DETERMINATION OF HEAVY METALS CONTAMINATION IN MAIZE FLOUR COLLECTED FROM LOCAL MARKETS OF BAREILLY CITY, UTTAR PRADESH

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Abstract: Maize flour is one of the important source of nutrients after wheat flour and rice among cereals. It is mostly consumed widely in parts of world including India as chapatis and flat breads. The paper presents the determine of concentration levels of aluminium, arsenic, cadmium, lead and mercury in maize flour consumed by consumers of Bareilly city, the sample was collected from different local market sites. These metals were assessed by atomic absorption spectrophotometer. The elements analyzed were compared with the standard acceptable limits. The results revealed that all the metals were found above the permissible limits. The addition of metals based fertilizers or pesticides; irrigation with contaminated water, transportation, processing or sales can be some of the reason of increased heavy metals content in sample. Consumption of these metals for prolonged period has long term destructive effects on human health. Strict regulatory measures aim to minimize risk of contaminants to public health. And a proper awareness among the consumers regarding possible outcomes of consuming contaminated food items is necessary.

Index terms: heavy metals, contaminants, permissible limit, sample, health, toxic

1. INTRODUCTION

Cereals are considered as a major source of food in many countries as they serve as a staple food for many people. They are considered essential for a balanced and healthy diet and a everyday consumption for a 4 to 6 portions of cereals derived products is recommended because of their richness in fibre, trace minerals and vitamins, and especially rich in carbohydrates (Doe et al, 2031). Maize (*Zea mays*) is an annual cereal crop and the third staple food after wheat and rice. It is a multipurpose crop because every part of it has economic value. The seed, cob, tassel, leaves and stalk can be used in producing various varieties of food and non food products. The main source of food of maize is the seed part, which can be consumed in processed or unprocessed form (Kumar & Jhariya, 2013; Gwirtz JA and Garcia-Casal MN, 2014; IITA, 2001). Since maize is very nutritious, its processing provides a variety of derivatives that are used for both the humans and animals feed, and one of the main forms of its products is the maize flour. Maize can be roasted, cooked and its flour is used in many food products (Kelte I et al, 2018). It is generally used to process into products like corn-meal, grits, starch, flour, tortillas, snacks and breakfast cereals, but its flour form is basically used to make chapattis or flat breads mainly consumed in the households, and eaten primarily in few Northern India (Mehta & Das, 1999).

In India, the main maize crop states are Uttar Pradesh, Bihar, Rajasthan, Madhya Pradesh, Punjab, Haryana, Maharashtra, Andhra Pradesh, Himachal Pradesh, West Bengal, Karnataka and Jammu & Kashmir, they account a 95% of the national maize production (Millind & Isha, 2013).

Cereals do also contain heavy metals which are not vital for the organisms, and break in through the ground, the air and through water (Golia EE et al, 2008). Heavy metals are the components of natural system, but various human activities have increased the quantities and the distribution of such metals in site (water bodies) and in atmosphere (Rajaganapathy V et al, 2011). Food toxicity can be caused by trace metals as a result of irrigation by means of contaminated water, or by the addition of fertilizers and metals based pesticides, industrial emission, transportation, harvesting processes, storage, sales/marketing and also local food processing methods. Metals intake especially to human food chain can also be done through food processing, as almost all the foods consumed locally are milled before they are consumed, so they could reach a significant stage where it can be a fatal with few exceptions (Jarup L, 2003; Salama and Mohamed, 2005; Bempah et al, 2011). The usage of such milling machines to produce locally food stuffs has become economically attractive in both urban and rural settings (Dallatu YA et al, 2013), different methods used for grinding of seeds into flour are done using blenders, mills and crushers, such machines while working, rub plates against each other to crush the food particles

into powder or paste and hence leads to various wear and tear process thereby introducing contaminants matrix into milled food stuffs (Ebenezer O et al, 2018)

These heavy metals are amongst the major contaminants to food supply and hence may be considered as the major setback to environment as their accumulation poses a direct threat to human health. They are highly toxic when present in high concentration in the system and even at a low concentration the long term consumption of metal contaminated food could be toxic and when they accumulate above the maximum levels, they then to be highly injurious to health (Radwan and Salama, 2006; Turkdogan et al, 2003; Rajaganapathy V et al, 2011). Acute toxicities of such metals can affect multiple organ system, endocrine system, kidneys, hair while chronic toxicity are the conditions that has been developed after over long period from chronic exposure, symptoms can be an increased risk of cancer (skin, kidney, lung, liver and kidney), weak mutagens, disruption of gene expression, deregulation of growth & developmental cells, etc. In general, metal toxicity can affect various organs, and can lead to arterial obstruction, hypertension, gastrointestinal tract infections, renal failure, liver dysfunction, neurological disorders, decreased bone mineralization, decreased lung function, anaemia an many more (Jang et al, 2011; Arita et al, 2009; Martinez-Zamudio et al, 2011).

Maize flour is consumed regularly by the consumers in form of chapatis and bread and metals tend to bioaccumulte in the human body, and there have been little information on the levels of heavy metals in the maize flour. So, the aim of this study was to determine the selected heavy metals (aluminium, arsenic, cadmium, lead and mercury) in maize flour brought from local markets of Bareilly city, Uttar Pradesh with the view of knowing the potential health effects associate with the consumption of maize flour in consumers.

2. MATERIALS & METHODS

2.1 Description of sampling site:

A survey was conducted among households of Bareilly district in Uttar Pradesh, a northern city; that showed information regarding consumption of maize flour was also high after wheat flour and rice among cereals. Maize flour is consumed by most of the families on daily and weekly basis. Bareilly is a city located nearby Ramganga River which flows from west to south. A number of industries and mills discharge their wastewater into this river and 'nallah's' of the city, and this polluted water leaches down to the soil and contaminate the crops and ground water. There are several local milling shops to grind seeds into flours in the city. The distribution/sales pattern of food stuffs is mainly on street or roadside shops.

2.2 Sample collection:

Maize flour was brought form four different (north, south, east and west) local markets (local shops-mills) sites of the Bareilly city. Sample was packed safely and neatly and sealed in polyethylene zip lock bags.

2.3 Sample preparation and metal analysis:

Sample of maize flour was weighed, and heated/dried in oven for several hours at a certain degree of temperature (70°C), cooled and homogenized. Afterwards, 0.5g of sample was digested by a wet digestion process at 80°C, several additions of mixture of concentrated HNO_3, $H2SO_4$ and $HClO_4$ in the ratio of 5:1:1 was made until the digest was colourless. After cooling, it was filtered by using Whatman No. 42 filter paper and then filterate was diluted up to 50ml with distilled water and stored in bottle for metal analysis. Blanks and calibration solution were also prepared (Allen SE, 1986).

Further, this bottled solution of sample was used for analyzing five heavy metals viz. aluminium, arsenic, cadmium, lead and mercury by atomic absorption spectrophotometer. Concentration of each metal was calculated on dry weight basis in mg/kg. These obtained concentration levels of five metals wee respectively compared with the standard allowable limits set by national/international bodies.

3. RESULTS AND DISCUSSION

3.1 Concentration of aluminium, arsenic, cadmium, lead and mercury in maize flour sample collected from Bareilly city local market:

The result of the analysis of five metals mean concentration namely Al, As, Cd, Pb and Hg analyzed in maize flour sample from atomic absorption spectrophotometer is shown in Table 1.

Table 1: Mean concentration of estimated heavy metals in maize flour sample in (mg/kg)

Sample	Aluminium (Al)	Arsenic (As)	Cadmium (Cd)	Lead (Pb)	Mercury (Hg)
Maize flour (*Zea mays*)	**1.210±0.010**	**0.390±0.010**	**0.200±0.010**	**0.300±0.010**	**0.200±0.010**

Results are expressed as mean ± SD of the three replicate analyses. The outcome of the analyses showed that concentration of the heavy metals to be Al (1.12 mg/kg), As (0.39 mg/kg), Cd (0.2 mg/kg), Pb (0.3 mg/kg) and Hg (0.2 mg/kg) for maize flour sample collected from local market sites of Bareilly city. This shows that aluminium has the highest concentration in sample followed by arsenic, lead, cadmium and mercury with the distribution pattern of Al>As>Pb>Cd/Hg.

Figure 1 show their comparison with the standard permissible limits (Awasthi SK, 2000) and found that all the heavy metals analyzed for maize flour were exceeding the allowable levels which means that consumption of this sample is may pose threat to the health status of the consumers in this study district. There are very leas studies in context to metals concentration in maize flour, but some researchers have reported metals status in different cereal grains or leaves, grown in fresh water and contaminated water. An assessment was done in cereals collected from local market of Ambo city, Ethiopia which showed Pb and Cd was not detected in maize (Tegegne WA, 2015). Another study was done on maize grains and leaves collected from different agro ecological zones in Uasi Gishu country, showed concentration of Cd and Pb as 0.03 mg/kg and 0.33 mg/kg in maize grains, which indicates cadmium was slightly lower than the present study and lead was quite similar to present study (Akenga T et al, 2017). Akenga T et al reported Pb (0.324 mg/kg) and Cd (0.225 mg/kg) concentrations in maize grain which depicts grain concentrations were slightly higher than the flour in present study.

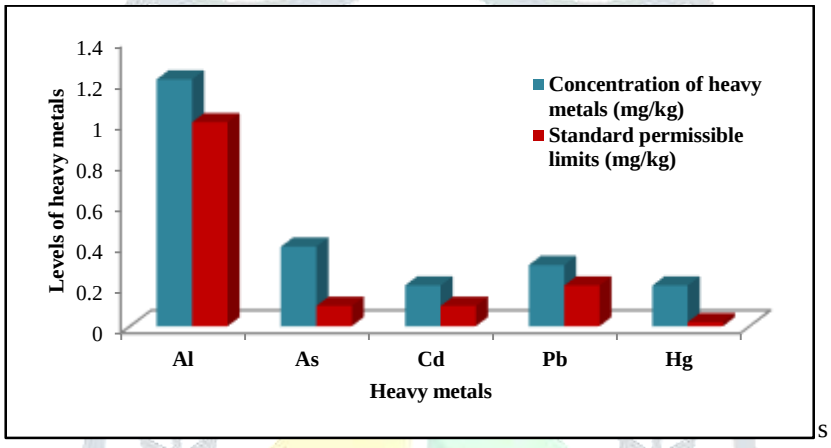

Figure 1: Mean heavy metals in maize flour sample (mg/kg)

3.2 Possible health impacts on human health:

There can be quite a few factors responsible for the severity and health outcomes of toxic metals exposure, which may take account of the category and variety of element, routes of exposure, duration of exposure and person's individual vulnerability (CDC, 2012).

Aluminium is one of the most ubiquitous elements found in nature and occurs naturally in most food and water. Aluminium concentrations when increased in blood and some tissues like in brain, muscles, bone, kidney and lungs can neuro-generative disorders, Alzheimer's disease; bone disease and microcyticanaemis, hematopoietic, skeletal, respiratory, and immunologic and other health impacts.

Arsenic occurs in nature in the atmosphere as organic and inorganic form. Drinking water and food containing arsenic is the most common route of exposure. Else sea food contains highest amount of arsenic. Once absorbed by body cells its binds to haemoglobin and is fastly circulated to the liver, kidneys, heart, lungs, nervous system, gastrointestinal tract and other parts and further can lead to anaemia, neuropathy, liver toxicity, skin lesions, hyperpigmentation, lesions, several types of cancers. Severe exposure of arsenic can lead to loss of circulation of extremities, which further can grow to be necrotic and gangrenous (black foot disease) (ATSDR, 2007; Ibrahim et al, 2006).

Cadmium has no favorable role in human metabolism; but its exposure can serve as a larger threat to human health. It can be ingested and absorbed in body through food and water (Thevenod et al, 2013; Sigel et al, 2013).Cadmium is considered as a extremely toxic non-essential. Even at low concentrations, Cd can be harmful to organisms. Its poisoning could lead to renal damage, cancer; bone disorders (Tegegne WA, 2015).

Lead is one of the frequent reported toxic metals and the leading reason of single metal toxicity among children (Bronstein et al, 2011). A child absorbs lead more efficiently than the adult (Abelsohn et al, 2010). Its toxicity may cause musco-skeletal, ocular, renal, neurological, reproductive, immunological, and developmental effects (Ambedkar and Muniyan, 2012), age related bone loss, fracture, hypertension, behavioral changes.

Mercury can cause pervasive toxicity and symptoms in quite a lot of organs such as nervous, cardiovascular, gastrointestinal, leading to tremors, memory deficits, loss of coordination, arterial obstruction, stroke, atherosclerosis,

heart attacks, inflammation, nausea, diarrhoea, ulceration, dermatitis, auto immune disorders and many more (Adeti PJ, 2015)

4. CONCLUSION

This paper concludes that consumption of the sample having higher levels of heavy metals is a threat to health of consumers. The concentration of Al, As, Cd, Pb and Hg were all above the recommended levels. Cereals are the most important constituent of their diet; they are highly consumed as it provides all essential nutrients to the body. But due to high consumption of maize flour, the presence of heavy metals at high concentration would be a health risk. Reasons can be based on the soil in which maize crop was grown, use of contaminated water through industrial emitted or drainage effluents sites, usage of metal based pesticides or fertilizers and can be the milling technology employed in making of the flour.

So a regular monitoring for these metals in food is vital to ensure consumption of safe food that avoids bioaccumulation in the food chain. Consumers should be made aware of the possible threats caused by the intake of contaminated food items in their diet and their health outcomes.

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D.S. did the experimental work, analyses of the data and further wrote the manuscript while G.B. edited it. Both the authors have thoroughly read, revised and approved the manuscript.

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