

DEVELOPMENT OF A MOTORIZED KNEADER FOR GROUNDNUT OIL EXTRACTION

J.N. Maduako; J. Mikailu; F.A. Maunde
Department of Agricultural Engineering
Yola- Nigeria,

ABSTRACT

A motorized groundnut-kneading machine was designed, based on the principle of a rotational viscometer, in which the viscous flow drag of rotating a body immersed in a liquid is measured as a function of speed. The machine was constructed, and evaluated for its performance in terms of, its kneading time and throughput capacity. In addition to eliminating the drudgery involved in the existing manual kneading tools, test result reveals substantial savings in kneading time. Kneading time was reduced by 80% and the throughput capacity of the machine in terms of weight of oil extracted per unit time was found to be 46.3 kg/hr. The machine promises a big relief from drudgery for groundnut processors.

INTRODUCTION

In Nigeria, a survey study conducted in some northern states (Kano, Kaduna, Adamawa, Niger, Bauchi; and Taraba) showed that traditional groundnut oil extraction is a profitable business, and mostly done by women. It was also found that out of 436 processors of groundnut oil in three of the states (Kano, Niger and Kaduna), 74% said that they were processing for income generation [1]. Groundnut is of course a very important raw material for industries, but it is presently under-utilized, in spite of its potential for conversion into various edible and commercial products, such as, shelled groundnuts, roasted groundnuts, butter, groundnut oil and groundnut cake.

Preliminary studies showed that groundnut seeds contain 42% to 52% oil, and most of the world groundnut processing is done for that oil. It is a desirable cooking and salad oil, because of its quality, containing about 80% unsaturated fatty acids, such as oleic and linoleic acids and so much protein [2].

The traditional use of mortar and pestle manually to process groundnut seeds for oil is a serious problem to the women that are engaged in the groundnut oil extraction business. The method is not only tedious and time consuming, but also a serious drudgery to the women.

It involves the following sequence of operations: shelling, sieving, sorting, roasting, cooling, skinning, winnowing, milling, (grinding to paste), kneading (oil extraction), frying the residue to cake locally called Kuli-Kuli and cooking the oil to refine it [3]. Kneading was then identified as the most tasking and energy

consuming among these operations, which underscores the need to develop a motorized machine.

The Institute for Agricultural Research (I.A.R) at Ahmadu Bello University, Zaria developed a traditional model for groundnut oil extraction in 1995. The model was operated manually, but the mortar was installed and cemented to the ground for stability, and the pestle was clamped on the mortar such that it could pivot on the casing as it kneaded the groundnut paste in the mortar [3].

Another work done at National Agricultural Extension and Research Liaison Services (NAERLS) Ahmadu Bello University, Zaria [4] attempted to replace the traditional mortar and pestle with manually operated drum chamber and a stirring shaft-and-finger mechanism.

Also a motorized model of groundnut oil extractor was designed, constructed and tested at Agricultural Engineering Department, A.B.U, Zaria [5]. The main features of the oil extractor include the kneading head, the conventional mortar, the transmission unit and the supporting frame. The intended quantity of paste is poured into the mortar and the machine is set up for kneading. Once the electric motor is switched on, rotary power is transmitted to the kneading shaft through the intermediate shaft to the input shaft on which the kneading shaft is hooked. Kneading is accomplished by the centrifugal effect of the rotating fingers on the oil molecules in the paste, with water added gradually as the process progresses until the end. It was observed that the average kneading time per unit weight decreased

with an increase in paste quantity for all the speeds, and slightly decreased with increase in speed for all paste quantities [5]. This paper presents another motorized prototype, which achieves higher throughput capacity within a shorter kneading time.

2. MATERIALS AND METHODS

2.1 Design of the Motorized Kneader.

The design method of the machine was based on the principle of a rotational viscometer. In this instrument, the viscous flow drag of rotating a body immersed in a liquid is measured as a

function of speed [6]. Using this principle, the shear stress and shear diagram could be established for a rotational concentric-cylinder viscometer (6). Therefore, by applying it to the kneading mortar and stirrer shown in figure 1, the following parameters were calculated: angular velocity of the stirrer shaft and the number of revolutions per minute (rpm), diameter of the stirrer shaft, radius of the stirrer fingers (R_s), torque acting on the stirrer shaft, radius of mortar (R_m), power requirement of the kneading operation and the height of groundnut paste inside the mortar (H).

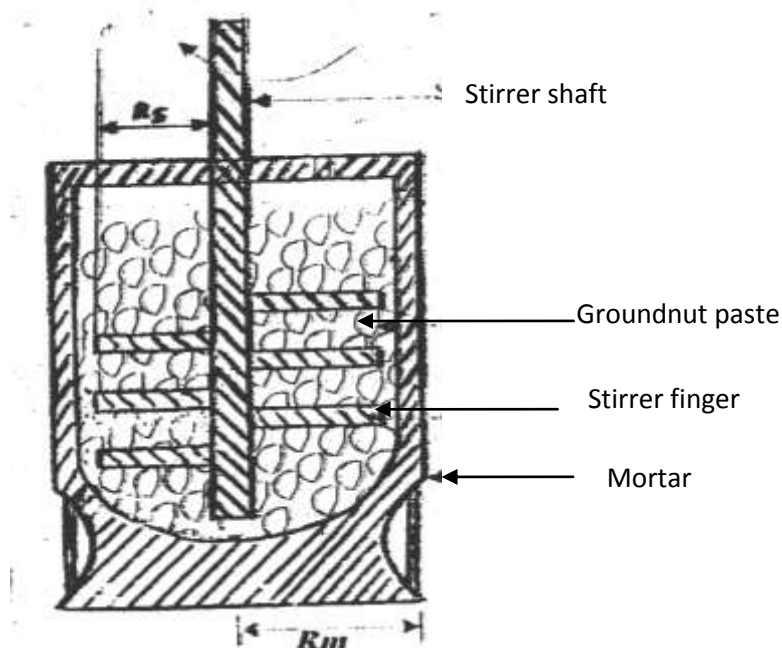


Figure 1: kneading mortar and stirrer

2.2 Description of the Motorized Kneader.

Figure 2 shows the main features of the motorized groundnut paste kneading machine, which are the conventional mortar, the transmission unit, the power unit, the kneading head and the supporting frames.

The conventional mortar (8) has an internal diameter of 280mm at the top and internal depth of 300mm with an oil drainpipe (9) inserted at the bottom for draining the extracted oil into the oil container. The mortar is held to the main frame (5) by four supporting members such that the base of the mortar is just touching the ground as shown in figure 2. The transmission unit consists of one V-belt, (3) two pulleys (2 and 4) and the stirrer shaft (6). The V-belt obtains its drive from the electric motor (1)

and passes the drive to the stirrer shaft through the pulleys. The shaft has six stirrer fingers (7) welded on to it for effective stirring of the paste inside the mortar. The shaft, the shaft bushing and the shaft fingers form the kneading head, and this replaces the traditional pestle.

The power unit consists of a 1.492 kW (2.0 hp) single-phase electric motor and its small pulley from where the V-belt obtains its drive. The electric motor is bolted to the upper part of the frame in a vertically downward position and supplies the necessary power for the rotation of the shaft. The positioning of the motor vertically downward was considered to be convenient for lack of space underneath and for operator's safety. The frame consists of angle iron bars constructed to support all the components of the machine.

For the operation of the machine, the paste quantity of known weight is poured into the mortar and the machine is set up as shown in figure 2. Once the electric motor is switched on, rotary power is transmitted to the kneading shaft through the V-belt. Kneading is accomplished by the centrifugal effect of the rotating fingers on oil molecules in the paste, with hot clean

water added gradually as the process progresses until the kneading ends. Figure: 3 (a, b, c) shows some views of the kneading machine. At the end of kneading by the machine, the residue is further pressed manually and deep-fried to extract the residual oil.

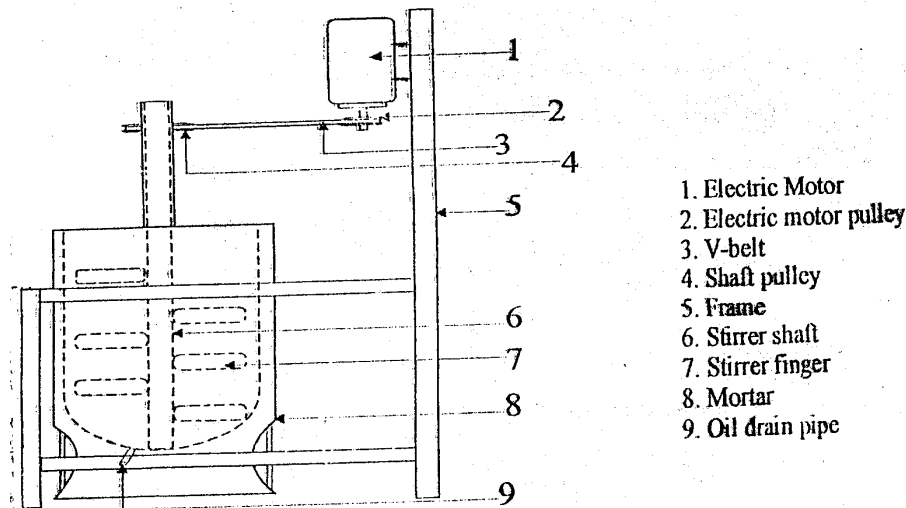


Fig. 2: Side view of the motorized kneader

2.3 Performance Testing

The groundnut-kneading machine was fabricated and tested at the Centre for Equipment, Maintenance and Industrial Training (CEMIT), Federal University of Technology, Yola.

A free-rotation test was first carried out on the machine to see how it functioned with empty mortar. Afterwards the machine was tested again under full load, with 8.0kg of groundnut paste poured into the mortar. To facilitate the oil extraction, as usual in traditional kneading, 16.0g of salt was added to it. When the machine was operated at a constant speed of 450 rpm, the stirrer shaft kneaded the paste with its fingers. As the process continued, 1.2kg of hot water was added to the paste gradually. The hot water diffused into the groundnut cells and displaced the lighter oil molecules. The kneading operation came to an end when the paste changed colour to brown and became sticky within eight (8) minutes. Afterwards, the residue was packed to one side in the mortar and the oil outlet pipe was opened. This allowed the oil to flow into the oil collector through the pipe. The amount of oil collected was measured and found to be 3.0 kg within eight (8) minutes of operation. The test was repeated five times. The

time taken (t) for each kneading operation was recorded with a stopwatch. The extracted oil collected through the oil outlet after each operation, plus the oil obtained during the manual pressing of the residual meal and deep-frying of the shaped and sized meal were weighed and recorded. The formulae used for computing the yield of oil (Y_o), and throughput capacity T_c are expressed in equations (1), and (2), respectively;

$$\text{Yield of oil; } Y_o(\%) = \frac{W_o \times 100}{W_p} \quad (1)$$

$$\text{Throughput capacity, } T_c = \frac{W_p}{t_k} \quad (2)$$

Where Y_o = Yield of oil extracted from groundnut paste in each batch (%).

W_o = weight of oil obtained after each kneading operation (kg).

W_p = weight of groundnut paste kneaded (kg).

T_c = throughput capacity (kg/hr).

t_k = kneading time (hr).

3. RESULTS AND DISCUSSION

The results obtained in the testing of the motorized kneader are shown in Table I.

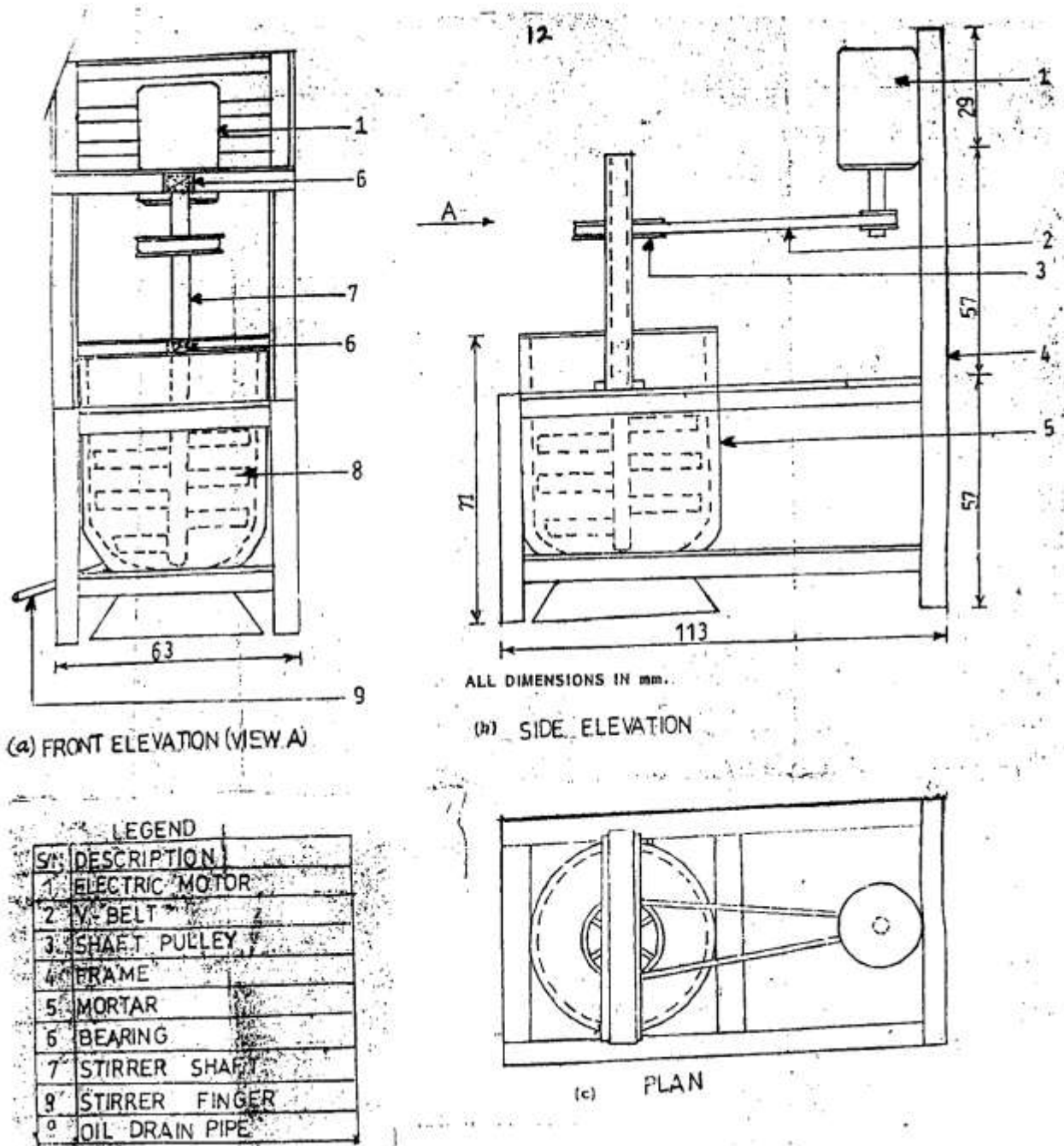


Figure 3: detailed drawing of the motorized kneader (a) front elevation (b) side elevation (c) plan

Table 1: testing result for the motorized kneader.

S/N	Paste quality W_p (kg)	Kneading time t_k (mm)	Weight of oil obtained W_o (kg)	Yield of oil Y_o (%)	Throughput capacity (kg/hr)
1	8.00	8.00	3.00	37.5	60.00
2	8.00	12.00	3.00	37.5	40.00
3	8.00	11.20	3.16	39.5	42.86
4	8.00	10.30	3.20	40.0	46.60
5	8.00	11.40	3.40	42.5	42.11
X	8.00 ± 0.00	10.58 ± 1.56	3.15 ± 0.16	39.40 ± 2.07	46.31 ± 8.01

Note: X = mean value of Samples \pm sample standard deviation

3.1 Yield of Oil (%)

The oil yield obtained from the Manipinta variety of groundnuts used for testing the kneading machine ranged from 37.5% to 42.5%, with an average of 39.4%, as shown in Table I. The significance of the yield of oil lies mainly in using it to estimate the quantity of oil to expect from kneading a specified quantity of groundnut paste. In this case, it averaged 3.15 kg of oil from 8.00kg groundnut paste.

3.2 Kneading Time (mins)

Table I shows a range of 8-12 minutes of kneading time for 8.00 kg groundnut paste. The average kneading time of 10.58 mins for 8.00 kg of groundnut paste compares favourably with the 11.25 mins used for 6.6kg of groundnut paste, as earlier reported [5]. It is also faster than the 25 mins spent by three operators exchanging hands in using manual rotary tools for kneading the same quantity (6.6kg) of groundnut paste [7].

Now, we have about 80% savings in kneading time for 8.00kg of groundnut paste with this motorized kneader, which compares favourably with the 45-76% savings of time recorded by some [5], and the 35% savings of time recorded by others [4].

3.3 Throughput Capacity (kg/hr)

The throughput capacity of the motorized kneader was found to range from 40.0 kg/hr to 60.0 kg/hr, which averaged 46.3 kg/hr, as shown in Table I. This is certainly better than a situation where 6.6 kg/hr of groundnut paste was kneaded in 25 mins (i.e. 15.84 kg/hr), as of one [7], or 6.6kg of groundnut paste kneaded in 1.25 mins (i.e. 35.2 kg/hr), as of another [5].

4. CONCLUSION.

This work has shown that there is always room for improvement in the development of processing machines. The achievement of faster kneading and oil extraction from groundnut paste by this machine is certainly a big relief from drudgery for groundnut processors. It is also an invention of the

farmer's dream of a more profitable and pleasurable agricultural business in groundnut production and processing. With 80% savings in kneading time and throughput capacity of 46.3 kg/hr, this motorized kneader is quite promising.

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