

PRODUCT SIZE-CUT RANGE FOR MAIZE FLOUR DRY-MILLED USING LOCALLY FABRICATED MILLING PLATES

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ABSTRACT

Plate mills are popular mills used for grinding grains into fine flour or meal in most rural communities in Nigeria. However, high cost of the imported grinding plates lead to the fabrication of local ones through copy technology from mostly Cast iron. When in service, iron and other alloying elements wears out into the milled product. To assess the quality of locally fabricated corn mill plates, Maize was dry-milled using two locally fabricated milling plates (GUK and Perpela), and an imported one (Premier), at three different product size-cut ranges ($<0.246\text{mm}$, $>0.246\text{mm}<0.880\text{mm}$ and $>0.880\text{mm}$). Results of the AAS analysis show that even though Fe (iron) was present in the initial maize samples ($68.2 \pm 0.11 \text{ mg/kg}$), Fe particles from the locally fabricated milling plates significantly increased the level of Fe contamination with the mean Fe concentration of the product size-cut range $<0.246\text{mm}$, used mostly for the preparation of “kunun tsamiya” (a light porridge taken with sugar or honey), to be above the FAO/WHO limit of 300mg/kg using the old plates. Dry milling of maize using the locally fabricated milling plates beyond product size cut of 0.246mm could cause immeasurable health consequences. This clearly indicates that not only is the quality of milling plate and fineness of the product particles played an important role in Fe contamination of the milled maize flour during dry milling process but also the age of the milling plate.

Keywords: Dry-milling, Maize, Product size-cut range, locally fabricated milling plate and mean Fe concentration.

1 INTRODUCTION

In most agricultural-based countries, value addition through local agro-processing is always encouraged as a way of stimulating economic growth. In Nigeria for instance, local maize processing Small and Medium Enterprises (SMEs) are common because maize is one of the most popular of all grain crops and is grown all over the country [1]. Depending on the eating habit of the consumer, maize can be taken whole such as cooked corn. While in many other forms, maize is processed into corn flour or corn flour paste and used in the preparation of many local foods, such as; “kunun tsamiya” (a light porridge taken with sugar or honey), “tuwo” (a stiff porridge eaten with soup), “ogi” (a weaning food), “masa (waina)” (fermented puff batter of rice, millet, maize, or sorghum), “kunun zaki” (a traditional, non-alcoholic, non-carbonated, sweetened thin free flowing gruel) and “pito” (a traditional, alcoholic drink). The maize foods are preferred in these forms for their texture and taste. This is unhealthy because of the likely consumption of extraneous matter (iron filings) in the foods [2]. Even though larger-scale mills are in operation in most African countries today. They mainly supply flour to larger cities and towns. These mills use fluted roller mills that operate to a higher technical standard than the small-scale local mills. The popular local mills include Hammer and plate mills. While Hammer mills are specially used for dry milling, plate mills are usually made for grinding soft fruits and vegetable [3]. High cost and power requirement of hammer mills make plate mills common in most rural communities and are used mostly for dry grinding of maize to flour. The fineness of grinding in the plate mills is controlled by the type of plate and the gap between them which is adjustable. These mills make use of toughened steel, stones, and hardened steel, toothed discs as milling plates. However, due to high cost of the imported grinding plates,

locally fabricated ones were developed through copy technology from mostly cast iron. Cast iron is an alloy of iron and carbon in which pigiron is melted in suitable furnace, and modified by addition of scrap or steel scrap before it is casted [4]. When in service, iron and other alloying elements wears out into the milled maize flour which when consumed could result in health implications. Even though Fe is an essential element in humans [5, 6], excess of it could result in toxicity and may be lethal [7]. Considerable number of studies (on both wet and dry milling) have been conducted on quality of locally manufactured corn mill grinding plates[8, 9], metal contaminants in locally ground foods[10], cookware as potential sources of heavy metals [11], Effect of milling on level of heavy metal contamination [12, 13] as well as levels of Fe in grains flour milled using commercial and domestic milling machines [14, 15].The authors reported various levels of Fe contaminations in the ground foods with some above the tolerable limits set by [16];these could be attributed to largely the fineness of the flour especially for dry milling. Although attempt was made by [13] to link Fe contamination to the frequency of milling of the flour, till today no product size-cut range for which maize can be milled using locally fabricated milling plates was established as the fineness of the flour cannot be clearly dependent on the frequency of milling of the flour. The objective of this investigation is to assess the quality of locally fabricated corn mill plates in terms of the level of Fe contamination in dry milling process of maize flour production, at different product size-cut ranges, compared with the foreign ones. Alloying elements such as Cr, Ni, Cd were not included in the investigation. Result of this investigation is expected to establish a safer product size-cut range for which maize can be milled using locally fabricated milling plates with respect to Fe contamination and thus reveal the suitability of the locally fabricated milling plates used in plate mills for dry milling of maize.

2 MATERIALS AND METHOD

2.1 Sample Collection and Preparation

10kg of dried maize seeds were purchased from Jimeta modern market. The maize bought were cleaned manually by using hand to picked out sand, stones and other impurities that may damage the milling plates. Chemicals such as HNO_3 , HClO_4 for the analysis were purchased from an agent of BDH Chemical Limited Poole England and were of analytical grade and all solutions used were prepared with distilled water. 20g of the dried maize sample was milled using a wooden mortar and pestle to estimate the initial concentration of Fe in the maize seeds, and thereafter, 500g each of the dried maize sample were ground into different particle size-cut as specified using three different milling plates old and new. The samples (flour)milled were screened and put into polyethylene bags and kept for further analysis.

2.2 Product Size- cut-Range Determination

The milled maize samples were subjected to a screening operation. If 95% of the feed either passed through a screen of mesh size D_{p1} and /or 95% is retained on a screen of mesh size D_{p2} then the product size-cut range is specified for the sample analysed accordingly.

2.3 Samples Digestion

Sample were digested according to method presented by [15]: 2g of each milled maize samples were poured into 250ml beakers and 10ml of the acid mixture were added (HNO_3 and HClO_4 (4:1 v/v). The solution were stirred and heated over a low temperature hot plate in fume cupboard for 4hours to achieve complete digestion, the digested samples were allowed to cool and distilled water were added and the samples were then filtered into beakers. The filtered samples were transferred into 50ml volumetric flask and were made up to mark with deionised water, and then were transferred into clean samples bottles for (AAS) analysis i.e. Atomic Absorption spectrophotometer model D100XB4J.

3 RESULTS AND DISCUSSIONS

The results of AAS analysis for the level of Fe present in the maize samples milled with a mortar and pestle was found to be 68.2 ± 0.11 mg/kg, which indicates the initial concentration of Fe in the maize seeds used in this study. In addition, the mean concentration (mg/kg) \pm SD of Fe using two different locally fabricated plates and one imported plate were presented below in Tables 1, 2and 3.

Table 1. Mean concentration (mg/kg) \pm SD of Fe from GUK grinding plate

Size-cut Range	<0.246mm	>0.246mm<0.880mm	>0.880mm	Recommended FAO/WHO limit
Old Plate	305.7 \pm 0.89	252.8 \pm 0.12	126.9 \pm 0.99	300
New Plate	248.3 \pm 0.62	233.8 \pm 0.39	103.3 \pm 0.67	300

Table 2. Mean concentration (mg/kg) \pm SD of Fe from Perpela grinding plate

Size-cut Range	<0.246mm	>0.246mm<0.880mm	>0.880mm	Recommended FAO/WHO limit
Old Plate	318.2 \pm 0.11	281.6 \pm 0.03	198.6 \pm 0.11	300
New Plate	230.2 \pm 0.11	220.6 \pm 0.88	120.8 \pm 0.15	300

Table 3. Mean concentration (mg/kg) \pm SD of Fe from Premier grinding plate

Size-cut Range	<0.246mm	>0.246mm<0.880mm	>0.880mm	Recommended FAO/WHO limit
Old Plate	75.8 \pm 0.72	74.3 \pm 0.44	72.6 \pm 0.21	300
New Plate	75.3 \pm 0.19	73.6 \pm 0.08	72.1 \pm 0.11	300

Table 1 showed the concentration of Fe in the milled maize at different product size-cut ranges, using GUK plate. It was observed that the concentration of Fe increases as the product is ground to fine powder. For a product size-cut ranges >0.88mm and >0.246mm <0.880mm, the concentration of Fe were lower than the recommended limit set by FAO/WHO, but for product size-cut range <0.246 mm, the concentration of Fe was higher than the recommended limit which may not be unconnected with the frequency of milling because achieve product size-cut range <0.246 mm, the maize seeds has to be milled over and over again. This however is in agreement with an earlier investigation by [13], that the frequency of milling directly affects the quality of the product. Similarly, Table 2 showed the concentration of Fe in the milled maize at different product size-cut ranges, using perpela plate which was also one of the locally fabricated plates. It was also observed that the concentration of Fe increases as the product is ground to fine powder. For a product size-cut ranges >0.88mm and >0.246mm <0.880mm, the concentration of Fe were lower than the recommended limit set by FAO/WHO, but for product size-cut range <0.246 mm, the concentration of Fe was higher than the recommended limit which was also similar to that discussed earlier for GUK plate. However, Table 3 showed that for all the product size-cut ranges; >0.88mm, >0.246mm <0.880mm and <0.246 mm, even though the concentration of Fe increases as the product is ground to fine powder, the concentration of Fe were by far lower (for all the three product size-cut ranges specified) than the recommended limit set by FAO/WHO. This however reaffirmed an earlier work by [8] that the concentration of Fe in milled products depends on the quality of the milling plates. This therefore indicates that the higher the quality of the grinding plates the longer it takes to wear out and the safer it is because there would be less worn out Fe in the corn flour. For both old and new plates of the three different plate types, except for product size-cut range <0.246 mm the concentration of Fe were lower than the recommended limit. But for the new plates, the concentration of Fe in all the plate types and the product size-cut ranges studied were below the recommended limit set by FAO/WHO. This has shown that not only quality milling plates and frequency of milling played an important role in contamination of milled maize flour by Fe during dry milling process [13], but also age of the milling plates. However, excessive wear is caused when the plates come into contact with each other.

A fine flour or meal from a plate mill is obtained by recirculating the product in the mill for a number of grind [3]. In the whole the mean concentration of Fe that were above the recommended limit set by FAO/WHO were those of GUK and perpela milling plates which were reported respectively as 305.7 ± 0.89 mg/kg and 318.2 ± 0.11 mg/kg using the old plates, at product size-cut range <0.246 mm. This could however be below the FAO/WHO limit if the initial mean concentration of Fe were not up to 68.2 ± 0.11 mg/kg in the maize. The high initial mean Fe concentration could be as a result of intake of the Fe by the maize plants from the soils during growth and/or contamination during post-harvest handling practices as suggested by [2].

4 CONCLUSION

Results of the AAS analysis showed that even though Fe was present in the initial maize samples (68.2 ± 0.11 mg/kg), Fe particles from the locally fabricated milling plates significantly increased the level of Fe contamination with the mean Fe concentration of the product size-cut range <0.246 mm, used mostly for the preparation of “kunun tsamiya” (a light porridge taken with sugar or honey) reported to be above the FAO/WHO limit of 300mg/kg using the old plates. Dry milling of maize using the locally fabricated milling plates beyond product size cut of 0.246 could cause immeasurable health consequences. This clearly indicates that not only is the quality of milling plate and frequency of milling played an important role in Fe contamination of the milled maize flour during dry milling process but also the age of the milling plate.

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