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Investigation into the Rate of Wear of Burrs and Presence of Metal Filings in Grounded Food Flours

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Abstract: *This research was carried out to investigate the rate of wear of a metal burr in food milling machine and the presence of iron filings in milled flour. A metal burr made of cast iron was used in a grain milling machine. Corn grains were milled at the same rate every month for five months. It was observed that, the rate of wear of the burr reduced with time. About 0.88 kg which represents 44 % of the original burrs was worn out at the end of the five months. About 90 % of the filings from the burr were found to be included in the milled flour at its finest particle size. Owing to the fact that the presence of iron filings is poisonous to the health, recommendations were made on how to prevent/minimize the filings from entering milled flours. This research will help reduce the rate of food contaminations during post-harvest processing of bio-materials and also safeguard people's health through food security.*

Keywords: *Burr, Contamination, Food flour, Health implication and Iron filings.*

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I. Introduction

Raw materials often are present in sizes that are too large to be used and they must be reduced in size [1]. It is frequently necessary to reduce for different purposes the size of solid materials in many food processes such as expression and extraction depending on whether the material is a solid or a liquid. The operation of a size reduction can be divided into two major categories. In the case of solids, the operations are called grinding and cutting. While in the case of liquid materials, the process is defined as emulsification or atomization [2].

Grinding and cutting reduce the size of solid materials by mechanical action, dividing them into smaller particles. Grinding of agricultural materials is one of the oldest cultural techniques of humanity. All civilizations that feed more or less exclusively from cereals were forced to develop technology for grinding grain crops. Perhaps the most extensive application of grinding in the food industry is in the milling of the grains to make flour, but it is used in many other processes, such as in the grinding of corn, for the manufacture of corn starch, grinding of millet, grinding of cassava [3]. In a traditional process used in many countries of Africa and Asia, decorticated grain is crushed to coarse flour either with a pestle and mortar or between stones [4].

Motorized mills were introduced as a result of the drudgery involved in grain grinding. Grinding machines are machines that use the principles of abrasion, compression, attrition/shearing, impact or friction forces to effect size reduction in Agricultural raw materials. The basic principle behind most of our local grinding machines is friction [1]. In order to effect size reduction, the two frictional surfaces of the grinding machines have to come together to crush the material between them [5].

When two metallic surfaces rub against each other, there is the production of metallic filings [6]. The grinding disc is usually made from cast and is toxic when assimilated into the body system. The effect is the damage of body organs when consumed. Thus, during grinding iron filings are produced when two disc surfaces rub against each other. Exposures to metal filings are man-made in nature and occur on a daily basis in minute amounts. The day to day metal to metal wear of the frictional faces, loose machine parts and broken parts of grinding mills contaminate our flour with metal filings [7].

Iron filings produced as part of the grounded food as a result of the grinding plates rubbing each other have some long term health effects on the human body. All metals are soluble to some extent in water. While excessive amount of any metal may present health hazard, only those metals that are harmful in relatively small amounts are commonly labeled toxic, "Dose makes the poison". Other metals fall into the non-toxic group [8]. The accumulation of metal filings in the human body system for a long time results to many of the lung and abdominal problems of the alimentary canal. Recently, it was discovered that, the frictional plates of the local Burr mills wear out too frequently. These plates are made up of heavily welded metal consisting of a lot of

alloys and cast iron. The grounded flour meals have been implicated in many of the health problems of the alimentary canal of humanity in our local communities due to the accumulation of very fine metal filings. This is a very serious situation that needs attention [9].

Thus, there is need to investigate the rate of wear of burrs in burr mill as this will help in redesigning of such mills to minimize contamination of the grinded foods.

II. Materials and Methods

Samples of rotating metal burr plate made of cast iron, shown in Fig. 1 was weighed on a weighing balance and the weights recorded. The two plates were coupled to a burr mill and used for grinding. For every one month, the plates were dismantled and re-weighed. This procedure was repeated for five months to determine the amount and rate of metal filings produced by a rotating burr mill, in grinding, over a period of time. The experiment was also repeated for a hammer mill made of mild steel.

Figure 1: The Rotating Burr or plate

In order to determine the quantity of iron filings in grounded food flour from the iron filings produced by a rotating blur mill and harmer, a "bowl of corn" experiment was conducted.

In the bowl of corn experiment, three different half bowls of corn were grounded in three different stages; the stages correspond to a distance of gap between the grinding plates of the mill. A magnet was used to stir the grounded corn after the grinding. The iron filings accumulated to the magnet was scraped off the magnet and collected on a clean white sheet of paper. The volume was recorded. The settings between the grinding plates were as follows;

1. Stage one: For stage one, the distance between the grinding plates were quite large.
2. Stage Two: For the second stage, the distance between the grinding plates was made a little closer than that of the first stage, but there was no contact between the plates.
3. Stage Three: In this stage, the adjustment on the gap in between the plates was almost zero, that is to say the plates made contact to each other.

III. Results and Discussions

The quantity of metal filings produced, with time, by a burr mill is shown in Table 1. It was observed from the Table 1 that, the quantity of iron filings produced by a burr mill in operation reduces with time. [7], obtained similar result in cassava grinding with a burr mill and hammer mill. This can be explained by the fact that newly produced or purchased burr has very sharp and protruded teeth and edges which wears out, relatively, easily. With time it becomes more stabilized and the rate of wear reduces. In all, about 44 % of the burr was lost as iron filings in a period of five months.

Surface hardening of the burr teeth after production and sharpening will go a long way in reducing the wear rate and inclusion of iron filings in grinded food flour. Such surface hardening will produce burrs that have hard enough surfaces to reduce wear while the inner core remains ductile enough to avoid cracking and failure.

Table 1: The quantity of iron filings produced by a Burr mill

Trial	Period of grinding (months)	Weight of beaters before grinding (kg)	Weight of beaters after grinding (kg)	Quantity worn out (kg)
1.	1st - 31st August, 2014	2.00	1.78	0.22
2.	1st - 30th September, 2014	1.78	1.58	0.20
3.	1st - 31st October, 2014	1.58	1.40	0.18

4.	1st - 30th November, 2014	1.40	1.23	0.17
5.	1st - 31st December, 2014	1.23	1.12	0.11
	Total			**0.88**

3.1 Analysis of Experimental Result for the bowl of corn method

It was observed that at the first stage, no traces of filings were seen on the magnet after the grounded corn was stirred with the magnet. The result of the second stage was not different from that of the first stage. However, it was also observed that the corn was not grounded to its finest particle in the first two stages.

In stage three, it was observed that iron filings were attracted by the magnet with the finest grind of the corn. The magnet was used to stir the corn flour several times and each time, the attracted filings were scraped off onto a plane sheet of paper.

These iron filings found in the flour corresponds to the mass loss of the burr in operation. This experiment ascertains the truth that indeed iron filings are found in grounded foods. These iron filings gets into the human body from the grounded food when taken. [10] wrote that, long time accumulation of metal filings into human body system has a negative health implication such as lung and abdominal problems of the alimentary canal. To reduce the inclusion of iron filings in grounded foods, there may be need to attach a magnet in food grinding machines. Such magnet should be placed in such a way as to attract the iron filings before the grinded food is discharged [11].

IV. Conclusions

This investigation was carried out to find the wear rate of metal burr in a burr mill and to ascertain the presence of metal filings in grounded food. The results obtained from the investigation showed that, the wear rate of metal burrs made with cast iron reduces with time. The wear was mainly caused by the contact made by the grinding discs which, in turn, produces the iron filings. Metal filings which correspond to loss in mass of the burr were found mixed with the grounded food. In order to reduce the inclusion of iron filings in grounded food, surface hardening of the burr and incorporation of separation magnet in the burr mill was recommended.

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