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Development and performance evaluation of a roasted groundnut dehulling machine

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Abstract
A roasted groundnut dehulling machine was designed, constructed and evaluated. The test results showed that the machine operating speed and the roasted groundnut moisture content has significant effect on the machine capacity and the dehulling efficiency. The efficiency of the machine decreased with increase in moisture content. The machine attained highest efficiency of 80% and 12% moisture content and operating speed of 180rmp. All the materials used for fabrication were sourced locally and the cost of producing a unit of the roasted groundnut dehulling machine was estimated to be forty-five thousand naira (N45, 000.00) including the cost of the electric motor. The machine is affordable, simple to operate and feasible and therefore recommended for both small and medium scale roasted groundnut processors and seller.

Keywords: Roasted groundnut, dehulling, moisture content, operating speed, efficiency

Introduction
Groundnut (*Arachis hypogaea* L.) otherwise called monkey nut belongs to the family Leguminosea. It originated from Latin America and the Portuguese were responsible for its introduction into West Africa from Brazil in the 16th century (Ahmed, 1989) [1], (Dill Hay and Tom, 2007) [2]. The specific name hypogeal means 'under the earth'; after pollination, the flower stalk elongates, causing it to bend until the ovary touches the ground. Continued stalk growth pushes the ovary underground where the mature fruits develop into a legume pod. Pods are 3 to 7cm long containing 1 to 4 seeds

Groundnut is one of the most popular commercial crops in Nigeria. Nigeria produces 41% of the total groundnut production in West Africa (Hommons, 1994) [3]. It is cultivated for its kernels, the oil and hay for the livestock. Ground cake is often deep fried or dried to make a snack locally called 'kulikuli', groundnut flour is used as an ingredient in soups, sweet, confectionaries and puddings. Groundnut especially those produced in developing countries has been used traditionally since the origin of humanity. It is rich in oil and protein and has a high energy value. Dry-roasted peanuts are good sources of essential nutrients including phosphorus, manganese, copper and foliate, (FAO, 2003) [4].

Groundnut produced in different countries are consumed in various ways depending on consumer preferences and food habit. The seed can be consumed raw (non-heated), boiled or roasted. Groundnut seeds are roasted using vegetable oil with or without salt by applying dry heat, or on sand for even distribution of heat. The dry roasted groundnut is useful in preparation of peanut butter, confectionary or bakery products. After roasting, the testa are removed and the dried cotyledons are consumed. Roasting reduces moisture content and develops a pleasant flavour which makes the product more acceptable for consumption. However, excess heating during roasting results in low nutritive quality of protein (Kadam and Chauhan, 1991) [5].

In Nigeria, the processing of groundnut into various products is mostly done by women either for home consumption or for commercial purposes. One of the most common commercial products is roasted groundnut which are sold at market places, institutions or hawked on the streets, (Aykroyd, and Doughty, 1982) [6]. The processing of groundnut is both the source of income and employment to a large population of women in the northern Nigeria (Adeeko and Ajibola, 1990) [7].

In the production of roasted groundnut, the thin covering called the testa or hull are traditionally removed manually by hand. In this method, a sizeable quantity of the groundnut is placed between the palms and gently rubbed together to remove the hull. Sometimes, a Reasonable quantity are placed in a flat tray or tied in a piece of cloth (scarf) and gently rubbed together. In both processes above, winnowing is achieved by blowing gentle breeze into it from the mouth. These manual methods are associated with the following shortcomings;

I. Products are subjected to exposure and contamination (during winnowing) and this is not good for human health.
II. Low capacity; the quantity of roasted groundnut that can be processed using manual method is quite limited compared to when a machine is used.
III. Time consuming; this method wastes useful time that would have been used in doing other jobs.
IV. Low efficiency of performance.

The above constraint work against the continuous adoption of the manual method of removing the hulls (testa) of roasted groundnut. Hence, the need to develop a machine that would be able to eliminate or reduced to the barest minimum all the above limitations associated with the manual method of removing the hulls of roasted groundnut.

Materials and method

Machine Description and Operation

The roasted groundnut dehulling machine have the following components; the frame, hopper, collecting tray, dehulling unit (rotary drum), the cleaning unit and the power transmission unit. The frame is the unit of the machine on which all other components are mounted and it is built with 50 by 50 (mm) angle iron. The hopper is made with a galvanize metal sheet and it is trapezoidal in shape to enhance easy loading and free flow of the product. The dehulling unit is made of 4inches stainless pipe on which plastic brush is attached. The cleaned roasted groundnut is collected through the collecting tray.

Dehulling is achieved by rubbing action of the plastic brush on the internal concave housing. The groundnut and the chaff are separated into fraction of nut and chaff by a blower through pneumatic mechanism powered by one horse power electric motor. The pictorial view of the machine is shown in plate 1.

Design of a Roasted Groundnut Dehulling Machine

Design considerations

Properties of seed

The properties of seed like the weight, moisture content and types were considered in material selection and design.

Ease of operation: The machine was designed to suit the convenience of the user.

Properties of fabrication materials

The strength, rigidity, reliability and durability of the materials were considered alongside availability.

Production cost

Use of locally available materials to reduce overall cost, thus making the machine cheap and affordable by local groundnut processors.

Other factors considered include, aesthetics, safety, and ease of maintenance.

Design Features/Analysis

1) The Hopper

The hopper serves as input. It is trapezoidal in shape, there is an open at the bottom of the hopper through which the groundnut enters the dehulling unit.

2) The Frame

The frame is made of 50 x 50 (mm) angle Iron with length, width and height of 900, 800, 106 (mm) respectively. The rectangular angle iron frame is firmly joined together by welding.

3) The Dehulling Unit

Dehulling of the roasted groundnut are effected in this unit. It consists of a stainless cylindrical drum to which a plastic brush at interval is attached. Rotation of the drum over a fixed concave metal below it effect the dehulling of the roasted groundnut by the rubbing action.

4) Cleaning Unit

The cleaning unit is an enclosed fan with blades built from 16 gauge metal sheet arranged on a shaft and enclosed in housing. The fan produces the air that effects the separation of the chaff from the nuts and other unwanted materials.

Performance Test of the Machine

The performance test of the roasted groundnut dehulling machine was carried out at the fabrication workshop of Agricultural and Bio-Environmental Engineering Technology Department of Rufus Giwa Polytechnic, Owo. The machine was evaluated at varying speed of 200, 180, and 160 rpm at a predetermined moisture content of 8, 10, 12, 14 and 16% wet basis. The machine speeds were achieved by varying the diameter of the machine pulley while the moisture content of each sampled was determined using the method described by ASABE (2006). The machine capacity and dehulling efficiency were calculated using the following equations;

$$\text{Machine Capacity} = \frac{\text{input weight}}{\text{time taken}} \text{ (kg/s)}$$

$$\text{Dehulling Efficiency \%} = \frac{\text{Ws}}{\text{Wi}} \text{ X } 100$$

Where: Ws = weight of dehulled roasted groundnut (kg) and Wi = Initial weight of roasted groundnut (kg)

Results and discussion

The performance evaluation was carried out at operating speed of 200, 180 and 160rpm respectively using roasted groundnut samples of 8, 10, 12, 14 and 16% moisture content (wet basis). The highest output was observed at 180rpm and moisture content of 7.5%. It was observed that machine capacity had inverse relationship with moisture content (Fig. 1). Increase in moisture content results to decrease in machine capacity.

Also, dehulling efficiency is also affected by the moisture content. From Fig. 2, dehulling efficiency had polynomial relationship with samples moisture content. The machine efficiency starting from low moisture content of 8% increase

to maximum at 12% moisture content and decreases as the moisture content go higher to 16%. The machine had highest efficiency of 80% at moisture content of 12% when the machine speed is 180rpm.

Conclusion

From the test carried out on the machine, it is concluded that the newly designed and fabricated roasted groundnut dehulling machine perform satisfactorily with optimum performance at 180 rpm machine speed and 12% moisture content (wb) roasted groundnut which gave 80% dehulling efficiency. The machine will therefore eliminate the constraints in manual processing and also provide improved quality product.

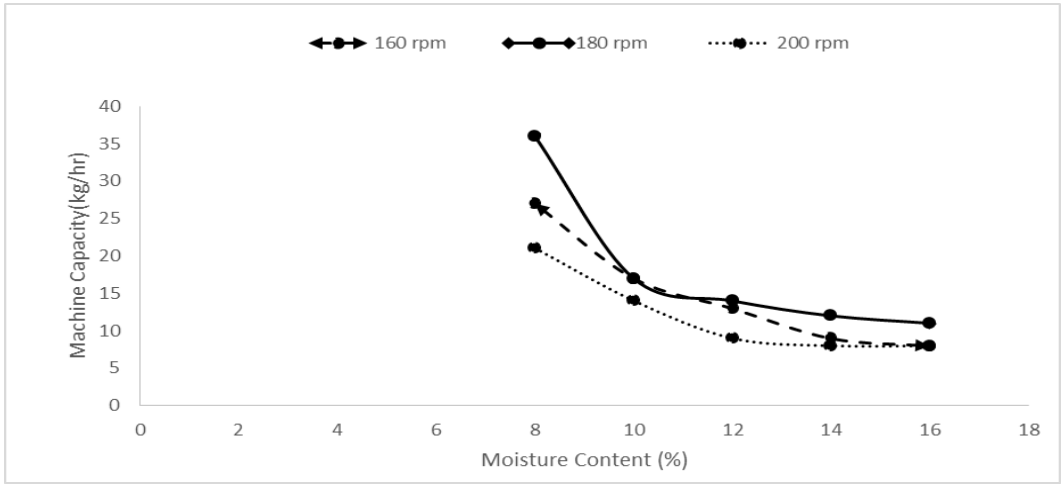

Fig 1: Machine Capacity versus Moisture Content

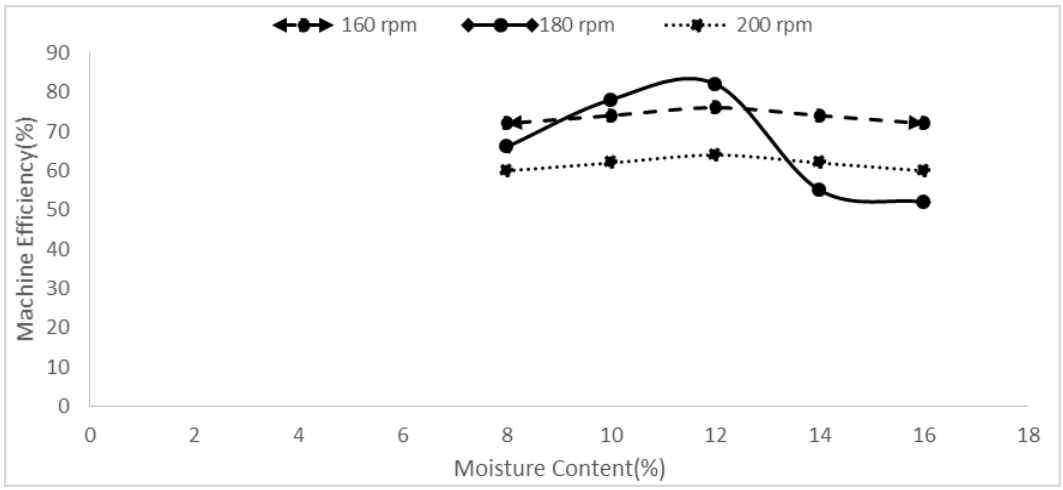

Fig 2: Efficiency versus Moisture Content

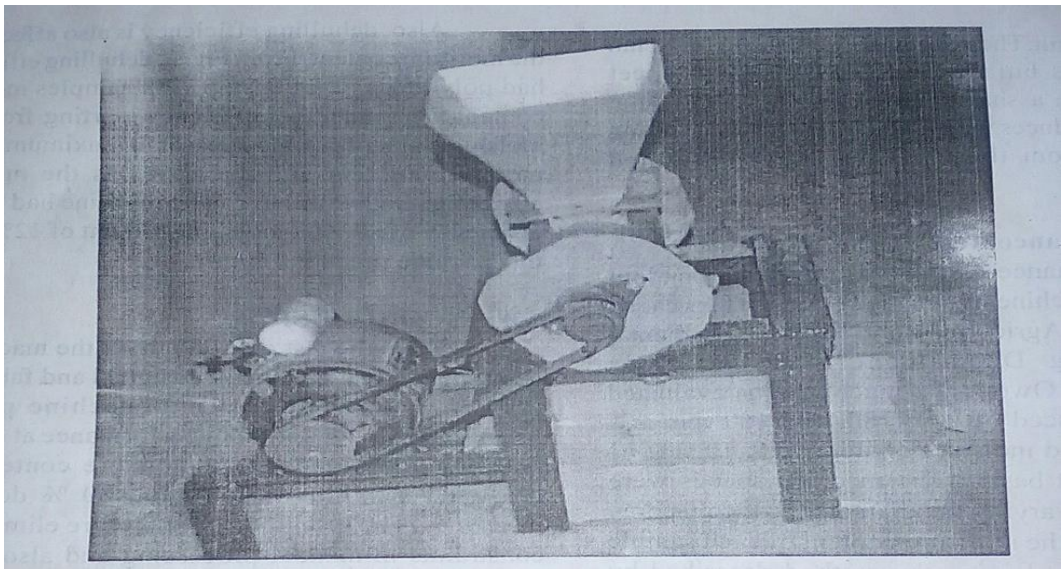

Plate 1: Pictorial View of the Roasted Groundnut Dehulling Machine

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