Original Research Article

Effect of Milling Equipment on the Level of Heavy Metal Content of Foodstuff

ABSTRACT

Aims: This study evaluated the concentration of heavy metal contamination of foodstuff by selected milling equipment (burr mill and hammer mill).

Study design:

Place and Duration of Study: Samples collected from a market in Akungba-Akoko Southwestern Nigeria; processed and analysed at Prof. Julius Okojie Central Research laboratory, Federal University of Technology, Akure, Nigeria between January and April, 2018.

Methodology: Selected food samples (yam, plantain, wheat, guinea corn, beans, soya beans, maize and cassava) were sourced randomly from a local market in Akungba-Akoko, Ondo State, washed with distilled deionized water, sun-dried and milled into their resulting flour product; a corresponding acid digested sample served as control. Heavy metal analysis of copper, iron, lead, cadmium, chromium and zinc were carried out using atomic absorption spectrophotometry [AAS].

Results: Results revealed that of the milling equipment used in this study, the burr mill introduced the maximum concentration of contaminant into food, while the hammer mill recorded level of contaminant in minimal doses. Fe was predominant in all the milled samples; the metallic composition of the mills being a contributory factor to the level of contamination. Cd was below detection limit in the analysed samples. Pb and Cr were found to be comparatively higher than the permissible limit of 0.3mg/kg and 2.3mg/kg respectively recommended by WHO/FAO. The concentration range of Cu and Zn were within acceptable limit and presents no risk of intake.

Conclusion: The higher concentration level of metals recorded in the milled samples in comparison to the control shows a level of contamination introduced by the mill.

Keywords: [Metals, millimg, foodstuff, contamination}

1. INTRODUCTION

Metal release from equipment contributes a substantial proportion to total contamination in humans. Food processing methods involve many operations, which include coarse grinding of food material called size reduction. Grinding of foods (size reduction) as part of food processing operation in the past was completely done by using traditional methods, which include stones, bricks, pestle and mortar [1]. These methods were effective but rather slow, time consuming and unhygienic [2]. As the need of the people for food increased, new technologies were developed and modern methods of grinding foods were invented such as blenders, mills and crushers. These mills make use of toughened steel, stones and hardened steel, toothed discs [1, 3]. When these machines are in operation, the plates revolve and rub against each other as the food stuff is being crushed into powder or paste. The sliding process of the plates generates friction which leads to wear and tear thereby introducing contaminants into the milled foodstuffs [4]. Common contaminants in processed (grinded) food item are most likely from the metal components of the mill, the soil, the paints used as coat for machine components, bushings, bearings, grease and grinding discs that originate from ageing and wearing [2, 5, 6]. [7] reported that improvements in the food production and processing technology have increased the chances of contamination of food with various environmental pollutants, especially heavy metals.

Heavy metals are common components of natural systems, but man's activities have increased the quantities and distribution of these metals in the site (water, rivers, lakes, streams and seas) and in the atmosphere. Heavy metals are highly toxic when present in these systems in high concentration and when they accumulate above maximum levels in any physiological system, they tend to be highly injurious to health [8]. The toxicity of heavy metals is one of the major current environmental health concerns and potentially dangerous because of bio-accumulation through the food chain [9]. The uptake of these heavy metals especially into the human food chain is done through the food processing and they have harmful effect on human health [10]. The presence of heavy metals in food is highly significant for they are capable of causing serious health problem depending on the nature of the heavy metal. They do this through interfering with the normal biological functioning of the human health. The heavy metals linked most often to human poisoning are lead, mercury and arsenic. These metals tend to accumulate in the brain, kidneys and immune system where they can severely disrupt normal function [11, 12, 13].

The use of milling machines to locally process foodstuff is all over the place and has become an economically attractive activity both in the urban and rural settings [14]. However, constant analysis of the potential metal contamination in these products by the milling equipment is lacking. Therefore, this study focused on how milling equipment contribute to the levels of heavy metals in food materials processed in them, and the possible risk of consuming such foods.

2. MATERIAL AND METHODS / EXPERIMENTAL DETAILS / METHODOLOGY

Food samples (yam, plantain, wheat, guinea corn, beans, soya beans, maize and cassava) were procured from a market in Akungba-Akoko, a town in Ondo State, south-western Nigeria and stored in polyethylene bags. Akungba-Akoko lies on longitude 5°44' E and latitude 7°28' N of the equator. Its climate is tropical with rainfall varying from 1100-2000 mm per annum and average temperature of between 26°C and 28°C. Host to a university, the population of the town, according to a 2006 national census, the population of the town was 15,579 [15]. The market from which the food samples were collected is a major market in the town where indigenes and students patronise. Some of the food materials are locally grown and processed while others like beans, wheat and soya beans come from northern Nigeria with Akungba-Akoko being one of the link towns on the only highway connecting northern and south-western Nigeria.

Fresh yam tubers, cassava tubers and plantain fingers (agbagba cultivars) were washed to get rid of sand, dirt and other extraneous materials. Thereafter, they were peeled, thinly sliced, treated with distilled deionized water and sun-dried to remove the moisture content. The cereals (wheat, guinea corn, beans, soya beans and maize) were cleaned by picking out sand, stones and other abrasive materials, and then winnowed to remove dusts and other light particles. The samples were also washed in deionized water and sun-dried. The cleaned samples were divided into three groups. A group was directly digested to serve as control while each of the remaining two groups of the sample was milled separately with one of the following milling equipment:
Burr mill, and
Hammer mill
The milling machines were thoroughly washed with distilled water before use in order to ensure that they were free from all forms of contaminants such as sludge from previously grinded substances. The flour samples were sieved for uniform particle size and stored in a well-labeled airtight polyethylene bag prior to analysis.

A

B

0.5g of each samples were weighed using analytical balance into a digesting tubes and 10ml aqua-regia solution were added and heated in a digestor at 700^{0}C until the fume of nitric acid and a clear solution obtained. The resulting solutions were filtered and the filtrate made up with distilled water into a 50ml standard volumetric flask. The digests were analyzed for metals using Atomic Absorption Spectrophotometer manufactured by buck scientific, model VGP210. Prof. Julius Okojie Central Research laboratory, Federal University of Technology, Akure, Nigeria

3. RESULTS AND DISCUSSION

Table 1 and Figures 2 – 9 summarize the comparative concentration of the atomic absorption spectrophotometric analysis of heavy metals present in food samples processed with the burr mill and hammer mill. The concentration of metals in the control represents the true level of metals in the foodstuffs. Generally, the increase in concentration of the heavy metals in the samples from the milling equipment over the control represents the amount of heavy metal added by the various mill.

Table 1: Comparative concentration of the selected metals in foodstuffs

Samples	Methods	Elements (mg/kg)					
		Cu	Fe	Pb	Cd	Cr	Zn
Yam flour	B.M	2	130	ND	ND	2	8
	H.M	4	69	8	ND	3	13
	Control	17	35	ND	ND	5	11
Plantain flour	B.M	6	105	ND	ND	5	7
	H.M	ND	20	ND	ND	13	6
	Control	ND	205	6	ND	4	6
Wheat flour	B.M	ND	151	2	ND	7	27
	H.M	2	64	ND	ND	4	15
	Control	ND	49	ND	ND	7	26

Guinea corn flour	**B.M**	ND	209	ND	ND	9	26
	H.M	3	49	ND	ND	16	25
	Control	8	41	ND	ND	3	20
Beans flour	**B.M**	5	141	ND	ND	2	40
	H.M	2	136	ND	ND	12	40
	Control	5	105	ND	ND	7	29
Soya beans flour	**B.M**	9	119	ND	ND	14	34
	H.M	10	130	ND	ND	9	42
	Control	1	46	ND	ND	2	20
Maize flour	**B.M**	ND	368	ND	ND	8	18
	H.M	2	50	ND	ND	2	22
	Control	ND	237	ND	ND	14	16
Cassava flour	**B.M**	2	65	ND	ND	7	14
	H.M	ND	54	ND	ND	17	12
	Control	ND	99	18	ND	9	12

ND - Not deposited
B.M - Burr mill
H.M - Hammer mill

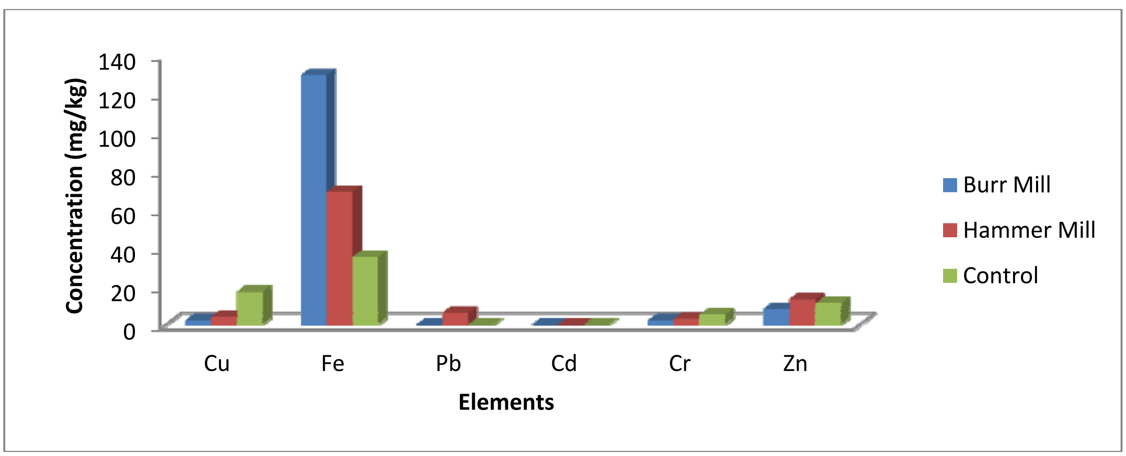

Figure 2: Comparative concentration of the selected metals in yam flour

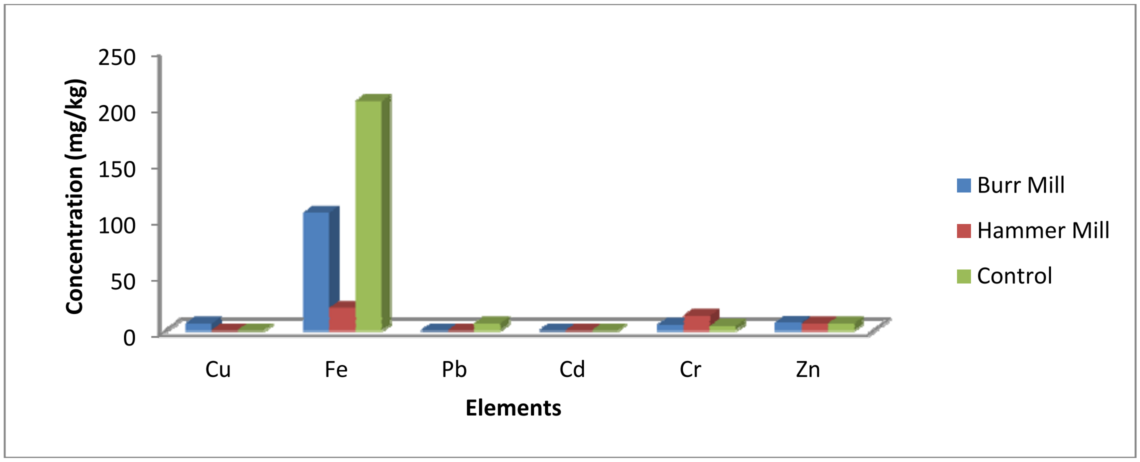

Figure 3: Comparative concentration of the selected metals in plantain flour

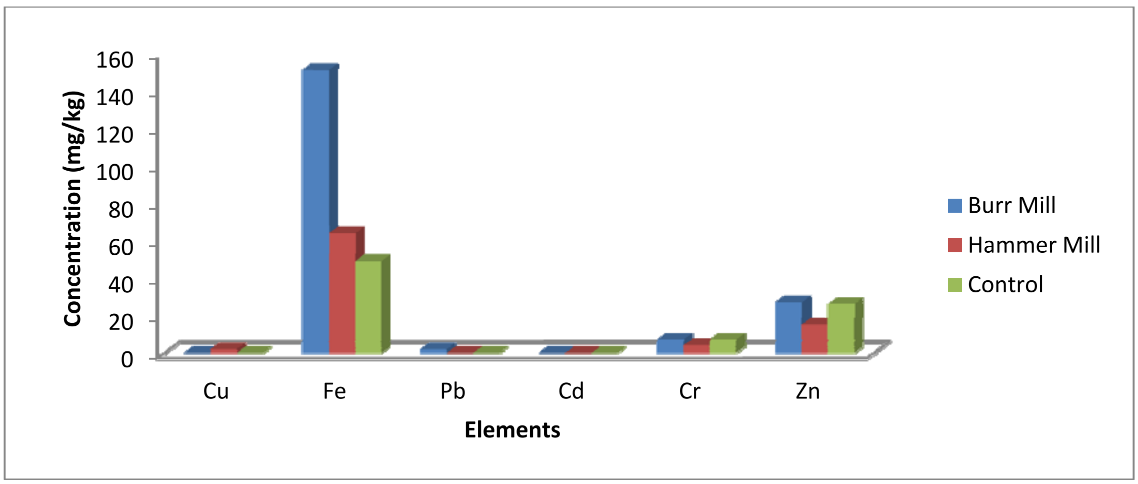

Figure 4: Comparative concentration of selected metals in wheat flour

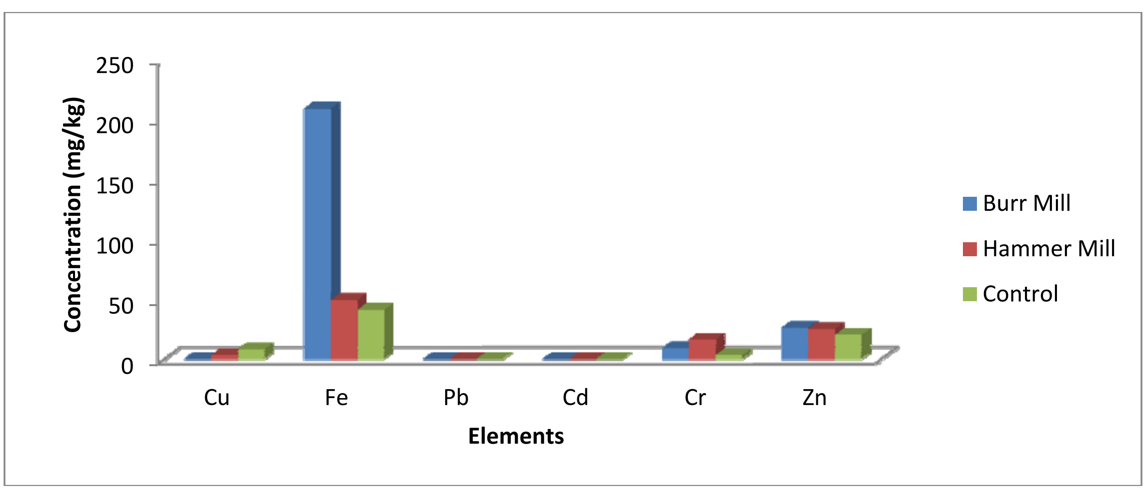

Figure 5: Comparative concentration of selected metals in guinea corn flour

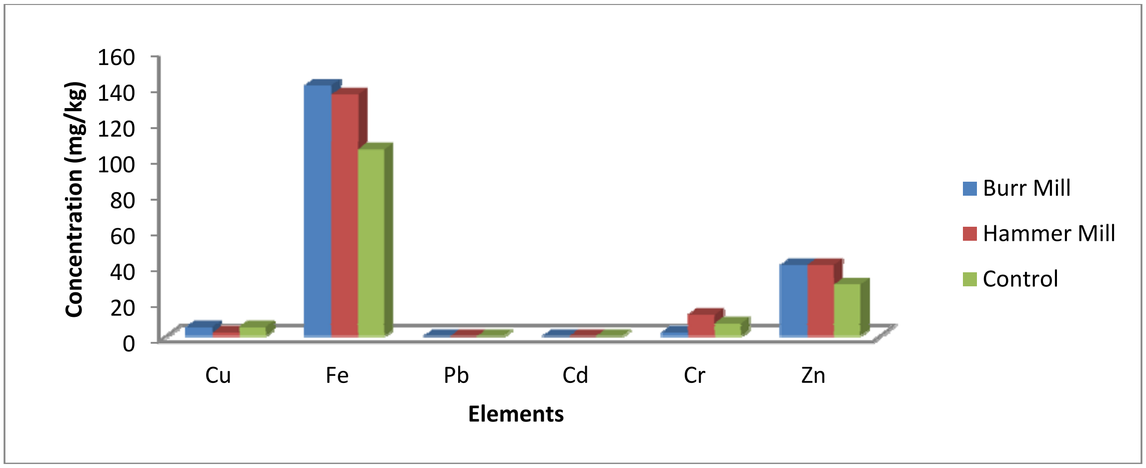

Figure 6: Comparative concentration of selected metals in beans flour

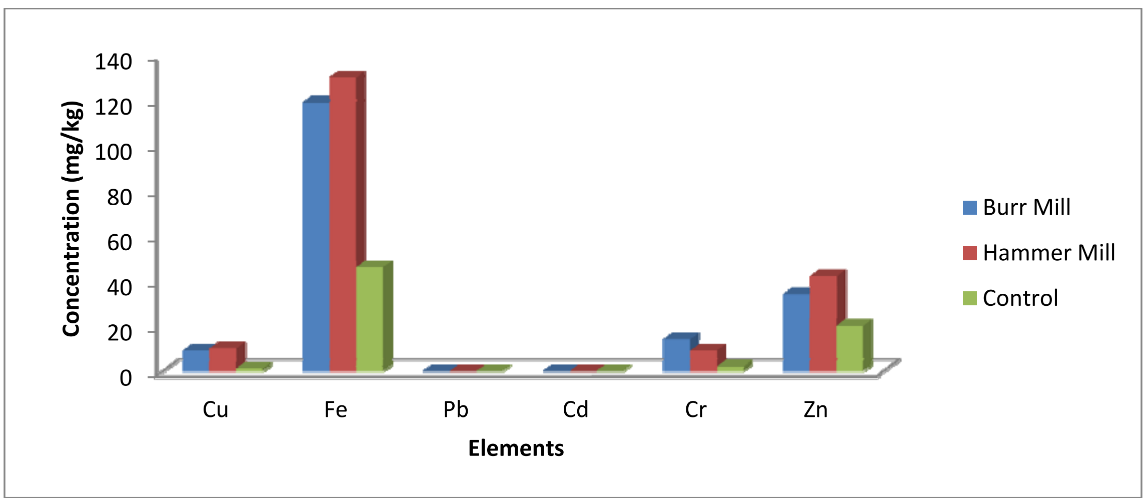

Figure 7: Comparative concentration of selected metals in soya beans

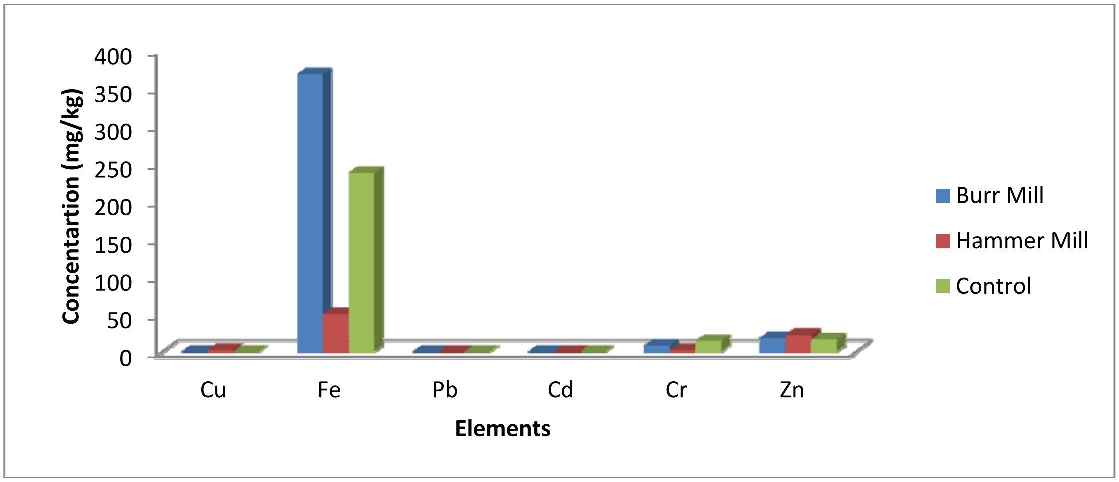

Figure 8: Comparative concentration of selected metals in maize flour

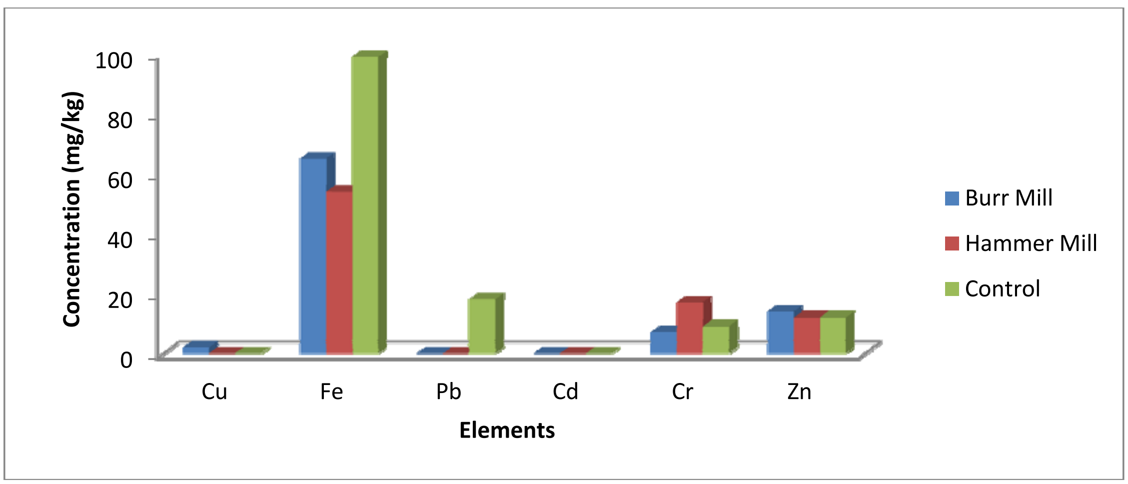

Figure 9: Comparative concentration of selected metals in cassava flour

Table 1 indicated that the concentration of Cu in the food samples ranged from being below detection limit to 9 mg/kg and 10 mg/kg in the burr mill and hammer mill respectively, indicating slight variations from its true value. Excessive concentration of Fe was obtained in the processed food samples in the burr mill with a mean concentration of 161 mg/kg; this indicated that the grinding discs utilized for size reduction leached considerable amount of contaminant into the flour. Grinding discs have poor wear resistance because of the materials used for their production [5, 16, 17]. During grinding of the flour, the shear force applied by the machine caused the grinding disc to rub against each other, and possibly caused wear and tear on the grinding disc. This wear and tear of the grinding disc was might be responsible for the high iron contaminant in the food. Pb was detected in the plantain and cassava control sample in disturbingly high amounts above the permissible limit of 0.3 mg/kg set by WHO/FAO. This high concentration might have emanated from growing the food crops on lead-contaminated soil. Lead is a cumulative poison which can cause profound and permanent adverse health effects, particularly affecting the development of the brain and nervous system. It can also cause miscarriage and stillbirth in pregnant women [18]. This endorsed an investigation into the agricultural area. The milling equipment also introduced some concentration of Pb contaminant into the yam flour and wheat flour, which could have deleterious effect on human health when consumed. Cd was not detected in any of the analysed food samples. This indicated a consistent result suggesting zero risk of contamination from the milling equipment. The level of Cr in the control samples were slightly above the recommended limit of 2.3 mg/kg and the milling equipment further altered the composition in varying amounts. The level from the burr mill correlated with the control with a mean concentration of 6 mg/kg while the hammer mill added a mean concentration of 9 mg/kg Cr contaminant. Zn concentration in the milled samples was in relative proportion in comparison to the control. A mean concentration of 21 mg/kg was deposited by both milling equipment, the value was within the permissible range and does not pose any risk of Zn intoxication. Zinc is essential to all organisms and has an important role in metabolism, growth, development and general well-being [19].

4. CONCLUSION

This study highlights the contribution of milling equipment to heavy metal contamination during the processing of food products. This is evident in the higher concentration level of metals recorded in the milled samples in comparison to the control. The milling process is a critical point in the production of food, and could determine the quality of the food presented to the consumers. The study revealed that milling foodstuffs using the milling plates released lead, nickel and iron metal into the foodstuffs. Dry milling was reported to introduce higher level of iron, lead and nickel contamination into foodstuffs than wet milling; thus making wet milling a “easier and safest” method than dry milling. Therefore, lower levels of heavy metals should be reasonably pursued by using good manufacturing and processing practices.

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