DEVELOPMENT OF AN IMPROVED PEPPER GRINDING MACHINE USING STAINLESS STEEL

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Abstract

A prototype of a new improved pepper grinding machine was designed using locally available materials to solve the problem of metal contamination, corrosion effect from machine parts and the manual means of applying water among other problems associated with the conventional pepper grinding machines that are used in Nigeria. It is designed to reduce noise pollution and to enhance the hygienic processing of pepper as well as individual entrepreneur for rendering milling services in the neighborhood and market place thereby creating employment for Nigerians. Food crops like tomatoes, cowpeas, maize and soybeans can also be milled using the machine. The machine consists of a hopper, water tank, 2hp electric motor, frame, shaft, bearing, grinding plate, the driving and driven pullets, v- belt, water sprinkler, discharge chute and water tap. The peppers are meant to be loaded into the hopper and to be collected through the discharge chute. The water from the water tank is being regulated by the tap and sprinkled on the pepper through the perforated pipe at interval depending on the speed of the machine. The average grinding capacity and grinding efficiency were determined as 2kg, 3kg, 4kg, 5kg, 6kg and 85% respectively. There was a significant difference (p< 0.05) between the grinding capacity and efficiency of the machine with water sprinkler and that of manual watering. The grinding capacity and efficiency of the machine with water sprinkler was higher when compared to the grinding capacity and efficiency of manual watering. The machine was observed to perform effectively and therefore, recommended for domestic and commercial use by the grinders in the market place.

Keywords: Development; Improve; Conventional; Pollution; Corrosion.

1.0 Introduction

Pepper is the genus piper of the pepper family (piperaceae) which includes white pepper, black pepper, green pepper, orange pepper or red pepper usually consists of ripe red pepper drupes preserved in brine and vinegar [1]. The botanical name of a red pepper is capsicum annuum also known as peppers, capsicum species has been used as medicines and lachrymatory agents. Pepper is one of the agricultural or food materials which are products from the farm either consumables or raw materials for industries. Its processing is a post- harvest operation that adds value to agricultural product [2-3]. Processing is a form of value addition its objective is to minimize the qualitative and quantitative deterioration of the materials after harvest [4]. Food processing and preservation is a branch of manufacturing that transforms raw animal, vegetable, or marine materials into consumable safe food product [5-7]
One of the major problems facing developing economies is that of engineering material development and processing. According to [8-12] 2007, the evolution of modern and appropriate agricultural machines for food crop processing in the country has been hampered as a result of non-availability of appropriate engineering materials and processing facilities used in the production of farm produce processing machine which helps in the transformation of agro-based produce from one form into another. Processing helps to improve the palatability, nutritive value and shelf-life of the agro produce [13]. Grinding stone is used to carry out grinding operation in the olden days. A lot of energy and time is required during operation (wwwcrushermachine.com). The principle of attrition milling in achieving size reduction of agricultural products introduced into it is used in the local pepper grinding machine. Efficiency of a locally fabricated burr mill machine depends on the moisture content of the food-materials as well as its mechanical strengths of its constituent composition [14]. Different challenges are involved while using primitive grinding pepper. Therefore, an improved pepper grinding machine was fabricated to overcome all the challenges. The development of stainless pepper grinding machine will enhance the hygienic processing of pepper. The means of motion transmission is through a belt mounted on a pulley which is mounted on the transmission shaft supported by bearings [15]. Processing is a form of value addition in order to minimize the qualitative and quantitative deterioration of the materials after harvest.

2. Methodology

2.1 Theory and Design
In the process of grinding, the water sprinkler introduced made the machine more effective compared to the manual application of water. There is a tap used control the flow of the water from the water tank into the sprinkling unit. The water tank attached to the machine is hand filled before the grinding process starts.

2.2 Materials used for Construction
The material used for fabrication of the pepper grinding machine was largely sourced locally in order to make it an indigenous one. The purpose is to reduce overall production cost, make it more hygienic, more affordable and acceptable by the end users. The materials were selected based on availability, suitability, cost, reliability, hygienity and durability.

2.3 Machine Description
The improved pepper grinding machine consists of the Hopper, frame support, groove pulley, belt, shaft, bearing, auger, water tap, perforated sprinkling hose, electric motor, water tank, top cover. The grinding mill is divided into six main units namely:

i. The hopper unit: This is a large pyramidal shaped container made of a stainless steel where the pepper or any other food stuff to be grinded is housed by the hopper unit or input unit in an hygienic manner to the crushing unit.

ii. The watering unit: The water tank was designed to hold water for the grinding purpose. This is attached to the hopper with a tap to control the flow rate of water or sprinkling rate of the hose to avoid excessive flow of water. The perforated hose is meant to sprinkle water on the pepper as at when due.
iii. The crushing unit: This consists of a space housing the shaft on which it is welded in a helical profile which makes it to become a screw. The food is crushed when the screw (helical profile) move as the shaft rotates.

iv. The power unit: An output torque through a belt drive connected to the crushing shaft is transmitted with the help of an electric motor. The electric motor drives the grinding disc with the aid of the belt pulley. This is the most preferred method of transmitting power from the electric motor which was attached to the pulleys.

v. The collection unit: The grinded items are collected at this point after which the grinding processes have been achieved.

2.4 WORKING PRINCIPLE OF THE MACHINE

The pepper of the required quantity was continuously fed via the hopper. As the augers are rotating in clock wise direction, a stick held by the operator was used to press the pepper against the auger. Water was also applied through the perforated hose for the free flow of pepper. Shaft diameter of 20mm is used and electric motor of 2.0hp (1.45kw) with a speed of 1200rpm was used based on the power requirement of the rotating shaft.

2.5 Design Consideration

The new improved pepper grinding machine was designed with the following considerations.

i. The machine should achieve a reduction in the overall cost and enhance production capacity.

ii. It should achieve decrease in pepper losses and improves hygiene during process.

iii. It should lead to reduction in drudgery and tedium associated with the manual watering during grinding process.

iv. The frame should provide structural support for the other members as well as not constituting an overload on draft force needed.

v. Materials used for the fabrication should be readily available and be such that will reduce the total power requirement.

2.6 DESIGN AND ASSEMBLY DRAWING

![Figure 1: Pictorial view of the hopper](image)
3.0 RESULTS AND DISCUSSION

The figures 1 to 3 above showed the different view of the developed pepper grinding machine. Tables 1 to 3 are the results of the pepper grinded, pepper not grinded and pepper damaged by the grinding machine respectively. The performance of the pepper grinding machine (pepper grinded, pepper not grinded) was significantly influenced by the spacing between two grinding plate, speed of the electric motor and flow rate of water (Table 4.1, 4.2, 4.3) at all the flow rate of water, mass of pepper and speeds investigated. The screw is the most essential part of the pepper grinding machine because it affects the grinding of the pepper.
Table 1: Pepper grinded for various combinations of mass of pepper, time taken and Constant speed

| Mass of pepper (kg) | Time taken (mins) 600rpm | Time taken (mins) 800rpm | Time taken (mins) 1000rpm |
|---------------------|--------------------------|--------------------------|---------------------------|
| 215                 | 7                        | 7                        | 7                         |
| 17.5                | 5                        | 7                        | 7                         |
| 20                  | 5                        | 8                        | 8                         |
| 15                  | 7                        | 7                        | 7                         |
| 17.5                | 4                        | 7                        | 8                         |
| 20                  | 7                        | 6                        | 6                         |
| 15                  | 5                        | 7                        | 6                         |
| 17.5                | 6                        | 7                        | 7                         |
| 20                  | 5                        | 8                        | 6                         |

Research has shown that once the diameter of the shaft has been selected, only the manner in which the shaft is rotated can be altered to effect different manipulations.

Table 2: Pepper not grinded for various combinations of mass of pepper, time taken and constant speed

| Mass of pepper (kg) | Time taken (mins) 800rpm | Time taken (mins) 1000rpm | Time taken (mins) 1000rpm |
|---------------------|--------------------------|--------------------------|---------------------------|
| 21.5                | 6                        | 3                        | 2                         |
| 17.5                | 6                        | 2                        | 2                         |
| 20                  | 6                        | 2                        | 3                         |
| 15                  | 6                        | 2                        | 2                         |
| 17.5                | 5                        | 2                        | 3                         |
| 20                  | 5                        | 2                        | 3                         |
| 15                  | 6                        | 1                        | 1                         |
| 17.5                | 6                        | 1                        | 1                         |
| 20                  | 5                        | 2                        | 2                         |

Table 3: Pepper damaged for various combinations of speeds, mass of pepper and Time taken

| Mass of pepper (kg) | Time taken (mins) 400rpm | Time taken (mins) 600rpm | Time taken (mins) 800rpm |
|---------------------|--------------------------|--------------------------|---------------------------|
| 15                  | 2                        | 2                        | 1                         |
| 17.5                | 2                        | 1                        | 1                         |
| 20                  | 3                        | 2                        | 2                         |
| 15                  | 3                        | 2                        | 1                         |
| 17.5                | 2                        | 3                        | 1                         |
| 20                  | 2                        | 1                        | 1                         |
| 15                  | 2                        | 2                        | 1                         |
| 17.5                | 2                        | 2                        | 1                         |
| 20                  | 2                        | 1                        | 1                         |
3.1 Effect of water content on grinding efficiency
The figure 4 below is a graph that revealed an increase in the grinding efficiency of the stainless steel pepper grinding machine as the water content increases since there is a decrease in the strength of the pepper. The strength of pepper reduces with increase in water content.

![Figure 4: Effect of speed on grinding efficiency](image)

3.2 Effect of water content on grinding efficiency
The soil moisture has an effect on the forward speed of the machine, as it required an increase in forward speed of the machine to lift cassava stem on a plant stand of high soil moisture. At high soil moisture content of 0.30 % and 0.35 % the forward speed required was high due to a decrease in the soil penetration resistance as shown in figure 5.

![Figure 5: Effect of water content on grinding efficiency](image)
4.0 CONCLUSION AND RECOMMENDATION

4.1 CONCLUSION
A pepper grinding machine powered by electric motor (2hp) was designed and fabricated from locally available materials as part of an on-going research for the development of a stainless steel pepper grinding machine. The tests have shown that the designed prototype stainless steel pepper grinding machine satisfied most of the general and functional requirements of a machine in this category. This stainless steel pepper grinding machine developed as a mechanized method of grinding pepper will be embraced by Nigerian farmers for its simplicity of use, low cost production or procurement, ease of fabrication and maintenance, low cost of maintenance combined with increase in the quality and quantity of grinded peppers. The machine at 8 km/hr average speed has a lifting efficiency of 80%.

5.2 RECOMMENDATIONS
The following areas are recommended for future modifications and research into the development of this prototype.

a) Effects of variable distance or spacing between the helical profile on the efficiency of grinding under varying crop conditions.

b) Empirical study of draft requirements of the pepper grinding machine under various, crop and operational conditions.

c) Provision of variable speed screws for the regulation of grinding speed.

d) Addition of a device for pressing pepper against auger.

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