Determination of total Arsenic (As) in Feed and Meat of the Chicken. A case study from Khyber Pakhtunkhwa (KPK) Pakistan

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Abstract

Arsenic concentration was evaluated in different parts of the chicken and ingredients of the feed used for the chicken feed. Arsenic was found in different feed ingredients and parts of the chicken though variations were found in the concentration of arsenic in meat and feed samples. Chicken stomach and liver were the major parts of the samples where higher arsenic concentrations were determined. Arsenic concentration in feed ingredients and meat samples ranged from 0.00-0.013 mg/Kg and 0-0.1566 mg/Kg respectively. Arsenic concentration in N long thigh, N liver, N stomach and C breast were found higher than WHO/FAO permissible limit of 0.1 mg/Kg while in other samples it was found within the limits of WHO/FAO. Estimated daily intake (EDI), target hazard quotient (THQ) and cancer target risk (CTR) were used to assess the risk of arsenic for chicken users in KPK, Pakistan. EDI was found between 0.0562–0.224 mg/Kg. THQ were found lower than 1. Considering the presence of arsenic in feed ingredients and meat samples the present study is very useful and provide fruitful information for the users of chicken meat in KPK Pakistan.

Introduction

Arsenic (As) in water and food is a matter of extreme concern for their users across the world. It is extremely carcinogenic and may cause health disorders such as respiratory, reproductive, digestive and may produce problems to the nervous system. Water and food are considered as the sources of human exposure to both organic and inorganic arsenic. Inorganic arsenic is more toxic than organic arsenic and among inorganic arsenic As^{3+} is more toxic than As^{5+}. Arsenic contaminated water, fertilizers and pesticides are the sources through which arsenic enters to the food cycle of human. Different food such as rice, wheat, sea food, red meat, chicken meat, milk powder, fruit juices and products produced from wheat, meat, fish and milk are the food through which exposure of human to arsenic has been reported [1–5]

Chicken meat is a rich source of proteins, minerals and aminoacids. Chicken meat is necessary to fulfill the basic need of the human food. Poultry industry contribute 9.48% of the total livestock in Pakistan's whereas the meat of the broiler chicken contributes 19% of the entire meat production in Pakistan [6, 7]. Arsenic in chicken meat need to be monitored because of its toxicity to humans. Fodder used for chicken is considered as the entrance source of As to chicken meat and finally to humans [6–10].

Health risk assessment tools such as estimated daily intake (EDI), target hazard quotient (THQ), hazard index (HI) are useful tools to calculate the health risk caused to the consumers of food from the heavy metals concentration all over the world. These parameters have been used to assess the health hazards of heavy metals in cereals, pulses, tea, fishes, fruit juices, meat. In this work total arsenic was determined in chicken feed ingredients and meat products and health risk techniques were used to assess the health hazards of arsenic to the chicken meat consumers in Khyber Pakhtunkhwa Pakistan [10–17].

Experimental

Sample collection

Different parts of the chicken (liver, stomach, brest, small thigh, long thigh), feed (Rice polish, cannola meal, poultry biproducts, Broiler grower, Soybean, maiz, vitamin and mineral, L- threonine, L- lysine) were collected from Peshawar (P), Mardan (M), Nowshera (N), and Charsadda (C) in KPK. Then the sample were stored in polythene bags and kept in a refrigerator at -18°C.

Reagents used

All the chemicals used during the analysis were of analytical grade and purchased from Sigma Aldrich and Fisher chemicals. The chemicals used are concentrated nitric acid (HNO_3 65%), and perchloric acid ($HClO_4$ 60%).

Sample Preparation

1.5g of each sample was digested in a mixture of HNO_3 and $HClO_4$ (3:1). The samples were heated in a digestion block heater for 1 hour at 95°C until a clear solution was obtained. The clear sample solution was diluted to 100 mL and filtered through Whatmann filter paper. The samples were stored in polyethylene bottles.

Intrumental conditions

A Hitachi z-2000 equipped with flame/graphite furnace with a hollow cathode lamp was used for all the analysis. The instrument is provided with a graphite auto sampler and Polarized Zeeman Background correction.

Estimated Daily Intake (Edi)

The EDI for arsenic was calculated using the following formula

$$\mathrm{EDI} = \frac{\mathrm{FIR} \times \mathrm{C}}{\mathrm{BW}}$$

where FIR is the ingestion rate of food (g/person/day), C is the arsenic concentration in food samples (mg/kg), and BW is the body weight [12, 15, 16].

Target Hazard Quotient (Thq)

THQ was used to calculate the non carcinogenic effect of As. Equation used

$$\mathrm{THQ} = \frac{M_c \times \mathrm{Cf} \times \mathrm{IR} \times \mathrm{EF} \times \mathrm{ED}}{\mathrm{RfD} \times \mathrm{BW} \times \mathrm{AT}} \times 10^{-3}$$

THQ is the target hazard quotient, EFr is the frequency of exposure (365 days/year), ED represent the duration of exposure (70 years), FIR is the ingestion rate of food (g/person/day), C is the arsenic

concentration in food (mg/Kg), RfD is the oral reference dose (mg/Kg/day), and AT is the average time for non carcinogens. The RfD for As is 3.0×10^{-4} [12, 15, 16].

Target Cancer Risk (Tcr)

Target cancer risk was used to evaluate the carcinogenic risk of arsenic for the chicken users in Pakistan.

$$\mathrm{TR} = \frac{\mathrm{EF} \times \mathrm{ED} \times \mathrm{FIR} \times \mathrm{CM} \times \mathrm{CPS_o}}{\mathrm{WAB} \times \mathrm{AT_c}} \times 10^{-3}$$

EF is the frequency of exposure to arsenic (365 days/), ED is the exposure duration (30 years)where TR is the target cancer risk, CM is the concentration of arsenic in chicken meat (µg/g), FIR is the ingestion rate of the chicken meat (g/day), CPSo is the carcinogenic potency slope, oral (mg/kg bw/day), and ATc is the averaging time, carcinogens (365 days/year for 70 year as used by USEPA 2011 [20]. The CPSo value for arsenic is 1.5 mg/kg body weight/day) [12].

Results And Discussion

The presence of arsenic in feed ingredients and in the different parts of the chicken is of huge concern. Arsenic was determined in chicken feed ingredients and meat of the chicken. Different parts of the chicken such as long thigh, small thigh, breast, stomach and liver) collected from different cities of Pakistan were analyzed. Variations were found in the concentration of arsenic. Arsenic was also determined in the feed ingredients of the chicken in order to find the source of arsenic in chicken meat. Arsenic was found in different ingredients of the feed such as canola meal, rice polish, sunson, maduramicin ammonium, choline, met amino, Zn-Bacitracin, L-Isolucine and L-Valine. Arsenic was also found in different parts of the meat though there were variations in the concentration of arsenic in different parts of the chicken. Arsenic concentration was found higher in liver and stomach samples except in the long thigh of the samples collected from Nowshehra.

Table 1
Arsenic level (mg/Kg) in ingredients of chicken feed and chicken meat. N = Nowshehra, P = Peshawar, C = Charsadda, M = Mardan

S.No	Feed Ingredients	As mg/Kg	Meat Samples	As mg/Kg
1	Broiler grower	N.D	N small thigh	N.D
2	Poultry biproduct	N.D	N long thigh	$10.96\times10^{-2} \pm 7.45\times10^{-3}$
3	Canola meal	$13.0\times10^{-3} \pm 4.36\times10^{-3}$	N breast	N.D
4	Rice polish	$12.15\times10^{-3} \pm 4.64\times10^{-4}$	N liver	$15.66\times10^{-2} \pm 8.33\times10^{-3}$
5	Soybean	N.D	N stomach	$11.99\times10^{-2} \pm 9.26\times10^{-3}$
6	L-Lysine	N.D	P small thigh	$39.33\times10^{-3} \pm 3.4\times10^{-3}$
7	Vitamins + mineral	N.D	P long thigh	N.D
8	Maize	N.D	P breast	N.D
9	Sunson	$4.34\times10^{-3} \pm 4.31\times10^{-4}$	P liver	$8.866\times10^{-2} \pm 2.344\times10^{-3}$
10	Maduramicin-Ammonium	$5.60\times10^{-3} \pm 7.09\times10^{-4}$	P stomach	$4.599\times10^{-2} \pm 1.599\times10^{-3}$
11	Choline	$5.22\times10^{-3} \pm 8.53\times10^{-4}$	C small thigh	$8.27\times10^{-2} \pm 2.49\times10^{-3}$
12	Met amino DLM	$3.56\times10^{-3} \pm 3.72\times10^{-4}$	C long thigh	N.D
13	Zn-Bacitracin	$6.23\times10^{-3} \pm 5.05\times10^{-4}$	C breast	$11.93\times10^{-2} \pm 4.66\times10^{-3}$
14	L-Isolucine	$1.92\times10^{-3} \pm 4.47\times10^{-4}$	C liver	N.D
15	L-Valine	$4.18\times10^{-3} \pm 4.13\times10^{-4}$	C stomach	$6.399\times10^{-2} \pm 5.11\times10^{-3}$

S.No	Feed Ingredients	As mg/Kg	Meat Samples	As mg/Kg
16	L-Threonine	N.D	M small thigh	N.D
17			M long thigh	N.D
18			M breast	$6.73\times10^{-2} \pm 4.54\times10^{-3}$
WHO/FAO				0.1 mg/Kg

Table 2
Estimated dietary intake (EDI) (mg/gay) of arsenic due to consumption of chicken meat, target hazard quotient (THQ) and target cancer risk (TCR). N = Nowshehra, P = Peshawar, C = Charsadda, M = Mardan

S.No	Meat Samples	Estimated Daily Intake (EDI)	Target Hazard Quotient (THQ)	Target Cancer Risk (TCR)
1	N small thigh	–	–	–
2	N long thigh	0.157	0.109	1.714
3	N breast	–	–	–
4	N liver	0.224	0.155	2.4497
5	N stomach	0.171	0.119	1.8756
6	P small thigh	0.056	0.039	0.6152
	P long thigh	–	–	–
8	P breast	–	–	–
9	P liver	0.1267	0.088	1.387
10	P stomach	0.0657	0.046	0.7194
11	C small thigh	0.1181	0.082	1.294
12	C long thigh	–	–	–
13	C breast	0.1704	0.118	1.866
14	C liver	–	–	–
15	C stomach	0.0914	0.064	1.001
16	M small thigh	–	–	–
17	M long thigh	–	–	–
18	M breast	0.0961	0.067	1.053

Arsenic concentration in feed ingredients ranged from 0.00-0.013 mg/Kg whereas in meat samples ranged from 0-0.1566 mg/Kg respectively (Table 1). In feed ingredients arsenic were found in the order Canola meal > Rice polish > Zn-Bacitracin > Maduramicin-Ammonium > Choline > sucson > L-valine > Met amino DLM > L-Isolucine, though arsenic was not found in the ingredients broiler grower, poultry byproduct, soybean, L-Lysine, vitamins/minerals, maize and L-threonine. Arsenic was found in variable concentration in different parts of the chicken. Its higher concentration was found in N liver (0.1566

mg/Kg) which was higher than permissible limit of WHO/FAO. In four samples i.e. N long thigh, N liver, N stomach and C breast were found higher than WHO/FAO permissible limit of 0.1 mg/Kg while in other parts its concentration was found lower than the limits of WHO/FAO [11]. Estimated daily intake (EDI) and cancer target risk (CTR) were used to assess the risk of arsenic for chicken users in KPK, Pakistan. EDI was found between 0.0562–0.224 mg Kg^{-1} (Table 2). EDI in N long thigh, N liver, N stomach and C breast were higher than recommended daily intake of arsenic (0.13 mg/person/day) [10]. THQ are very important to know the toxicity of arsenic. THQ higher than 1 is of concern while lower than 1 is acceptable to the users. The THQ values were found lower than 1, which means that arsenic concentration in different parts of the chicken may not be that much serious as it is in the higher concentration. The presence of arsenic in the feed and meat is of a little bit concern. Arsenic moves from feed to the chicken and from chicken to the consumers of chicken. Arsenic concentration is lower than WHO permissible limits but its bioaccumulation may cause some serious health problems.

Conclusion

The current study is very useful and provide fruitful information for the chicken users in Pakistan. Arsenic was found in variable concentration in feed ingredients and in the samples of different parts of the chicken meat. Arsenic presence in feed is seems to be a major source of arsenic in chicken meat. Arsenic concentration in meat samples were within the WHO/FAO permissible limits except N long thigh, N liver, N stomach and C breast. Health risk techniques were very effective in finding the health hazards of chicken meat due to the presence of arsenic. EDI was found higher in some samples while THQ was found lower than 1, which means that arsenic concentration in chicken meat are not that much toxic for chicken users in Pakistan, but care must be taken as bioaccumulation may lead to various disorders.

Declarations

Acknowledgement

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Competing interest

The authors declare no competing interest.

Ethics approval

The manuscript has been prepared according to the ethics of the journal.

Consent to participate

Not applicable

Consent to Publish

We agree to publish the manuscript after acceptance.

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Data availability statement

All the data has been included in the manuscript and will be available after publication.

Authors Contribution

Mr. Shah Hussain collected and prepared the samples whereas Muhammad Idrees designed the project and prepared the manuscript.

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