pakistan. High trend of Pb accumulation in liver and kidneys of animals has been reported by Aranha [22] and Danev *et al*. [34] indicating that liver (86%) and kidney (100%) were contaminated above the limits set by the country regulations. Similarly, Maldonado *et al*. [35] noted significantly higher levels of lead in liver and kidneys during lactation in rats. The levels of Pb in liver, kidney and meat of beef, mutton caprine and chicken ranged from 0.1 to 1.34 µg/g [32]. Spierenburg *et al*. [36] reported significantly high amounts of Pb in liver and kidneys of cattle in Nigeria, Pb concentration in different organs and muscles of cow ranged from non-detectable to 1.22 mg/kg [37]. In contrast, under permissible levels of Pb has been noted by Stabel-Taucher *et al*. [38] and Jorhem *et al*. [28]. Low level in liver (42.70 µg/kg) and kidney (109.42 µg/kg) of cattle slaughtered in the Beni-Suef abattoir in Egypt was reported by Khalafalla *et al*. [25]. Accumulation of absorbed lead normally occurred in liver and kidneys [39, 40]. Airborne sources like industrial emissions and combustion of fuel having Pb additives may affect grazing animals [41]. Chances of Pb accumulation in different organs are mostly in animals that reared around refineries than reared in rural areas [42]. Abou Donia [43] pointed out that concentration of Pb was higher in livers and kidneys of animals from industrial areas. Indication of lower levels of Pb in some organs during the present investigation may be the results of the notable reduction in emission from automobiles resulting into reduced Pb level in meat tissues during the recent decades [42]. In spite of notable reduction in Pb level worldwide, the present results indicated that Pb residues still exists in non-industrialized rural localities. The entry route may be sewerage drains passing through this area containing untreated effluents from industrial or chemical processing units located way from this site. It may happen that from sewerage drains, the untreated waste water may find their way to irrigation channels and consequently through soil pollute the fodder.

It is obvious from the results that some organs contain higher amount of Ni. This element is present in a number of enzymes in plants and microorganisms. In humans, it regulates prolactine and stabilization of RNA and DNA structures [44]. In contrast, excessive intake of Ni can cause severe allergic reaction [45]. Majority of food products contains Ni less than 0.5 mg/kg fresh weight [46]. According to Solomons *et al*. [47], meat contains low levels of Ni (<0.2 µg/g). Open literature indicated that there is no set recommended amounts of Ni intake. However, the hypothetical human requirement for Ni would be 16 to 25 µg/1000 kcal or about 75 µg of elemental Ni per day [47]. In human, Ni deficiency has not been observed [48]. A wide variation in Ni levels in organ meat has been reported. Korenekova *et al.* [15] reported 0.23-0.35 mg Ni /kg in beef. Nwude *et al.*[37] documented 0.09 to 0.44 mg/kg of Ni level in liver and 0.30 to 0.57 mg/kg in kidneys. Sabir *et al*. [16] reported Ni concentration as 2ppm and 1ppm in mutton and beef, respectively. Akan *et al*. [32] found Ni concentration in liver (0.29; 0.19 µg/g) and kidneys (0.16; 0.13 µg/g) of cattle and goats. Aslam [11] documented Ni concentration in liver (12.18 mg/kg), lungs (13.27 mg/kg) and kidney (5.75 mg/kg) of goat meat obtained along the main sewerage drains of Faisalabad city. Higher level of Ni (101mg/kg) was also observed in livers of poultry at Faisalabad [49].

In conclusion, the results mentioned in preceding lines clearly indicated that concentration of Pb and Ni has been found higher in organ meat of buffalo and goat than the permissible limits of 1ppm and 0.2ppm, respectively. The presence of heavy metals residues in meat obtained from non-industrial areas is an indicative of continuous pouring of untreated industrial waste water from sewerage drains passing through these areas. Consequently, uptake of heavy metal residues by the fodder cultivated on this soil may occur that may be a cause of this pollution in non-industrialized rural areas.

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