European Journal of Nutrition & Food Safety

14(2): 15-27, 2022; Article no.EJNFS.86434
ISSN: 2347-5641

Comparative Study of Iron, Manganese and Nickel Contamination Potential of Disc and Hammer Milling Equipment and their Toxic Effect on Rat Kidney

Blessing H. Isa [a*], Jonathan D. Dabak [a], Umar Umar Dalhatu [a] and Panshak Kumbet Daman [a]

[a] *Department of Biochemistry, University of Jos, P.M.B 2084, Jos, Nigeria.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/EJNFS/2022/v14i230477

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/86434

Received 15 February 2022
Accepted 25 April 2022
Published 02 May 2022

Original Research Article

ABSTRACT

Aim: To investigate the effect of hammer and disc milling equipment on the levels of Iron (Fe), Manganese (Mn) and Nickel (Ni) contents in maize (Zea mays) flour and the consequent impact on the kidney of albino rats.
Study Design: The rats were randomly divided into groups of five rats per group. Six of the groups were fed with maize flour milled with a hammer mill, while the other six groups were fed with maize flour milled with a disc mill, and the thirteenth group was fed with crushed flour in a mortar and pestle as a control. The rats were sacrificed by decapitation under anesthesia on the 14th and 28th days.
Place and Duration of Study: Departments of Biochemistry and Histology laboratories of the University of Jos, Nigeria, between, January to June, 2021.
Methodology: For six days, a portion of the maize grains was milled with a hammer mill, another with a disc mill, and a third fraction was crushed into flour with a wooden mortar. The inductive coupled plasma mass spectrophotometric method was used to determine the levels of Fe, Mn, and Ni in maize flour. To avoid lysing the blood, blood samples were carefully collected by allowing it to run down the test tube's wall. The blood was allowed to coagulate at room temperature before being centrifuged and the serum collected and frozen until it was time for biochemical analysis. The kidneys of the rats were excised, cleaned, and preserved in chloroform until histological examinations were required.

**Corresponding author: Email: blessinghjoisa@gmail.com;*

Results: The results show that Fe (325.16 ± 30.00 mg/kg and 205.05 ± 30.20 mg/kg) and Ni (20.92 ± 5.92 mg/kg and 18.00 ± 2.70 mg/kg) levels were extremely high in both disc and hammer milling machines. The Fe and Mn values in disc milled maize flour were higher than those in hammer milled maize flour. Rats in all groups had significantly higher serum urea, creatinine, K+, Na+, and Cl- levels than the control group. The kidney tissues of all the rats in the control and hammer-milled flour groups were normal, except for group 1 of the disc mill, which showed mild damage, according to the histopathological analysis.

Conclusion: The Day 1 group fed with disc-milled flour showed a dense cast, atrophy, and nuclei loss in their kidney tissue. According to the results of the study, hammer milled maize flour is less harmful than disc milled maize flour, as shown by kidney histopathology.

Keywords: Iron; manganese; nickel; contamination; maize flour; hammer mill; disc mill decapitation; histopathology.

1. INTRODUCTION

Food processing methods involve several operations, which include size reduction of the food stuff by milling (grinding) into coarse or fine particles. Grinding of foodstuff like dry grains in the past was done by using traditional methods, which include stones, bricks, wooden mortars and pestle. These methods were effective but rather slow, energy sapping, time consuming and unhygienic. 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 [1].

Commonly used milling machines in Jos include Hammer and Disc (plate) Mills. Hammer mills consist of a series of hammers (usually four or more) hinged on a central shaft and enclosed within a rigid metal case. It produces size reduction by impact. The materials to be milled are struck by these rectangular pieces of hardened steel (ganged hammer) which rotates at high speed inside the chamber [2]. A Disc mill is one of the milling machines that can be used for reducing material size. This apparatus has been widely used in agriculture [3]. Disc mill is a combination of Hammer Mill and Roller Mill technologies. It is worked by applying punches and pressures in reducing sizes of materials [4]. The advantages of disk mill are: The final size distribution is relatively homogenous, the milling process is not time-consuming, and the process can be done continuously [5].

Maize (Corn) also called Zea mays is a cereal known and consumed by humans in most parts of the world. It is the cereal with the highest production rate globally and is also used for livestock feed and fuel [6]. It can be consumed directly(as cooked or roasted corn) or indirectly by further process-ing alone or alongside other food items as corn meal which bears different names and procedure of making in different parts of the world. As part of its processing, maize can be milled or grinded in dry, paste and wet form depending on the need and meal.

It is also largely consumed in sub-Saharan Africa for meals of different forms. It is a good source of carbohydrates and vitamin B-complex. It contains vitamins C, A, and K together with a large amount of beta-carotene and fair amount of selenium that help to improve thyroid gland. The composition of maize kernel are vitamin C, vitamin E, vitamin K, vitamin B1 (thiamine), vitamin B2 (niacin), vitamin B3 (riboflavin), vitamin B5 (pantothenic acid), vitamin B6 (pyridoxine), folic acid, selenium, N-p-coumaryl tryptamine and N-ferrulyl tryptamine. Potassium is a major nutrient present which has a good significance because an average human diet is deficient in it [7].

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 [1]. These contaminants include heavy metals and other potentially toxic substances like grease and paintings used to cover the outer surface of the metals. Heavy metals can be defined as a group of metals and metalloids having atomic density greater than 4g/cm^3, some of which at very low levels, can be useful in metabolic activities in the body but as their concentrations exceed permissible levels, they constitute varying degrees of health hazards to man [8]. Examples are iron, manganese, nickel, zinc, lead, copper, cadmium, and chromium. Ingestion of heavy metals through food has been shown to have serious consequences on health and thereby economic development, associated with a decline on labour productivity as well as increased direct costs of treating illnesses such as kidney diseases, damage to the nervous system, diminished intellectual capacity, heart disease, gastrointestinal diseases, bone fracture, cancer and death [9]. Generally, heavy metals disrupt basic metabolic functions in human body in two ways: firstly, they disrupt the functioning of vital organs and glands such as the brain, kidney, or liver; they prevent uptake of nutrients that are essential for biological functions [10].

However, with the current emphasis on eating more healthy diets which should not contain toxic metals, it is very essential to assess the chemical composition and heavy metal concentration in maize flour that is popularly consumed by Nigerians. This study is aimed at investigating the effect of hammer and disc milling equipment on the levels of some heavy metals contents in *Zea mays* flour and the consequent impact on the kidney of albino rat.

2. MATERIALS AND METHODS

2.1 Study Area

Maize cobs were obtained in sufficient number from farmlands around Mandung, Maikatako community of Bokkos Local Government Area in Plateau State, which had been left to dry out while still on their stalks.The cobs were de-husked, shelled, and the seeds sundried before being stored in plastic containers for further analysis.

2.1.1 Milling machines

Both hammer and disc milling machines privately owned by individuals from Dadin-kowa first gate Jos-south, Plateau state were used, particularly when the plates have been recently sharpened up to the time the plates were needed to be changed

2.1.2 Mortar and pestle

Wooden mortar and pestle were used to crush some of the maize and used as control for the experiment.

2.1.3 Grinding plates

The Used grinding plates from hammer and plate mill were obtained and thoroughly washed with de-ionized water after which 1.0g was cut out for elemental analysis of iron, manganese and nickel using Atomic Absorption Spectrometry Techniques.

2.2 Methods Applied

2.2.1 Experimental rats and design

Sixty-Five (65) male albino rats with average weight of 262.50g were obtained from the Animal House unit, University of Jos. The rats were housed in well-ventilated plastic rat cages and fed with standard rat pellet and tap water ad libitum throughout the study. Thereafter, the rats were randomly divided into thirteen groups of five rats per group as follows:

Group 1-6: Rats fed with 2g each of the maize flour milled with hammer mill
Group 6-12: Rats fed with 2g each of the maize flour milled with disc mill.
Group 13: Rats fed with the 2g of the crushed maize flour daily which served as the control, for a period of 28 days
On the 14th and 28th days, the rats were sacrificed by decapitation under anesthesia.

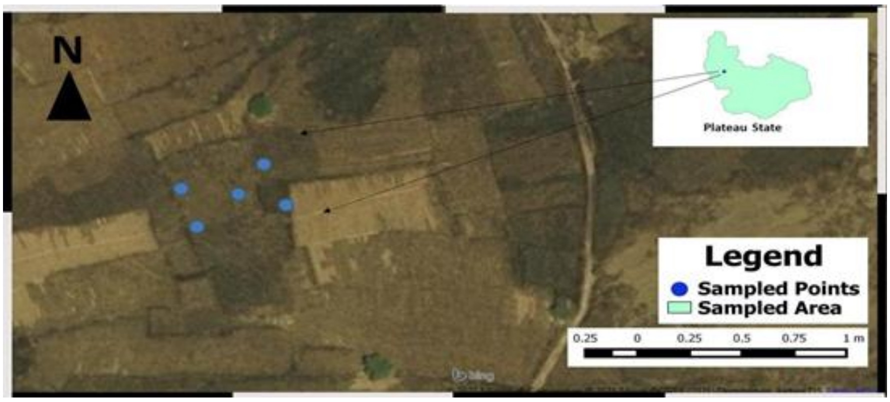

Fig. 1. Satellite image showing maize sample location within the study area

2.2.2 Processing of maize grains into flour

I. Preparation: The interior of the milling machines was thoroughly washed with distilled water in order to ensure that they are free from previously ground material. The mortar and pestle were equally washed with distilled water for the same purpose. The machines and mortars were air dried before the milling processes began.
II. Crushing: For three days,1 kilogram of maize was crushed using a dry mortar and pestle at a five-hour interval until it was powdered.
III. Milling: 3kg of maize seeds were processed in hammer milling and disc milling machines till maize flours were obtained. Samples were taken every day for 6 days for both the hammer and disc milling machines.
IV. Sieving: The maize flour samples obtained as described by Ebenezer [11].

2.2.3 Analysis of maize flour and soil samples

2.2.3.1 Digestion of the maize flour and soil samples

0.5g of maize flour and soil samples were digested according to the Acme laboratory's method and methodology in Vancouver, Canada. The milled maize samples were all leached in cold nitric acid before being digested in a hot water bath. After cooling, each sample was given a modified Aqua Regia solution containing equal parts concentrated HCl, HNO3, and DI H2O to leach in a hot water bath heating block.Dilute HCl was used to label samples, which were subsequently filtered using Whatman filter paper No.42.

2.2.3.2 The Determination of metal contaminant

The Nickel, Iron and Manganese metals in the digested samples were determined according to the manual of each instrument carried out in Acme laboratory, Vancouver, Canada. The concentrations of Nickel, Iron and Manganese metals in the digested maize flour were determined using NexION 300 Inductively Coupled Plasma Mass Spectrometry (ICP-MS).

2.2.4 Digestion protocol adopted for the grinding Plates

Each plate sample was sliced into 1.0 g and immersed in 37 percent HCl for 30 minutes before being rinsed with deionized water.This was done to prevent contamination from outside sources due to handling and dust exposure. The method of VARIAN was adopted afterwards [12].

A B C

Fig. 2. Grinding methods: (A) mortar and pestle; (B) Hammer mill and (C) Disc Mill

A B

Fig. 3. Grinding Machine Discs: (A) Hammer plates; (B) Disc plates

2.2.5 Determination of urea, creatinine, Na+, K+, Cl- and histopathological analysis of the kidney

Serum urea was determined by the method of Fawcett and Scott [13], using Randox commercial kit, while Serum creatinine was determined by the method described by Tietz [14], using Randox commercial kit while Serum Sodium ion concentration was determined by the method of Trinder [15] while Serum Potassium were determined using the method described by Egbung [16]. Serum Chloride was determined by Mercuric Nitrate titrimetric method of Skeegs and Hochestrasser [17]. The rats were sacrificed by decapitation after anaesthesia. Kidney excised, washed with ice cold saline to remove blood and stored in saline until required for histopathological study.

3.2 Statistical Analysis

The data were expressed as mean (of 3 replicates) ± SEM. It was then subjected to statistical analysis using the Graphpad prism version 9.0. All significant differences were determined by one-way Analysis of Variance (ANOVA) and Post Hoc. Multiple comparisons were done using Tukey -Kramer multiple comparison test. The significance level was set at $p<0.05$, $p<0.0001$ and $p<0.01$ respectively

3. RESULTS

3.1 The Mean Concentration of Fe, Mn and Ni metals in the Disc and Hammer Milling plates used in the Experiment

The elemental concentrations of the grinding plates of both machines are presented below in Fig. 4. The result showed that Iron had the highest concentrations of (325.16 ±1.80mg/kg and 205.05 ±1.83mg/kg) in the plate's analysis for both disc and hammer mill while manganese had the lowest concentration of (6.30±0.31 mg/kg and 5.51±0.41 mg/kg) respectively for both milling plates. Nickel had the second highest concentration in both plates of the hammer and disc mill (20.92±1.40mg/kg and 15.3 ±1.30mg/kg).

3.2 The Mean Concentration of Fe in the Maize Flour Samples Obtained from Hammer and Disc Milling Machine for a Period of 6 Days

The concentration of iron in mg/kg in the maize flour samples obtained from hammer and disc milling machine for a period of six days are presented below on Fig. 5. The concentrations of Fe in the maize flour obtained from hammer mill on days 2, 3 and 4 were significantly ($p< 0.05$), ($p< 0.01$) and ($p< 0.0001$) respectively higher than that of the control. The results of the Fe concentration in maize flour milled with disc mill shows that day 1 was ($p<0.001$) while the values from days 2-6 were significantly ($p< 0.0001$) higher than that of the control.

3.3 The mean Concentration of Mn in the Maize Flour Samples Obtained from Hammer and Disc Milling Machine for a period of 6 Days

The concentration of manganese in the maize flour samples obtained from disc milling machine over a period of six days are presented in Fig. 6. The concentrations of Mn in all the flour mills obtained from both milling machines were not significantly different from control.

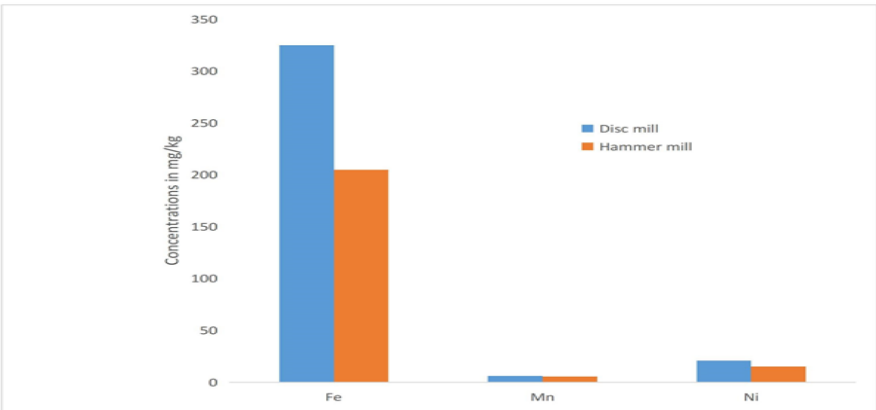

Fig. 4. Mean concentration of Fe,Mn and Ni metals present in Disc and Hammer Milling plates

Fig. 5. Fe concentration in maize flour milled with hammer mill and disc mill

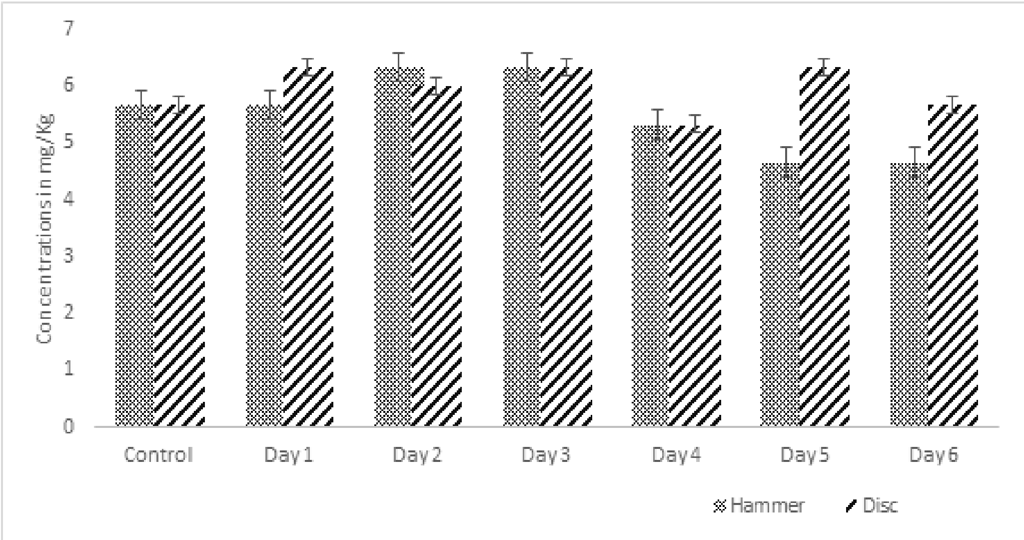

Fig. 6. Mn concentration in maize flour milled with hammer mill and disc mill

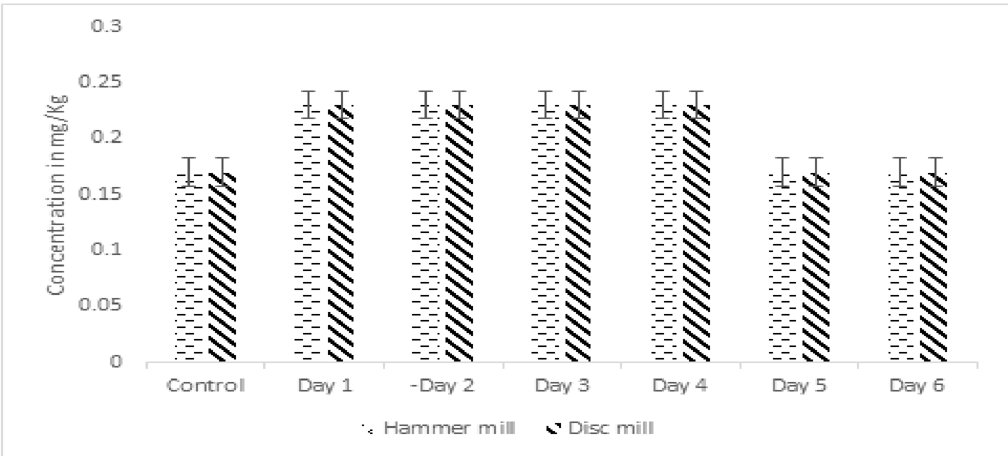

Fig. 7. Ni concentration in maize flour milled with hammer mill and disc mill

3.4 The Mean Concentration of Ni the Maize Flour Samples Obtained from Hammer and Disc Milling Machine for a Period of 6 Days

The concentration of Nickel in the control maize flour and the maize flour samples obtained from disc and hammer milling plates over a period of six days is shown on Fig. 7. The concentration of Nickel increased on day 1 and day 2, which was significantly different ($p<0.005$) from control for both the disc and hammer milling plates. However, there was no significant difference ($p>0.005$) between day 3, 4, 5 and 6 with the control for both disc and hammer milling plates.

3.5 Serum urea Concentration in Rats Fed with the Processed Flour Milled with Disc Milling Plates for 14 and 28 Days

Fig. 8 shows the result of urea concentration in rats fed control maize flour and the groups fed with the maize flour from disc plates of days 1 to 6 for 14 and 28 days. Result showed that there was significant difference ($p<0.005$) between control group and the group fed with day 1 flour for 14 and 28 days, but there was no significant difference ($p>0.005$) between the urea concentration of day 14 and day28, although there was a decrease on day 28. A similar trend was observed for the groups treated with the four of day 2, 3, 4, 5 and 6 of the disc milling plates. The result showed that the increase in number of feeding days beyond 14 to 28 days did not increase nephrotoxicity.

3.6 Serum urea Concentration in Rats Fed with the Processed Flour Milled with Hammer Milling Plates for 14 and 28 Days

The results of urea concentration in rats fed with control maize flour and maize flour from hammer milling plates of days 1 to 6 for 14 and 28 days are shown in Fig. 9.The results demonstrate that there was a significant difference ($p<0.005$) between the control group and the groups 1 and 2 fed with hammer milled maize flour for days 1 and 2 for 14 and 28 days, however there was no significant difference ($p>0.005$) between the urea concentrations on days 14 and 28.There was no significant difference between the control group and the groups 3, 4, 5 and 6 treated with the hammer milling plates flour on days 3, 4, 5, and 6.

This finding indicates that the hammer milling plate is less nephrotoxic as only the groups treated with day 1 and 2 flour showed some level of damage but groups 3 to 6 were not significantly different ($p>0.005$) from control.

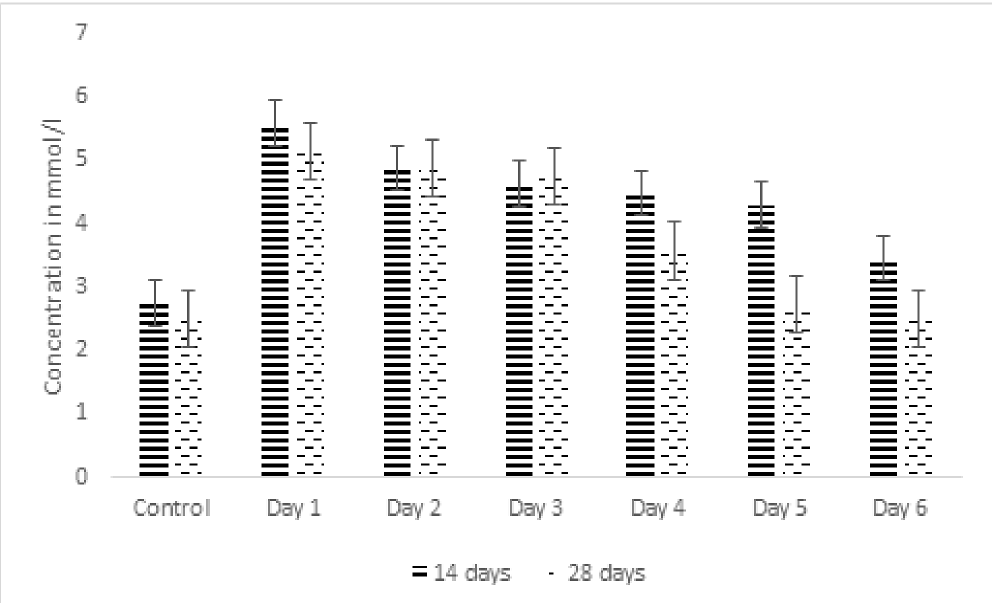

Fig. 8. Urea concentration in rats fed with control maize flour and maize flour milled with disc milling plates for 14 and 28 days

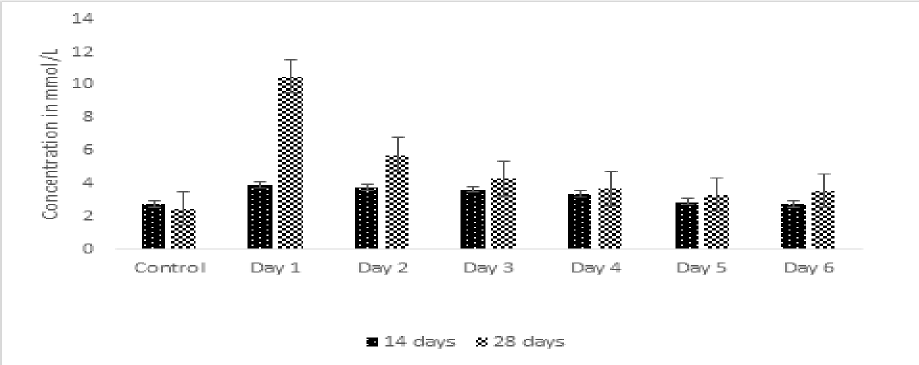

Fig. 9. Urea concentration in rats fed with control maize flour and maize flour milled with hammer milling plates for 14 and 28 days

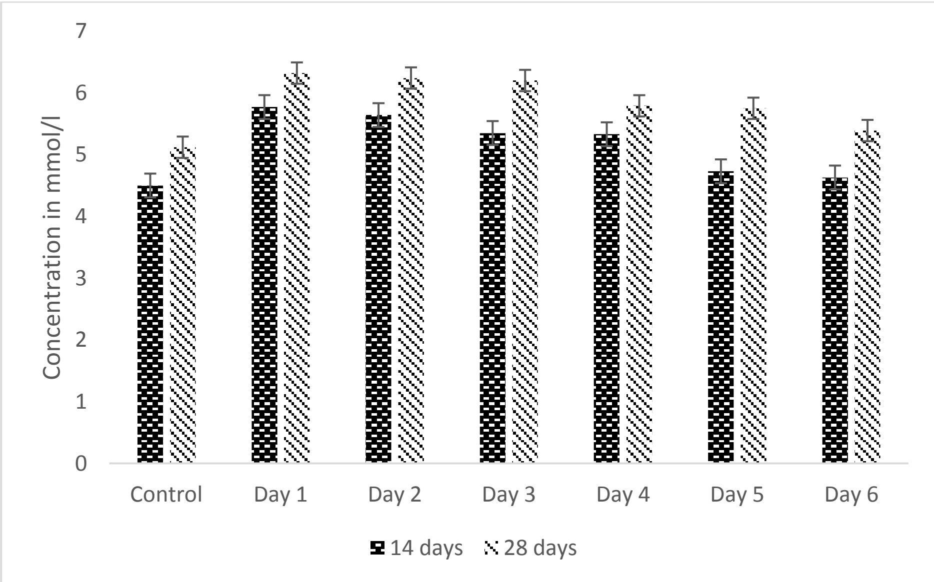

Fig.10. K^+ concentration in rats fed with control maize flour and maize flour milled with disc milling plates for 14 and 28 days

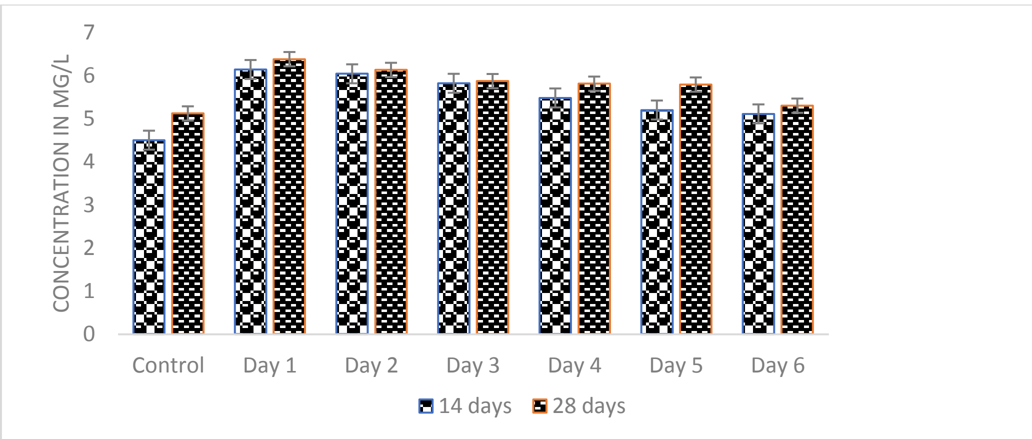

Fig. 11. K^+ concentration in rats fed with control maize flour and maize flour milled with disc milling plates for 14 and 28 days

3.7 Serum K^+ Concentration in the Rats fed with the Processed Flour Milled with Disc Milling Machine

Fig. 10 shows the result of K^+ concentration in rats fed control maize flour and the groups fed with the maize flour from disc plates of day 1 to 6 for 14 and 28 days. Result showed that there was significant difference ($p<0.005$) between control group and the group fed with day 1 flour for 14 and 28 days, but there was no significant difference ($p>0.005$) between the K^+ concentration of day 14 and day 28, although there was an increase on day 28. A similar trend was observed for the groups treated with the flour of day 2, 3, 4, 5 and 6 of the disc milling plate. The result showed that the increase in number of feeding days beyond 14 to 28 days did increase nephrotoxicity.

3.8 Serum K^+ Concentration in Rats Fed with Control Maize Flour and Maize Flour Milled with Hammer Milling Plates for 14 and 28 Days

Fig. 11 shows the result of K^+ concentration in rats fed control maize flour and the groups fed with the maize flour milled with hammer milling plates of day 1 to 6 for 14 and 28 days. Result showed that there was significant difference ($p<0.005$) between control group and the group fed with day 1 and 2 flour for 14 and 28 days, but there was significant difference ($p>0.005$) between the K^+ concentration of day 14 and day 28. There was no significant difference between the control group and the groups treated with the four of day 3, 4, 5 and 6 of the hammer milling plates. This result show that the hammer milling plate is less nephrotoxic as only the groups treated with day 1 and 2 flour showed some level of damage but groups 3 to 6 were not significantly different ($p>0.005$) from control.

3.9 Serum Creatinine, Na^+ and Cl^- concentrations in rats fed with the Processed Flour Milled with Hammer and Disc Milling Machine

The results show that there was no significant difference between any of the groups with the control both after 14 days and between 28 days of feeding for both milling machines.

3.10 Histological Analysis of the Kidney of Rats

Plate 1 shows the kidney section of the rats fed with maize flour crushed with mortar and pestle having normal glomerulus and normal convoluted tubule with normal nuclei arrangement (up-pointing arrow). Plate 2 is the Kidney section of the rats fed with maize flour from hammer milling plate showing relatively normal glomerulus and normal convoluted tubule with normal nuclei arrangement (up-pointing arrow). Plate 3 is the Kidney section of the rat fed with the flour from disc milling plates showing loss of nuclei in the convoluted tubule (up-pointing arrow) and acinic differentiation in the glomerulus (down-pointing arrow).

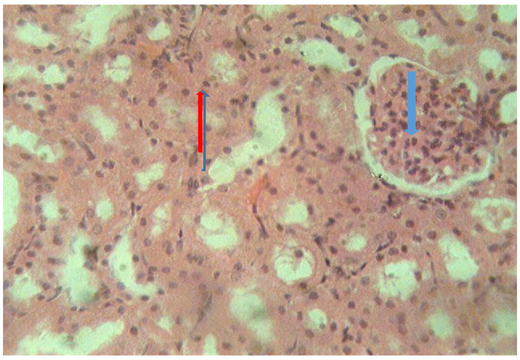

Plate 1. Photomicrograph of the kidney tissue of the control group of rats fed with maize flour crushed with mortar and pestle (x40). Arrows up and down shows normal nuclei and glomeruli

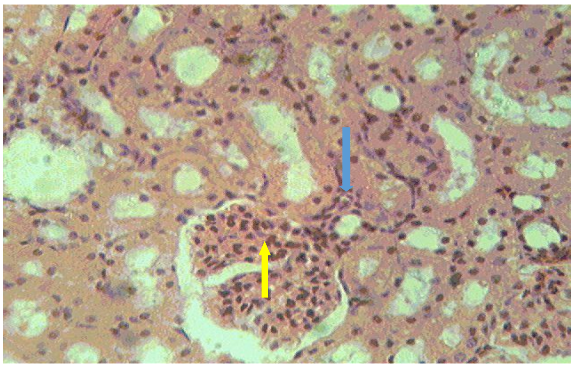

Plate 2. Photomicrograph of the kidney tissue of rats fed with maize flour milled with hammer milling machine (x40). Arrows up and down shows normal nuclei and glomeruli

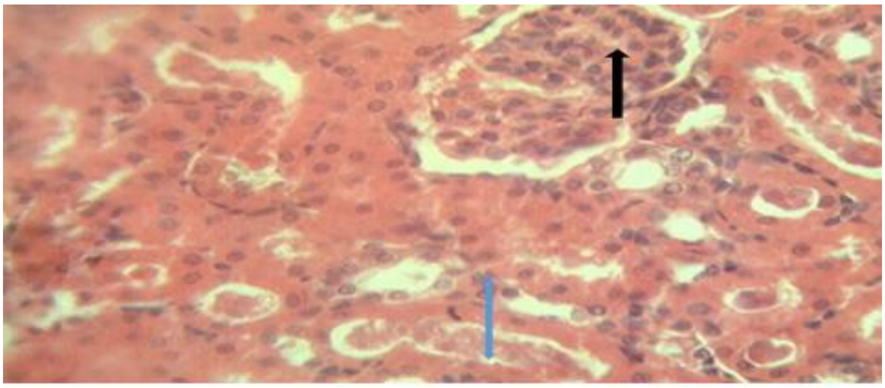

Plate 3. Photomicrograph of the kidney tissue of rats fed with maize flour milled with disc milling machine (x40). Arrows up and down shows loss of nuclei and dense glomeruli

4. DISCUSSION

Iron had the highest concentration in the disc and hammer milling plates. This means that if the tensile strength of the plates are low, there is the risk of iron contamination in food that is prepared by the use of these grinding machines. The Fe concentration recorded in all the milled maize flours were much higher than that obtained in the control maize flour. This shows that the milling process introduced some amount of Fe into the maize flour. The high difference between Fe content in the control of maize flour and that of the maize flour from the grinding plates could be attributed to the abrasive friction of the grinding disc as the grains sample come in contact with it during grinding which results in its chipping off into the milled sample as observed and reported by [18]. Fe forms the highest percentage concentration of the alloy used for the grinding plates, during grinding of the flour. This wear and tear of the grinding disc could be responsible for the high iron concentration in maize flour. Iron (Fe) is an essential element in man and plays a vital role in the formation of haemoglobin, oxygen and electron transport in human body [19]. Excess Fe in humans is stored in the liver, heart and pancreas, which can lead to organ damage [20].

4.1 Manganese

All of the milled maize flours had higher Mn concentrations than the control maize flour, although there was no significant difference.On the third day, the highest level of 6.33 mg/kg was obtained in maize flour processed by disc mill and hammer mill machines. This shows that the milling process introduced some amount of the Mn metal into the maize flour. Generally, the concentration of Mn in the maize flour processed from Hammer mill were higher. Manganese is the least toxic of the essential metals and it is toxic to varying degrees, depending on the type of ion and its oxidation state. Growth retardation, nonspecific anemia, metal fume fever and psychic and neurological disorders are some of the symptoms of manganese intoxication. Its deficiency causes reproductive failure in both male and female [21].

4.2 Nickel

Ni in the grinding plates was 20.92 mg /kg and 15.3mg/kg. This shows that the milling process could introduced some amount of Ni into the maize flour. The Ni mean concentration ranges between 0.17-0.23 mg/kg respectively for both milling machines. Excessive intake of Ni has been linked to lung and nasal cancer in workers of Ni smelters [22].There was no significant difference ($p>0.005$) between the two milling machine in mean nickel concentration and that of control. The nickel concentration in the maize flour was below the maximum permissible limit and hence, it is considered safe from the hazardous effect of nickel. Low concentrations of Ni are needed in the human body for vital functioning of certain organs, and it is how ever unsafe when taken into the body at high and increased levels. Ni contamination has been reported to majorly occur in food products as it is used together with its alloys in manufacturing food processing ma-chines [23].

4.3 Biochemical Indices

Urea and creatinine are among the metabolic waste products produced by the kidney, whereas electrolytes are reabsorbed to keep the body in equilibrium.Non-protein nitrogenous metabolites such as creatinine and urea are removed by the kidney by glomerular filtration.Serum urea, creatinine, and electrolytes (Na+, K+, Cl-, HCO3) are important and sensitive biochemical markers that are used to diagnose kidney damage and failure.

4.4 Serum Urea

Urea is the major nitrogen-containing metabolic product of protein catabolism. Urea level in blood rises when there is kidney impairment, which prevents the kidneys from filtering urea out of the blood. The results implies that the rate of filtration and subsequent excretion of urea in the blood may have been affected by the high concentration of urea in the serum of the test groups as compared to the control group. Urea is a molecule produced in the liver as a bye product of protein metabolism, so blood levels of urea will rise when there is impairment of the kidney [24].

4.5 Serum Creatinine

Creatinine is produced endogenously in the muscle by a non-enzymic action on creatine phosphate. Creatinine clearance is the volume of blood plasma that is cleared of creatinine per unit time and is a useful measure for approximating the globular filteration rate [25]. The results of creatinine obtained for both milling machines showed no significant difference between any of the groups with the control both on the 14th day and the 28th day of feeding. This indicates that there was no significant impairment of the kidney which could have been as a result of the copping strategy of the cell [24].

4.6 Serum Potassium (K^+)

Potassium ions play an important role in the way in which nerve impulses are propagated along the nerve cells and transmitted to receptor cells. In this study the significant ($p<0.0001$) decrease in serum potassium content may be attributed to an abnormal increase in blood pH and/or decreased reabsorption of potassium ions at the renal tubules. Since potassium ion is a major electrolyte in intracellular fluids, a consistent decrease in serum potassium levels may lead to hypokalemia, a condition implicated in some cardiac diseases as well. In humans, the reference range for serum potassium is 3.6 - 5.0 mmol/L. Potassium levels below 3.0 mmol/L are associated with arrhythmia (irregular heartbeat), tachycardia (rapid heartbeat) and cardiac arrest [26].

4.7 Serum Na^+ and serum Cl^-

The result of Na^+ and Cl^- obtained in this study for both milling machines showed no significant difference between any of the test groups with the control group on the 14th day and the 28th day of feeding. This indicates that there was no significant injury done on the kidney. Sodium is primarily responsible for maintaining osmotic pressure. Increased serum sodium is present in states of dehydration as a result of diarrhea or vomiting. Low sodium levels usually are as a result of too much water in the body. High levels of sodium can raise blood pressure and may indicate dehydration [27]. Elevations in Cl- ion have been seen in certain kidney diseases, diarrhea and sometimes in over-activity of the parathyroid glands. Decreased Cl- ions in the cell could be as a result of lost in the urine, sweat, and stomach secretions. Excessive loss could also occur from adrenal gland and kidney disease, heavy sweating and vomiting [28].

The histopathology of the kidney shows the kidney section of the rats fed with maize flour crushed with mortar and pestle had normal glomerulus and normal convoluted tubule with normal nuclei arrangement. The Kidney section of the rats fed with maize flour from hammer milling plate showed relatively normal glomerulus and normal convoluted tubule with normal nuclei arrangement but the Kidney section of the rat fed with the flour from disc milling plates showed loss of nuclei in the convoluted tubule and acinic differentiation of the glomerulus. This goes to suggest that the disc milling plate has the highest potential to cause nephrotoxicity.

5. CONCLUSION

The results of this study indicated that both disc and hammer milling plates contain high Fe and Ni content and maize processing into flour has very high potential of metals contamination. Disc milling plates have higher potential than hammer milling plates for metals contamination. The Kidney section of the rat fed with the flour of day 1 of the disc milling plates showed loss of nuclei in the convoluted tubule and acinic differentiation of the glomerulus. This goes to suggest that the disc milling plate has the highest potential to cause nephrotoxicity.

ETHICAL APPROVAL

All experiments involving animals complied with the ethical standards of animal handling which was approved by the Ethical Committee Animal Experimental Unit of University of Jos with Ref. no: F17-00379.

RECOMMENDATION

i. Individuals should make use of hammer milling machines for grinding of grains, as it is less harmful than disc milling machine.
ii. The grinding machine should have a compartment that will remove Fe filings introduced into the food sample ground by magnetization.
iii. There should be an improvement in the hardness and metal contents of milling plates to prevent the high contamination of metals in milled products. iv. The manufacturers of grinding plates should be well monitored to ensure that their product meets the required quality.

DISCLAIMER

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Oniya EO, Olubi OE, Ibitoye A, Agbi JI, Agbeni SK, Faweya EB. Effect of milling equipment on the level of heavy metal content of foodstuff. Physical Science International Journal. 2018;20(2): 1-8.
Available:http://doi.org/10.10002/jcb.26234.
2. Pharmapproch. Hammer mill;2019.
Available:http://www.pharmapproch.com/hammer-mill.
3. Sasaki K, Okamoto M, Shirai T, Tsuge Y, Fujino A, Sasaki D, Morita M, Matsuda F, Kikuchi J, Kondo A. Toward the complete utilization of rice straw: Methane fermentation and lignin recovery by a combinational process involving mechanical milling, supporting material and nanofiltration. Bioresource Technology. 2016;216:830-837.
4. Ariwibowo D, Mrihardjono J, Handayani SU. Energy consumption characteristics of disc mill to produce cob flour. Advanced Science Letters. 2018;24(12):9589-9591.
5. Uzun RO, Durmuş H. Effect of mill type onmorphology of AA6013 aluminium powder. Matéria (Riode Janeiro). 2016;21(3):647-654.
6. Gwirtz JA, Nieves Garcia-Casal M. Processing maize flour and corn meal food products, Ann. N. Y. Acad. Sci. 2014;1312:66.
Available:https://doi.org/10.1111/nyas.12299.
7. Kumar D, Jhariya NA. Nutritional, medicinal and economical importance of maize: A mini review. Research Journal of Pharmaceutical Sciences. 2013;2:7–8.
8. Ogunlalu O, Ademola O, Oluwasina OO, Aiyesanmi AF. Impact of Grinding Machine on Trace Metal Levels in Soup Condiments. International Journal of Food Science and Biotechnology. 2017;2(4):130-133.
9. Yashim Z I, Suleiman H. Effect of Grinding Plates (GUK, Parpela and Premier) on Maize Flour Milled within Samaru, Nigeria. International Journal of Biochemistry Research & Review. 2016; 12(1):1-7.
10. Odusotea JK, Soliub GA, Ahmeda II, Abdulkareemb S, Akande KA. Assessment of Metallic Contaminants in Grinded Millet using Domestic Grinding Machine. Nigerian Journal of Technological Development. 2017;14: 1
11. Ebenezer OO, Omodele EO, Ayodeji I, James IA, Samuel KA, Ebenezer BF. Effect of Milling Equipment on the Level of Heavy Metal Content of Foodstuff. Physical Science International Journal. 2018;20(2):1-8.
Article no. PSIJ.42572 ISSN: 2348-0130.
12. VARIAN. Publication No 85- 100009-00 Revised March 1989.
13. Fawcett JK, Scott JE. A rapid and precise method for the determination of urea. Journal of clinical pathology. 1960;13(2):156–159.

14. Tietz NW. Clinical Guide to Laboratory tests (3rd ed.). Philadelphia. WB. Saunders. 1995;518-519.
15. Trinder P. Analyst. 1951;76:596.
16. Egbung GE, Essien NA, Mgbang JE, Egbung JE. Serum lipid and electrolyte profiles of Wistar rats fed with Vernonia amygdalina supplemented Vigna subterranea (Bambara groundnut) pudding. Calabar J Health Sci, 2019;3(2):40-5.
17. Skeggs LT, Hochstrasser HC. Thiocyanate (colometric) Method of Chloride Estimation. J. Clin. Chem. 1964;10:918.
18. Yahaya DB, Aremu DA, Abdullahi I. Investigation of Metals Contaminates in Locally Ground Food (Beans as Tomatoes). Journal of Emerging Trends in Engineering and Applied Sciences. 2012;3(1):331-343.
19. Kalagbor I, Diri E. Evaluation of heavy metals in orange, pineapple, avocado pear and pawpaw from a farm in Kaani, Bori, Rivers State Nigeria. Int. Res. J. Public Environ. Heal. 2014;1(4):87-94.
20. S. Afshan, S. Ali, U. S. Ameen, M. Farid, S. A. Bharwana, F. Hannan and R. Ahmad. Effect of Different Heavy Metal Pollution on Fish. Res J. Chem. Environ. Sci. 2014;2(2):35-40.
21. Saraf A, Samant A. Evaluation of some minerals and trace elements in Achyranthes aspera Linn. Int. J. Pharma. Sci. 2013;3(3):229- 233.
22. Zaigham H, Zubair A, Khalid U, Mazhar-UII, Rizwan UK, Jabar K. Civic pollution and its effects on water quality of River Toiat District Kohat, NWFP. Res. J.Environ. Earth Sci. 2012;4(3):334-339
23. Sharma AD. Low Nickel diet in dermatology. Indian Journal of Dermatology. 2013;58(3):240. Available:https://doi.org/10.4103/0019-5154.110846
24. Chatterjea C, Shinde R. Textbook of Medical Biochemistry. 8th ed. Jaypee Brothers Medical Publishers, New Delhi, India. 2012;470– 487.
25. Nosek, Thomas M. "Section 7/7ch04/7ch04p11". Essentials of Human Physiology. Archived from the original on 2016-03-24. – "Glomerular Filtration Rate"
26. Palmer BF. Regulation of Potassium Homeostasis. Clinical Journal of the American Society of Nephrology. 2015;10(6):1050 - 1060.
27. Yousafzai A, Ara S, Javed F, Jahan N, Ahmed N, Waseem M, Asif M. Kidney function tests and serum electrolyte disorders in different ethnic groups of Balochistan. Journal of Applied And Emerging Sciences. 2011;2:164-170.
28. Abdulkareem AO, Olafimihan TF, Akinbobola OO, Busari SA, Olatunji LA. Effect of untreated pharmaceutical plant effluent on cardiac Na+-K+- ATPase and Ca2+-Mg2+-ATPase activities in mice (Mus Musculus). Toxicol Rep. 2019;6:439-443. DOI: 10.1016/j.toxrep.2019.05.002

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/86434