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# Residual level of Chromium, Copper and Manganese in Soil and Water of N-24 Parganas (West Bengal) and its Relation to Chevon quality

G. Mahapatra*, S. Biswas, D. Bhattacharya and G. Patra

Dept. of Livestock Products Technology, F/O Veterinary and Animal Sciences, West Bengal University of Animal and Fishery Sciences, 68, Kshudiram Bose Sarani, Kolkata, West Bengal (700 037), India

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**Corresponding Author**

G. Mahapatra

*e-mail*: drgargimahapatra@gmail.com

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***Data Availability Statement:*** Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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## Abstract

An increase in human population coupled with urbanization, has resulted for higher demand in meat per capita.Meat and meat products are important for human diet as they provide a great part of nutrients, including necessary trace elements which act as micronutrients. The present study focuses on the concentration of trace elements (chromium, copper and manganese) in the meat of goats (40 weeks age) reared in the three targeted zones of West Bengal, where high heavy metal concentrations in soil and water is a matter of concern. Soil, water and chevon samples were collected from three targeted zones of West Bengal.The meat samples were taken from free range goats grazing locally. Over a span of six months samples were collected, digested and analyzed by atomic absorption spectrophotometry. The mean values of heavy metals in soil samples ranged from 29.96-49.260 ppm of chromium, 14.65 to 38.3 ppm for copper and 198.6 to 482 ppm for manganese. The mean values of heavy metals in water ranged from 0.006-0.02 ppm for chromium, 0.0024 to 0.0180 ppm for copper and 0.068 to 0.436 ppm for manganese . Soil samples revealed high concentration of chromium and copper whereas water samples revealed high concentration of manganese. These levels did not impact the edible quality of meat. Hence advocating that risks associated with chevon consumption from goats (40 weeks age) reared in areas having high heavy metal residual content are negligible and consumption of such meats should not necessarily cause any dilemma.

***Keywords:*** Heavy-metal, micro-nutrients, meat/chevon

## 1. Introduction

In the recent times goat meat has become an ideal choice of red meat for health conscious consumers due to its lower fat percentage compared to beef and lamb (Casey et al., 2003). Meat and meat products contribute significantly to the intake of energy, protein and important micronutrients, at least when consumed frequently (McAfee et al., 2011). According to USDA (2007) every 100 g of goat meat 0.038 mg of manganese (Mn) and 0.256 mg of copper (Cu). These elements are basically heavy metals which are classified as micronutrients for the vertebrates (Hogan, 2010). These elements are essential in small amounts but they tend to become toxic if a specific concentration level is exceeded (Peralta-Videa et al., 2009). These elements in large quantities can cause acute and chronic toxicity whereas long term exposure may result in slowly progressing physical, muscular and neurological degenerative diseases (IOSHC, 1999).

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Environmental pollution nowadays is a big concern. Anthropogenic activities like mining, industrial operations and agricultural activity have altered the environment significantly. Environmental contaminants are widely distributed in air, water and soils therefore they will have an effect on the tropic chain. Contamination with heavy metals is a serious threat because of their toxicity and tendency for bio-accumulation and bio-magnification in the food chain (Demirezen and Uruc, 2006). The uptake of heavy metals by cereals and vegetables is likely to be higher in polluted soil and water (Yusuf et al., 2003). Due to grazing of cattle and goat on the contaminated soils, higher levels of trace metals have been recorded in beef and mutton (Sabir et al., 2003).

According to Rooke et al. (2010) and De Smet and Vossen (2016) the regulation of some trace elements occurs mainly at the site of absorption. The most important dietary factors that interfere are chelating agents, that may inhibit as well as promote bioavailability, and metal ion and other trace element interactions that are mostly inhibiting absorption and bioavailability (Van paemel et al., 2010).

Chromium, manganese and copper are basically heavy metals which act as micronutrients for the human body but their accumulation at toxic levels is a matter on great concern. The present study was conducted to explore the concentration of these elements in the soil, water and meat of the goats reared locally in targeted areas of North-24 Parganas district of West Bengal, India, thus establishing a relationship between the residues of these heavy metals in the environment and determining the safety of the chevon, for human consumption.

## 2. Materials and Methods

The study was conducted on samples of soil, water and chevon collected from 3 sub-divisions of North- 24 Parganas of West Bengal namely Barrackpore (22.76°N 88.37°E), Barasat (22.72°N 88.48°E) and Bashirhat (22°39'26''N 88°53'39''E). Sample collection was continued for a period of six months i.e. from the month of November 2011 to May 2012. All samples were taken in 5 replicates per month.

Soil samples were collected once each month, during the six months time-frame. Soil was dug to a depth of 15 cms from the surface.These samples were collected in sealed plastic sachets. The samples were then dried at 105±5 ˚C, ground and then sieved through a 2 mm mesh and transferred to sterile polyethylene bottles until further analysis.

In case of water samples, the sampling, preservation and analysis were carried as per APHA (Anonymous, 1995) guidelines. Water sources from where the animals consumed water for drinking purpose were identified. The samples were then collected in sterile plastic bottles without filtration. The frequency of sample collection was once every month for a period of six months.

For our study we targeted castrated goats of Black Bengal breed growing up in these areas, on free range system and aged at around 40 weeks. Such goats were purchased locally, fasted overnight with free access to water and were slaughtered as per standard procedures. Following the Indian Standard Institution (Anonymous, 1963) six primal wholesale cuts were made out of which only three cuts were taken into consideration namely leg, loin and shoulder. These cuts were then vacuum packed and frozen at -20 ˚C until further analysis.

The samples collected were digested by tri-acid (Datta et al., 2010). The digest was then slowly evaporated to near dryness, cooled and dissolved in 2.0% $HNO_3$. These digests were subsequently filtered through Whatman Filter Paper no. 42 and diluted to 50 ml with 2.0% $HNO_3$. The solution obtained were analyzed for chromium, copper and manganese by Atomic Absorption Spectrophotometer (GBC, 932 Plus-AAs, Australia) in Flame Mode using air-acetylene flame. The absorption of the elements were compared to standard absorption and the residue levels were expressed as parts per million.

For each table, the data presented are in parts per million (ppm) and BDL- below detection limit, wherever applicable. Each S. No. refers to the consecutive months of samples collected in the 6 months period and the total number of samples analyzed were 180 (samples in replicates of five for each month,for each of soil, water and chevon) here n=30 (samples collected for six consecutive months in replicates of five). All data which were obtained during the present investigation were analyzed statistically to draw valid conclusion in SPSS (version 16.0) software. Data related to the effect of different wholesale cut were analyzed by one way ANOVA according to Duncan's multiple range test (Duncan, 1995) and data related to the effect of breed were analyzed with the help of Independent sample T test at 5% level of significance. The results were expressed in terms of mean and standard error (SE) of mean. A probability value of $p<0.05$ was described as significant and $p<0.01$ was noted highly significant.

## 3. Results and Discussion

For most of the above observations, the analysis of variance indicated no significant difference ($p>0.05$), rest are indicated.

### *3.1. Chromium (Cr)*

The residual level of chromium is presented in Table 1.

On analysis it was observed that the chromium content in the soil of Barasat ranged from 30.86-38.64 ppm and of Bashirhat ranged from 29.96- 39.54 ppm, which according to Roychowdhury et al. (2002) were slightly above the indicated normal range. The content of chromium in the soil samples of Barrackpore ranged from 41.799-49.260 ppm. The concentration of chromium in the soil of Barrackpore was much higher than the normal range as indicated by Roychowdhury et al. (2002). On analysis of water it was observed that the chromium content in the surface water of

Table 1: Residual content of chromium

| Area | Barrackpore | | | | | Barasat | | | | | Bashirhat | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | Soil (ppm) | Water (ppm) | Chevon (ppm) | | | Soil (ppm) | Water (ppm) | Chevon (ppm) | | | Soil (ppm) | Water (ppm) | Chevon (ppm) | | |
| | | | SHL | Thigh | Loin | | | SHL | Thigh | Loin | | | SHL | Thigh | Loin |
| 1. | 45.539+ 0.0365 | 0.009+ 0.0039 | BDL | BDL | BDL | 33.25+ 0.0306 | 0.006+ 0.0029 | BDL | BDL | BDL | 35.81+ 0.0395 | 0.009+ 0.0325 | BDL | BDL | BDL |
| 2. | 49.260+ 0.0294 | 0.012+ 0.0046 | BDL | BDL | BDL | 35.24+ 0.0332 | 0.016+ 0.0040 | BDL | BDL | BDL | 36.54+ 0.0326 | 0.008+ 0.0031 | BDL | BDL | BDL |
| 3. | 41.799+ 0.0358 | 0.014+ 0.0048 | BDL | BDL | BDL | 38.64+ 0.0280 | 0.013+ 0.0047 | BDL | BDL | BDL | 37.64+ 0.0321 | 0.013+ 0.0036 | BDL | BDL | BDL |
| 4. | 48.304+ 0.0376 | 0.019+ 0.0054 | BDL | BDL | BDL | 34.52+ 0.0325 | 0.011+ 0.0047 | BDL | BDL | BDL | 29.96+ 0.0392 | 0.020+ 0.0054 | BDL | BDL | BDL |
| 5. | 46.275+ 0.0324 | 0.017+ 0.0048 | BDL | BDL | BDL | 32.58+ 0.0311 | 0.014+ 0.0054 | BDL | BDL | BDL | 33.45+ 0.0322 | 0.014+ 0.0028 | BDL | BDL | BDL |
| 6. | 45.912+ 0.0311 | 0.018+ 0.0038 | BDL | BDL | BDL | 30.86+ 0.0328 | 0.007+ 0.0056 | BDL | BDL | BDL | 39.54+ 0.0311 | 0.013+ 0.0031 | BDL | BDL | BDL |

SHL: Shoulder; n=30

Barrackpore, Barasat and Bashirhat ranged from 0.009- 0.019 ppm, 0.006-0.016 ppm and 0.008-0.020 ppm, respectively. BIS (1991) allows a maximum of 0.05 ppm of chromium in drinking water. Most of the values recorded were with in the BIS (1991) standard for drinking water. These results obtained were in coherence to the findings made by Kar et al. (2008). Irrespective of the chromium concentration recorded in the soil and water of these three areas it was noted that the residue level of chromium found in chevon of Barrackpore, Barasat and Bashirhat all were Below Detection Level (BDL), even if taken every muscle part of shoulder, thigh and loin individually.

*3.2. Copper (Cu)*

The copper concentration recorded in the soil, water and chevon of Barrackpore, Barasat and Bashirhat are presented in Table 2.

In the present study it was observed that copper content in soil of Barrackpore ranged from 30.5-38.3 ppm, Barasat ranged from 14.65-24.61 ppm and for Bashirhat ranged from 15.64-22.85 ppm, which according to Roychowdhury et al. (2002) were above normal range. On analyzing the water samples

Table 2: Residual content of copper

| Area | Barrackpore | | | | | Barasat | | | | | Bashirhat | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameter | Soil (ppm) | Water (ppm) | Chevon (ppm) | | | Soil (ppm) | Water (ppm) | Chevon (ppm) | | | Soil (ppm) | Water (ppm) | Chevon (ppm) | | |
| | | | SHL | Thigh | Loin | | | SHL | Thigh | Loin | | | SHL | Thigh | Loin |
| 1. | 30.5+ 0.0615 | 0.0050+ 0.0408 | BDL | BDL | BDL | 18.8+ 0.0494 | 0.0032+ 0.0073 | BDL | BDL | BDL | 19.06+ 0.0492 | 0.0026+ 0.0061 | BDL | BDL | BDL |
| 2. | 33.8+ 0.0620 | 0.0180+ 0.0404 | BDL | BDL | BDL | 0.0180+ 0.0404 | 0.0043+ 0.0070 | BDL | BDL | BDL | 17.89+ 0.0544 | 0.0062+ 0.0070 | BDL | BDL | BDL |
| 3. | 33.2+ 0.0614 | 0.0103+ 0.0406 | BDL | BDL | BDL | 24.61+ 0.0537 | 0.0041+ 0.0077 | BDL | BDL | BDL | 15.64+ 0.0527 | 0.0054+ 0.0058 | BDL | BDL | BDL |
| 4. | 38.0+ 0.0618 | 0.0074+ 0.0415 | BDL | BDL | BDL | 20.54+ 0.0495 | 0.0024+ 0.0067 | BDL | BDL | BDL | 20.95+ 0.0494 | 0.0068+ 0.0069 | BDL | BDL | BDL |
| 5. | 38.3+ 0.0617 | 0.0086+ 0.0105 | BDL | BDL | BDL | 16.69+ 0.0547 | 0.0031+ 0.0062 | BDL | BDL | BDL | 22.85+ 0.0549 | 0.0045+ 0.0062 | BDL | BDL | BDL |
| 6. | 36.9+ 0.0621 | 0.0061+ 0.0108 | BDL | BDL | BDL | 14.65+ 0.0543 | 0.0035+ 0.0081 | BDL | BDL | BDL | 20.64+ 0.0541 | 0.0034+ 0.0070 | BDL | BDL | BDL |

SHL: Shoulder; n=30

it was observed that copper residues in surface water of Barrackpore ranged from 0.005-0.018 ppm, Barasat ranged from 0.0024-0.0043 ppm and Bashirhat ranged from 0.0026-0.0068 ppm. All the observations made were in coherence to the findings of Kar et al. (2008) which indicated that all water samples were with in the range of 1.5 ppm, the BIS (1991) standard for maximum amount of copper in drinking water. The residues of copper found in chevon of Barrackpore, Barasat and Bashirhat all were Below Detection Level (BDL), even if taken every muscle part of shoulder, thigh and loin individually

*3.3. Manganese (Mn)*

The residual level of manganese in the soil, water and chevon of Barrackpore, Barasat and Bashirhat are presented in Table 3.

On analysis of the collected samples it was observed that the Manganese content in the soil samples of Barrackpore ranged from 198.6-311.8 ppm, Barasat ranged from 342-380 ppm and Bashirhat ranged from 244-482 ppm. Theses values according to Roychowdhury et al. (2002) were all with in normal range. The manganese residues in surface water of Barrackpore, Barasat and Bashirhat ranged from 0.134-0.293 ppm, 0.068-0.412 ppm and 0.163-0.436 ppm, respectively. According to the BIS (1991)the maximum level of manganese permitted in drinking water is 0.3 ppm. Most of the values observed, were in coherence with the findings made by Kar et al. (2008),except a few samples obtained from Barasat and Bashirhat area which pertained to a p value of $p<0.05$ and was considered to be significant. Even-though water samples indicated high concentration of magnesium the residues of manganese found in chevon of Barrackpore, Barasat and Bashirhat all were

Table 3: Residual content of manganese

| Area | Barrackpore | | | | | Barasat | | | | | Bashirhat | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Param-eter | Soil (ppm) | Water (ppm) | Chevon (ppm) | | | Soil (ppm) | Water (ppm) | Chevon (ppm) | | | Soil (ppm) | Water (ppm) | Chevon (ppm) | | |
| | | | SHL | Thigh | Loin | | | SHL | Thigh | Loin | | | SHL | Thigh | Loin |
| 1. | 198.6+ 0.0647 | 0.134+ 0.0174 | BDL | BDL | BDL | 352+ 0.0419 | 0.369+ 0.0172 | BDL | BDL | BDL | 368+ 0.0436 | 0.163+ 0.0165 | BDL | BDL | BDL |
| 2. | 208.5+ 0.0552 | 0.139+ 0.0146 | BDL | BDL | BDL | 368+ 0.0439 | 0.251+ 0.0144 | BDL | BDL | BDL | 349+ 0.0416 | 0.177+ 0.0136 | BDL | BDL | BDL |
| 3. | 212.6+ 0.0646 | 0.293+ 0.0151 | BDL | BDL | BDL | 342+ 0.0447 | 0.412+ 0.0149 | BDL | BDL | BDL | 482+ 0.0448 | 482+ 0.0448 | BDL | BDL | BDL |
| 4. | 311.8+ 0.0543 | 0.197+ 0.0312 | BDL | BDL | BDL | 380+ 0.0416 | 0.085+ 0.0311 | BDL | BDL | BDL | 406+ 0.0429 | 0.417+ 0.0312 | BDL | BDL | BDL |
| 5. | 264.5+ 0.0445 | 0.158+ 0.0181 | BDL | BDL | BDL | 362+ 0.0425 | 0.068+ 0.0180 | BDL | BDL | BDL | 284+ 0.0440 | 0.436+ 0.0182 | BDL | BDL | BDL |
| 6. | 289.3+ 0.0416 | 0.182+ 0.0169 | BDL | BDL | BDL | 349+ 0.0416 | 0.111+ 0.0169 | BDL | BDL | BDL | 244+ 0.0449 | 0.251+ 0.0167 | BDL | BDL | BDL |

SHL: Shoulder; n=30

Below Detection Level (BDL), even if taken every muscle part of shoulder, thigh and loin individually.

Even though, Robinson (1994), John and Jeane (1994), Sabir et al. (2003) and Coleman et al. (1992) have found the presence of heavy metal residue in meat and meat products obtained from animals reared in polluted environments but our investigation yielded results contrary to these findings. On the contrary the results of our investigation were in coherence to the findings made by Rooke et al. (2010) and De Smet and Vossen (2016) which states that the response in muscle to increased dietary concentrations of copper and manganese is mostly absent.

## 4. Conclusion

Our findings clearly indicated that chevon obtained from goats up to 40 weeks age group, have Chromium, Copper and Manganese contents safe residual limits, even if procured from areas having high heavy metal concentration either in soil or in water.

## 5. Further Research

Presence of residues of other heavy metal should be tested in muscles as well as vital organs such as liver, kidney, lungs etc in different species of animals and birds which are also consumed by humans. There is a need to test the meat and organs over a prolonged period of exposure to determine whether there is a reverse impact in future.

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and analyze data at their facility.

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