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DEVELOPMENT OF EGUSI MELON SEED EXTRACTOR

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ABSTRACT

In West Africa Egusi melon (colocynthis citrullus L.) seeds obtained from egusi melon plant are a common component of daily meals. The seeds which are extracted manually from the fruit are used in the preparation of local soup. Manual extraction of melon seed involves a great deal of drudgery and time wasting in addition to the losses associated with it. In this work a motorized melon seed extractor was developed. To aid the design, some engineering properties of melon fruit such as; the weight, major diameter, minor diameter, volume, compression and shear forces were determined. The components of the extractor are: perforated drum, blades, rakes, reciprocating sieve, hopper and water sprayer. A 7.6kw electric motor was used to power the extractor and it operates with the principle of wet seed extraction. During operation ripe melon fruits are fed into crushing chamber through the hopper, water was sprayed simultaneously into the crushing chamber. The materials are crushed by fast rotating blades and conveyed by rakes mounted on the rotor. Sprayed water washed out the seed through the seed outlet and the crushed pulp was ejected out through the pulp collector. The extractor was tested using melon fruits which were subjected to different treatments (whole fruit, fruits sliced in to two, sliced and partially fermented for 2 days and sliced and fully fermented for 5 days). The result showed that the rate of extraction was highest for the sliced and fully fermented fruits (1.631kg/s) and lowest for the whole fruits (0.609 kg/s). The extraction efficiency was also highest for fully fermented sample (81.57%) followed by partially fermented sample (77.9%) and (70.55%) for the sliced sample, while the whole fruit has only 39.6% extraction efficiency. The machine has high seed separation efficiency for all the treatments. At a crushing speed of 300rpm the capacity and water requirement of the machine was 1032kg of melon fruit and 60liters of water per hour respectively.

Keyword; *Melon fruit, Melon seed, Development, Extractor, Efficiency*

INTRODUCTION

Egusi melon (*Colocynthis citrullus L.*) is popular in Nigeria because of the edible seeds which have been used in preparation of local soup. It is one of the members of the family *Cucuritaceae* which has a bitter fruit pulp. A creeping annual herb, the egusi melon has hairy stems, forked tendrils and three-lobed hairy leaves; it has a very extensive and superficial root system. Unlike the common watermelon, whose flesh is sweet and red, the egusi melon's juicy flesh is pale yellow or green, it tastes bitter and is inedible figure1a. Melon seeds are basically small with oval shape figure 1b. The seed coat may be thin and thick or encrusted with flat or molded edge [1]. The origin of melon is Africa and Asia and it is widely cultivated in the Caribbean, Indonesia and Africa. Several varieties are grown in Nigeria and are locally referred to as thin skin, thick edge and the white big size varieties.

Fig.: 1a Egusi Melon Fruit

Fig: 1b Egusi Melon Seeds

NAERLS [2] stated that melons thrive on a variety of soils; they do best on a sandy-loam naturally well drained soil. Acidic soils are not suitable to the production of melons. NAERLS [2], reports further that seeds are generally sown at the beginning of the rains (May/June) or towards the end of the raining season (August/September). Its main area of production in Nigeria is confined to the forest, derived and southern guinea savanna ecological zone of Nigeria. The seeds are sown 2 to 3 per hole with 2x2 meter spacing. Seedlings appear in 4 to 7 days and later thinned to one per hole.

Melon fruit reach full maturity in about 80-120 days from planting. It could be harvested when the fruits stalk attached to the vine (neck) is dry. The first unit operation in the traditional method is plucking and gathering of the fruits. Then the fruits are sliced into halves and heaped up to ferment. Thus allowing the pulp to rot or decay for a period of two to five days. After fermenting the seeds are scooped along with the rotten pulp (fruits). The scooped seeds poured into a perforated basket or bucket is then placed in a stream or any water reservoir, the content stirred and agitated with the hand. The pulp, which forms slurry, is separated from the seeds through the perforated sieve. Drying is done by spreading it outside under the sun on a drying mat/floor NAERLS [2]. The seeds could be shelled to obtain the final edible seeds. This could be done manually, by twisting the seeds between the fingers and thumbs of the two hands. Also shelling could be done by motorized melon shellers.

In West Africa grinded egusi melon seeds are common component of daily meals. Egusi seed oil contains a high level of unsaturated fatty acids which has a wide use both for domestic and industrial purposes. Domestic use of egusi oil include soup cooking, frying etc, while industrially it can be used for production of soap, pomade, metal polish, lubricant adhesive, candles, feed for cattle such as poultry, pigs, sheep and goats.

A number of machines have been designed to separate melon seed from melon fruit. However, most of these machines perform the unit operation of de-poding or washing. Melon washing machines developed usually consists of a water drum with a rotating shaft as the washer and a sieve to separate the clean seed [3] [4] [5]. All the developed melon washing machines require the separation of the fermented melon pod from the fruit manually. Oloko and Adbetoye [6] designed and fabricated a melon depodding machine. After depoding the pod removed has to be washed to separate the seed from the pulp. Akubuo and Odigbo [7] reported that a coring machine was designed to remove the seed bearing core of the mesocarp and endocarp. The purpose of the coring is to expose the seed bearing core to microorganism to achieve complete decomposition of the mesocarp and endocarp within a short period of time. However, after decomposition the core must be washed to separate the pulp and the seed.

Seeds extractors have been developed to remove seeds from fruits such as tomato, chili pepper, cucumber and pomegranate. Different principles were employed to extract the seed from the fruit. However, crushing the fruit and washing the seed out is prominent among all the methods.

Kailappan *et al.*, [8] reported on fabrication and testing of tomato seed Extractor. The unit consisted of a fruit squeezing chamber, and seed separation unit. In the fruit squeezing chamber, the tomato fruits were pressed and squeezed by a rotating screw auger and discharged to the seed separation chamber. At the seed separation chamber nozzles at the top spray water and wash the seed from the fruit flesh. The sprayed water carries the seed through the perforated cover and it is collect in a removable perforated tank placed inside the main tank.

Kachru and Sheriff. [9] designed an axial flow vegetable seed-extracting machine. In this machine the fruits were sliced, pulped, and seed were extracted. The pulp was discharged along with wash water. Wehner and Humphires [10] developed a single fruit seed extractor. A cone present in the machine excavated the seed in the central cavity of the fruit, then washed and collected the seed through a strainer. In this method 100% seed germination was recorded. Kingsly [11] fabricated a brinjal seed extractor. It consisted of a fruit-crushing chamber and seed separation unit. In the crushing chamber the brinjal fruit were crushed into pulp by crushing rods. The pulp was fed into the seed separation unit and continuously agitated by a shaft rotating at 35 rpm. Due to the difference in specific weight, the pulp floated and the seed sank in the bottom, and were collected through a seed outlet.

The objective of this study is to develop a mechanical melon seed extractor, which will improve the quality and quantity of melon seed extracted and reduce drudgery.

MATERIALS AND METHOD

The main factors that govern the design of crop processing machines are engineering properties of the material. In the design of melon seed extractor the knowledge of some physical and mechanical properties of melon fruit is essential. In this study some physical properties such as the (weight of the melon fruits, major diameter, minor diameter, volume) and mechanical properties such as the (compression and shear forces were determined). The values obtained were used in the design of the extractor.

Sample Collection and Preparation

Ripe melon fruits were collected from a farm in Nasarawa state of North Central Nigeria. Twenty melon fruits of various sizes were selected from the harvested fruits and were grouped into five groups of four fruit each. The grouping was done based on the sizes of the melon fruit and the fruit were labeled A to E. Group A_1 to A_4 represented the smallest size and E_1 to E_4 represented the largest sizes of melon fruit.

Determination of Some Engineering Properties of Melon Fruit

The physical properties studied were major diameter, minor diameter, mass and volume of the melon fruits and the mechanical properties were the compression and shear forces. These properties were required to determine the size of the hopper, the clearance between the crushing blade and the concave, the distance between blades and the force required to crush the melon fruit. Major and minor diameters were measured using a vernier caliper with accuracy of 0.01mm. Volume of melon was determined by water displacement [12]. The mass of each fruit was obtained using electronic weighing balance with 0.01g accuracy. The density was determined from the volume and weight measurements as:

$$density\ \left({}^{kg}\!/\!{}_{m^3}\right) = \frac{mass}{volume}\ .$$

The mechanical properties were determined using a 50kW capacity automated universal testing machine (testometric, series 500-532). All the measurements were replicated four times for five different sizes of the melon fruit.

Design Process

The melon seed extractor was conceived as a simple device which will remove seeds from the melon fruit and separate the seed from the pulp by water pressure. In the design process the following assumptions were made;

Desired drum speed = 300 rpm [8].

Length of drum = 1.52m

Power required to crush melon fruit; $P = F_T V$

Where

P = Power

V = Velocity of the rotary crusher

F_T = Total force required to fracture melon fruit

The force obtained from the mechanical properties test to crush the biggest melon fruit which was 1915N was used. The belt, pulley and Shaft selection was based on machine design theory; [13] [14].

Description and Operation of the Melon Seed Extractor

The machine is mainly made up of the following components as shown in figure 1 and figure 2.

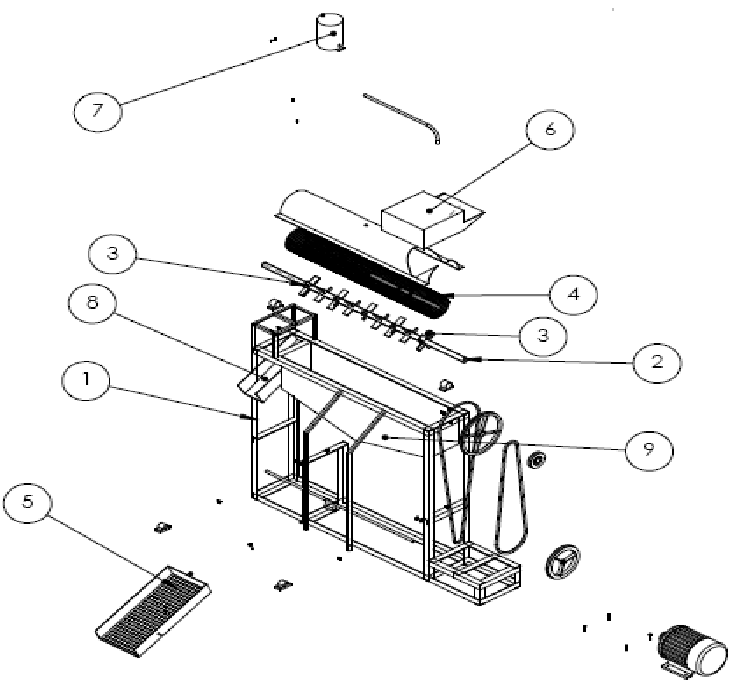

Fig. 1: Component Parts of the Melon Seed Extractor

S/no	Part name	Material	Qty
1	Frame assembly	Mild steel	1
2	Shaft	Mild steel	1
3	Rake and blade	Mild steel	1
4	Perforated Drum	Mild steel	1
5	Seed Collecting Sieve	Mild steel	1
6	Hoper	Mild steel	1
7	Water tanker	Mild steel	1
8	Shaft Outlet	Mild steel	1
9	Seed Outlet	Mild steel	1

Fig. 2: components of machine

Hopper: The hopper feeds and regulates material into the crushing chamber.

Shaft: The shaft which is 1.7m long and 30mm diameter rotate at 300rpm. It carries 12 pieces of rakes and 12 pieces of knives

Rakes: The rakes are mounted on the shaft to move materials along the axis of the shaft. They are made of 110 mm long mild steel flat bar

Blades: The blades are mounted on the shaft to crush the fruits as it revolves inside the crushing chamber.

Perforated Drum: The shaft blade and knife assembly were positioned inside the perforated drum. The seed from the crushed melon fruit drop through the perforation and the pulp is raked out through the pulp outlet.

Top Cover: Encloses the rotor completely.

Water Spraying Pipe: The pipe is fitted along the length of the rotor on top of the rotor cover. This delivers water inside the crushing chamber.

Pulp Outlet: It is the discharging unit for pulp after separation from seeds.

Seeds Outlet: This is the outlet for seeds into container

Fine Sieve: the fine sieve allows the collection of clean seeds on the top container and waste water at the bottom.

Frame: The frame carries all the components.

Electric motor: This is the source of power drive to the rotor, a 10hp electric motor is used for this purpose.

Mode of Operation of Melon Seed Extractor.

To operate the extractor effectively, the operator should be able to identify the major components parts and understand the basic working principles of each component. Figure 3 shows the isometric view of the melon seed extractor.

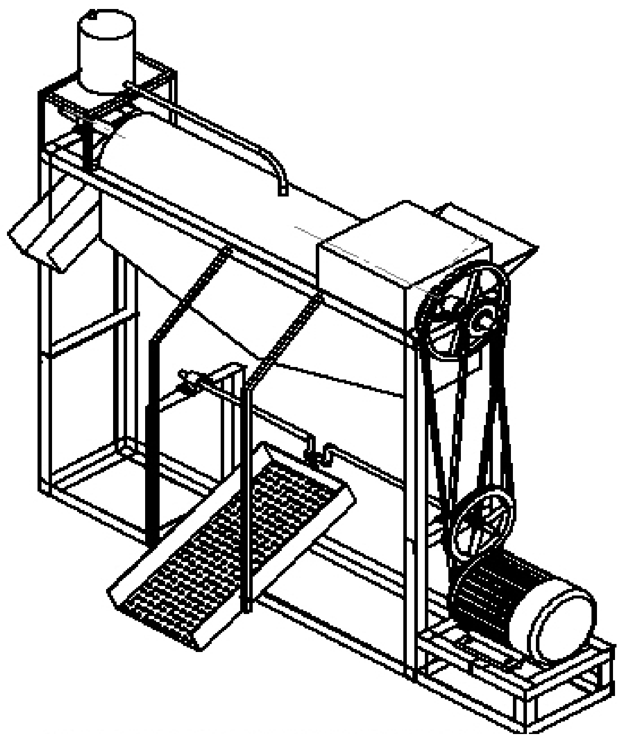

Fig. 3: Isometric View of the Melon Seed Extractor

The machine could be installed near a water source which is kept at least 1 meter above the extractor. This is because the machine works on the principles of wet seed extraction. After setting and starting, the operator feeds ripe melon fruits through the hopper uniformly into the crushing chamber. The water spray is operated simultaneously to feed water into the crushing chamber. The melon fruits are crushed by fast rotating blades and conveyed by the rakes mounted on the rotor. During this process sprayed water wash the seed out through the seed outlet. The crushed pulp is ejected out through the pulp collector. Finally the clean seeds are collected over a sieve and water is collected at the bottom of the sieve. This water can be re-circulated into the system continuously while in operation.

PERFORMANCE EVALUATION OF THE MACHINE

Test Sample Preparation

Five hundred (500) melon fruits of 0.6 ±0.1 kg weights were randomly picked and divided into five groups each of 100 fruits. The samples were weighed and subjected to different treatment as shown in the table 1. The last treatment which is the manually extraction was used as the basis to compute the extraction efficiency.

Table 1: Sample Preparation and Treatment.

S/No	No. of fruits	Sample	Total Weight (kg)	Treatment
1.	100	A	126.6	Whole fruits (not sliced and not fermented)
2.	100	B	137.5	Slice into two (not fermented).
3.	100	C	132.1	Sliced and fermented for three days
4.	100	D	120.4	Sliced and allowed to completely ferment for 7days
5	100	E	130.5	Fermented and the seeds were removed manually

Testing of the Machine

The machine was switched on and melon fruits (hundred fruits in each group) were fed with water being supplied. The time required to complete the extracting of seeds for each treatment was recorded. For each treatment seeds and waste were collected and dried. The dried waste for each treatment was winnowed manually and seeds recovered from them, and weighed. The extraction efficiency, seed separation efficiency, seed loss and the total seed to fruit ratio is computed using the relationship given below:

$$\text{Extraction Efficiency} = \frac{\textit{Percentage seed extracted}}{\textit{Percentage seed extracted using manual method}}$$

$$\text{Seed Separation Efficiency} = \frac{S_1 \times 100}{S_1 + S_2}$$

Where; S_1 = weight of seed collected from seed outlet (g)

S_2 =Weight of seed collected from the waste. (g)

M = weight of manually extracted seed (g)

$$\text{Seed loss} = = \frac{S_2 \times 100}{S_1 + S_2}$$

Total seed to fruit ratio = $\frac{S_1 + S_2}{fruit \quad weight}$

RESULT AND DISCUSSION

Result of the Engineering Properties Studied

Table 2: Result of the physical properties of melon fruits.

	Major Diameter (MD) mm	Minor Diameter (MnD) mm	Weight (g)	Volume (Ml)
Mean	100.78	104.93	604.5	642.75
S.D	24.71	23.37	418.07	486.37

Table two shows the mean and standard deviation for the physical properties studied. These values were used to determine the standard opening for the feeding of the fruit into the extractor, the arrangement of the crusher, and the blade size. The average value of the force required to crush the melon was obtained from the mechanical properties studied [15]. For this design the force required to crush biggest melon fruit (group E1 & E2) which is 1950N was used for computation.

Result of the Performance Evaluation of the Machine

Table 3: Time Required for extraction and Rate of Seed Extraction

S/No	Treatment	Time Taken (s)	Rate (Kg/s)
1.	A	207.6	0.609
2.	B	141.6	0.971
3.	C	120.0	1.101
4.	D	73.8	1.631
5.	E	14400	0.009

Table 3 shows the time taken to extract the sample and the rate of extraction in kg of melon fruit per second. From the table the sliced and fermented sample has the lowest time required to extract the seed and high extraction rate. While the whole unsliced sample has the lowest extraction rate. Slicing the melon fruit and fermenting eases the removal of seed thus reducing the time required to extract the seed. The manual extraction took 4 hours to remove the seed from the 100 fully fermented fruit. Thus the rate of extraction was very slow and the work very drudgery.

Table 4:. Total seed collected and seed to fruit ratio

S/No	Treatment	Weight of fruit (kg)	Seeds Collected (Kg)	Seed Recovered from dried waste (Kg)	Total seed weight	Total seed to fruit ratio
1.	A	126.6	1.180	0.0505	1.2305	0.0097
2.	B	137.5	2.355	0.0200	2.375	0.0173
3.	C	132.1	2.516	0.0102	2.5262	0.019
4.	D	120.4	2.317	0.0098	2.3268	0.0193
5	E	130.5	3.200	--	3.2	0.025

Table.4. Shows the weight of the seed collected from the seed out let and seed recovered from the pulp which is the waste. The seed extracted was dried before it is weighed. In sample E where the seed was extracted using manual method care was taken to remove all seeds from the fruit and no seed was left in the pulp. Thus it is assumed that 100 melon fruit of similar size has 3.2 kg of dried melon seed.

Table 5: Total seed collected, extraction efficiency and seed separation efficiency

Treatment	Weight of fruit	Seed collected	Seed from waste	Total seed	Extraction efficiency	Seed separation efficiency
A	126.6	1.180	0.0505	1.2305	39.6	95.89
B	137.5	2.355	0.020	2.375	70.55	99.16
C	132.1	2.516	0.0102	2.5262	77.9	99.59
D	120.4	2.317	0.0098	2.3268	81.57	99.57
E	130.5	3.200	--	3.2	100	100

The extraction efficiency was computed based the manually extracted melon seed. From the table extraction efficiency was highest when sliced and fermented melon fruits were fed into the machine. The highest extraction efficiency 81.57% was obtained when the fruit was completely fermented. The least efficiency 39.6% was obtained when whole unsliced fruits were fed into the machine. In this case some of the seeds would have been crushed and pulped with the waste. However cutting and fermenting enables the rakes to scoop out the fruit with the inner pulp and expose it to the running water which washes it and passes it through the seed outlet. While fermenting the flesh has lost griped on the seed inside and makes it easier to separate and clean the seed by the extractor due to biological activities that takes place. Also processing time for the fermented fruits is less as indicated in table 3. Generally the seed separation efficiency of the machine for all sliced treatments is high. However fermenting increases the efficiency and the quality of the seed. Generally the seed separation efficiency was very high for all the treatments. The seed was separated from the pulp with running water. Only in the unsliced sample the seed separation was 95.89 % while for all other treatments it is above 99%. Comparing with sample A, loss (4%) is greater than in sample B. From sample C and D, in which material were sliced and fermented, the efficiency of the machine was 99% and their seed losses were 0.67% and 0.74% respectively. Sliced and fermented melon fruits when fed into the extractor separate fester. The average input capacity of the machine is 10320 kg/ hour of melon fruits and output capacity is 140kg/ hour of melon seed. Approximately 60 liters of water is required per hour of operation.

CONCLUSION AND RECOMMENDATION

Conclusion

A simple melon seed extractor has been developed, preliminary test were carried out on the Extractor to ascertain its performance. The water spray and the reciprocating sieve provide necessary cleaning operation required. The cost, safety, durability and efficiency were critically taken into consideration in the design. The results of the preliminary tests carried out on the machine showed a very remarkable and promising success as far as the functional requirement of the Extractor is concerned.

Recommendation

The effort to develop a melon seed extractor to alleviate the problems experienced with manual method definitely conforms well with the National Policy on technology development.
Therefore, it would be very appropriate if users and future fabricators would take note of the normal mode of operation of the machine, maintain the required adjustments and precautions.

The melon fruit should be allowed to over ripe a little without slicing before feeding to the extractor to extracts the seed. This will alleviate the drudgery of slicing and fermentation of melon fruit and to save the farmer's time in the processing. More opening should be provided in the water spraying system for thorough washing in the extractor.

To reduce or minimize water waste especially where there is no enough water, filter and water pump should be installed at the bottom of the reciprocating sieve to re-circulate the used water for better water management.

REFERENCES

[1] Oyolu, C 1977. A quantitative and Qualitative Study of Seed Types in Melon, Melon Topical, pp 123-125
[2] NAERLS 1985. Study on melon production, ABU Zaria publication.
[3] Oloko S. A, B.J. Agun and A..G. Jimoh 2002. Design and Construction of a melon washing machine World journal of Biotechnology 3(2). 431-436.
[4] Aviara C. N. 1996. Design and construction of a simple manual melon washer. Unpublished PhD Thesis, Department of Agric. Engr. Obafemi Awolowo University Ife, Nigeria.
[5] NCAM 2002. Design and construction of melon washer, National center for Agricultural Mechanization, Ilorin

[6] Oloko S. and I Adbetoye 2006. Development and Performance Evaluation of Melon Depoding Machine. The CIGR Journal, Vol VII

[7] Akubuo C. O and Odigboh E. U. 1999. Egusi Fruit Coring Machine. J. Agric. Engineering Res. 74, Pp121 -126., Article No. 1999.0418 available online at http//www.idealibrany.com on IDEAL.

[8] Kailappan R., Varadharaju N., Krishnasaamy V., Parveen Kasur Baig and Appavu K. 2005. Fabrication and testing of Tomato seed Extractor, Journal of Agricultural Mechanization in Asia, Africa, and Latin America, Vol. 36 No. 2

[9] Kachru, R.P and J.T Sheriff. 1992. Performance Evaluation of Axial Flow Vegetable Seed Extractor. Indian Journal of Agricultural Engineering, 2(1): pp 37 – 40.

[10] Wehner T. C. and Humphires E. G. 1995. A fruit seed Extractor for Cucumbers, Horticultural Technology 5(3) pp 268 – 273

[11] Kingsly, A. R. P. 1998. Fabrication and Performance Evaluation of Brinjal Seed Extractor. Unpublished M.Eng Thesis, Tamil Nadu Agricultural University, Coimbatore.

[12] Mohsenin, N. N. 1986. Physical Properties of Plant and Animal Materials, Gordon and Breach Science Publishers , New York. Pp 20-85

[13] Khurmi A. and Gupta C. 2007. Machine Design India

[14] ASAE 1998. Standard Engineering Practices Data, ASEA Standard 45th edition, USA pp 156 – 160

[15] P. V. Kwaya, **Z. D. Osunde** and I. M. Dagwa 2009. Determination of Physical Properties of Melon Fruit . *Journal of Agricultural Engineering Technology (JAET)*; Vol 18,.No 1, pp 116 – 122.