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THROUGHPUT AND PERFORMANCE EVALUATION OF A DESIGNED AND FABRICATED EGUSI SHELLING MACHINE

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ABSTRACT
A motorized Egusi shelling machine was, designed, fabricated, and tested. The seeds samples that were used for the testes were divided into five treatments; storage moisture content, soaking for 0, 30, 60, 90 and 120 minutes. The results indicated that the best performance were obtained at the 60 minutes soaking period. The following results were obtained; throughput capacity of 6.98kgh^{-1}, coefficient of performance of 23.87%, percentage purity of 48.38%, wastage percentage of 14.80%.
Keywords: Throughput, Performance, Purity, Wastage

INTRODUCTION
Egusi (Citrullus Vulgaris, L) originated from Africa and Asia (Douglas, 1982). It is widely cultivated in the Caribbean, Indonesia and Africa.In Nigeria, the existence of Egusidates back to the 17th Century (Omidiji, 1977). Egusi is a popular fruit in Nigeria because of its edible seeds which are commonly used in the preparation of local soup or stew and snack such as fried egusi seed ball known as “robo” in south – west Nigeria. Recent statistics show that 100,000 and 480,000 metrictones ofequsi were produced in Nigeria in 1992 and 1997 respectively (Federal Office of statistics, 1998).

Among the post harvest operations of egusi are deppoding, cleaning and drying, and last one is shelling. In most cases, all these, operations are performed manually by farmers. A lot of time is usually wasted, besides the fact that manually handling of this operation is tedious as being a limitation to large scale production (Fashina, 1986). Hence the need for machines that can facilitate the post harvest operations becomes very necessary.
Fashina (1986) established that egusi seeds could be shelled mechanically either by mechanical or centrifugal impaction. He describes a straight uniformly rotating tube used as a centrifugal fan to impact uniform velocities to seeds. He also developed a simple device which constituted of tube rotating its axis thereby subjecting individual seed to an impact force. The impact force would throw the seeds against steel impact cylinder surrounding the tube.
Fashina (1986) revealed and explained many physical and aerodynamic properties of Egusi seeds that would aid the plan, design and fabrication of a separating units and egusi shelling machine. Furthermore, he (Fashina, 1986) looked in to physical properties such as shape, size, projected area and moisture content of egusi seeds.
The force exerted on the mixture of the shelling seeds of both epicarp and mesocarp were at the same time put into consideration. The force exerted by the air, produced by the vane of separation unit, is employed to separate the epicarp out of mesocarp (Fashina, 1998). He explained further that, by throwing the seeds into wind and recovering them in a tray, a farmer separates theepicarp from the

mesocarp. But the method is ineffective because some of the needed mesocarps are lost during the process. So the properties, he suggested, could help in designing a separating unit of a shelling machine.

MATERIALS AND METHODS

Operation of the Egusi Shelling Machine

The Egusi shelling machine was operated when the electric motor was switched on. The machine was allowed to run for five minutes before the Egusi seeds were introduced through the hopper. The falling seeds' shells were broken by the impact force of the vanes while the shells detachment from the seeds was by the rubbing action of the drum against the concave.

After this, the shelling Egusi seeds moved down to the separation unit. The separation unit separated the chaff and light weight seeds away from the kernels. Both the unshelled seeds and the kernels were collected from the seeds discharge outlets while the shells and immature seeds were collected from the shell outlet (Fig. 1)

Experimental Procedure

The Egusi seeds samples that were used were divided into five treatments; storage moisture content, soaking for 0, 30, 60, 90 and 120 minutes. Each treatment was fed to the running machine separately and samples were taken from seeds and shells outlets at intervals of two minutes. There were five replications per treatment. Each collected sample was weighed and later separated to whole kernels from seeds outlet, broken kernels, unshelled seeds, shells and kernels from the shell outlet.

Throughput of Egusi Shelling Machine

This is the total weight of the material discharged per hour of the machine. This comprises of the weight of the whole kernels, weight of unshelled seeds, weight of chaff and weight of broken seeds per hour of time.

$$\text{Throughput capacity (kg/h)} = \frac{(W_K + W_C + W_{US} + W_{KC})\text{kg}}{\text{Time (h)}}$$

W_K = Weight of whole kernels, kg
W_C = Weight of whole chaff, kg
W_{US} = Weight of unshelled seeds, kg
W_{KC} = Weight of broken kernels in chaff, kg

Fig. 1: Isometric View of Egusi Shelling Machine

Coefficient of Performance of Egusi Shelling Machine [C_p (%)]

This is the actual performance or efficiency of the Egusi shelling under different levels, of soaking period. It was calculated from the ratio of the weight of the whole kernels, $W_{K,}$ to the total weight of the sample after soaking, W_{sas} expressed in percentage.

$$CP\% = \frac{W_K}{W_{sas}} \times 100$$

Percentage Purity of the Seeds from the Egusi Shelling Machine [P_S (%)]

This was evaluated as the ratio of the weight of the whole kernel W_k to the total weight of the whole kernel W_K and the weight of the kernels in the chaff, $W_{KC,}$ expressed in percentage.

$$P_s (\%) = \frac{W_k}{W_k + W_{kc}} \times 100$$

Percentage Wastage from the EgusiShellin Machine ($W_{st,}$ %)

This was deduced from the ratio of the weight of the broken kernel in the chaff, W_{kc} to the total weight of the weight of the broken kernels in the chaff and the weight of the whole kernels, W_k expressed in percentage

$$W_{st} (\%) = \frac{W_{kc}}{W_{kc} + W_k} \times 100$$

RESULTS AND DISCUSSIONS

Throughput Capacity of the Egusi Shelling Machine

From the Table 1, the maximum value obtained was 6.98kgh^{-1} while the minimum was 2.27kgh^{-1}.It is to be recalled that the throughput capacity is not in percentage, then under 30minutes soaking period we have the maximum while under 120 minutes soaking period we have the minimum,values of average throughput capacity. The maximum value of standard deviation was deduced under 90 minutes soaking while the minimum value of standard deviation was obtained under 30 minutes and

120 minutes. Reason for this was due to that the weight of the seeds sample, used, were varied and the parameters used in calculating through are heterogeneous.

Table 1: Average throughput capacity of the Egusi Shelling Machine

Soaking period, minutes	0 minutes	30 minutes	60 minutes	90 minutes	120 minutes
Throughput kg/h	**Kg/h**	**Kg/h**	**Kg/h**	**Kg/h**	**Kg/h**
1	2.33	7.04	3.03	2.32	2.16
2	2.58	6.94	3.27	2.53	2.37
3	2.47	7.04	3.21	2.78	2.20
4	2.48	7.07	3.17	2.72	2.29
5	2.31	6.82	2.2.91	2.50	2.32
X	2.43	6.98	3.12	2.57	2.27
S.D	0.11	0.10	0.14	0.18	0.10

Coefficient of Performance, Cp %, of the Egusi Shelling Machine

Table 2 gave details about efficiency of the machine. From the table, it was unveiled that the highest value of average machine coefficient of performance fell under 60 minutes soaking period while the lowest average machine coefficient of performance appeared under 0 minutes i.e storage moisture content. The maximum value of standard deviation was 2.51 under 30 minutes soaking period, while the minimum value standard deviation was 0.26, under 120 minutes soaking period.

The maximum average coefficient of performance was 23.87% while the minimum value was 8.74%.

Table 2: Average coefficient of performance, Cp %, of the Egusi Shelling Machine

Soaking period, minutes	0 minutes	30 minutes	60 minutes	90 minutes	120 minutes
C_P	**%**	**%**	**%**	**%**	**%**
1	9.41	20.00	22.84	21.44	20.24
2	7.65	17.10	25 .60	20.60	19.50
3	8.83	16.90	25 .20	24.64	19.88
4	9.20	20.42	23.00	20.80	19.88
5	8.60	14 .30	22.70	20.61	19.89
X	8.74	17.74	23.87	21.50	19.87
S.d	0.69	2.51	1.41	1.46	0.26

Percentage Purity (Ps) of the Seeds from the Machine

Table 3: Average percentage, Ps, of the Egusi Shelling Machine

Soaking period, minutes	0 minutes	30 minutes	60 minutes	90 minutes	120 minutes
Ps %	**%**	**%**	**%**	**%**	**%**
1	23.10	44.35	43.80	43.36	41.75
2	25.59	33.63	53.91	45.39	42.29
3	23 .10	33.74	46.79	44.63	41.69
4	24.52	42.03	48.82		
5	23.50	32.00	48.56	43.27	41.30
X	23.96	37.15	48.38	43.67	41.62
S.D	1.08	5.62	3.69	1.42	0.46

Table 3 underscored, in detailed, percentage purity of the machine. From the table, maximum value of percentage purity fell under 60 minutes soaking period, and deduced to be 48.38% while the minimum value arose under 0 minutes, storage moisture content, and deduced to be 23.96%. The highest standard deviation value was found under 30minutes soaking period and was 5.62 while the lowest was 0.46, found under 120 minutes soaking period. This variation was a s a result of different in levels of period soaking from where the optimum soaking period, under coefficient of performance and percentage purity, was deduced to be 60 minutes for these analyses.

Wastage Percentage, W_{st}%, of the Egusi Shelling Machine

From the table 4, it was observed that the maximumvalue of wastage percentage, W_{st}% fell under 0 minutes soaking period, at storage value was content, and deduced to be 82.22% whereas the minimum value was deduced to be 14 .80%, which fell under 60 minutes soaking period, This actually showed the work and importance of soaking on the shelling, purity and wastage percentage of the machine.

Conclusively the 60 minutes soaking period gave the optimum average value of both coefficient performance (%), percentage purity and gave the least value of average percentage.

Table 4: Average Wastage Percentage, of the Egusi Shelling Machine

Soaking period, minutes	0 minutes	30 minutes	60 minutes	90 minutes	120 minutes
Wst %	**%**	**%**	**%**	**%**	**%**
1	79.51	14.60	11.21	15.77	19.61
2	83.91	16.32	13.65	23.01	21.83
3	81.97	12.12	13.85	18.21	21.29
4	82.38	15.37	14.73	24.30	21.7
5	83.29	29.25	20.55	17.93	21.74
X	82.22	17.53	14.80	19.84	21.25
S.D	1.71	6.73	3.47	3.63	0.94

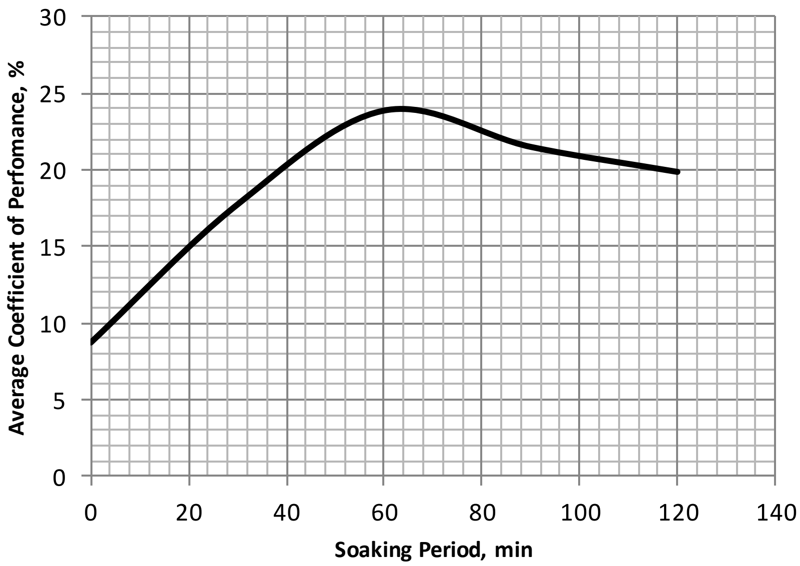

Fig 2: Average Coefficient of Performance (%) of the Egusi Shelling Machine versus Period of Soaking Minutes.

CONCLUSION

To know the actual efficiency of the machine, its coefficient of performance, C_p (%), explains better. Analyses of this Egusi shelling machine under variable of the seeds soaking period of constant drying period under the ambient environment condition show that the 60 minutes soaking period gave the optimum result which had been explain and interpreted. Graphically, in figure 2. Appendixes 1 – 5 give results of the analyses under 0, 30,60,90 and 120 soaking period.

APPENDIX 1:

Shelling Analysis for 0 Minutes at Storage M.C. Soaking Period

Descriptions	CAN A	CAN B	CAN C	CAN D	CAN E
Weight of sample before shelling (W_{sbs}) g	79.70	99.30	84.90	84.10	80.30
Weight of kernels fater shelling (W_k) g	7.50	7.60	7.50	7.70	6.90
Weight of unshelling seeds (W_{us}) g	16.00	16.60	15.80	15.30	13.10
Weight of chaff, (W_c) g	25.00	22.10	25.00	23.70	22.50
Weight of broken kernels in the chaff	29.10	39.80	34.10	36.00	34.40
W_{kc} coefficient of performance C_p (%)	9.41	7.65	8.83	9.20	8.60
% purity	23.10	25 .59	23.10	24.52	23.50
% impurity	76.90	74.41	76.90	75.48	76.50
Material discharge efficient (%) $(E_m) = \frac{WK + W_c}{W_{sbs}} \times 100$	40.78	30.00	38.28	37.34	36.61
Wastage & (W_{st})	79.51	83.97	81.97	82.38	83.29
Through put (kg/h)	2.33	2.58	2.47	2.48	2.31

APPENDIX 2:

Shelling Analysis for 30 Minutes at Storage M.C. Soaking Period

Descriptions	CAN A	CAN B	CAN C	CAN D	CAN E
Weight of sample before shelling (W_{sbs}) g	272.90	242.20	264 .30	269.50	244 .60
Weight of sample after shelling (W_{sas}) g	350.90	305.80	343.30	346.10	314.60
Weight of moisture added (W_m) g	78.00	63 .60	79.00	76.60	70.00
Moisture content (%) $M_s = \frac{W_m}{W_{abs}} \times 100$ (d.b)	28.60	26.30	29.30	28.40	28.60
Weight kernels $W_{kc,}$ g	70.20	53.30	58.00	58.90	45.00
Weight of unshelling seed, W_{us} g	64.30	65.50	54.60	70.70	68.10
Weight of chaff, W_c, g	88.10	103.20	113.90	97.50	95.70
Weight of broken kernels in the chaff, W_{kc}g	12.00	10.20	8.00	10.70	18.60
Coefficient of performance C_p (%)	20.00	17.10	16.90	20.42	14.30
% purity	44.35	33.63	33.74	42.03	32.00
% impurity	55.65	66.37	66.26	57.97	68.00
Material discharge efficient (%) E_m	45.11	50.85	50.07	45.19	44.72
Wastage % (W_{st})	14.60	16.32	12.12	15.37	29.25
Throughput (kg/h)	7.04	6.94	7.04	7.07	6.82

APPENDIX 3:

Shelling Analysis for 60 Minutes at Storage M.C. Soaking Period

Descriptions	CAN A	CAN B	CAN C	CAN D	CAN E
Weight of sample before shelling (W_{sbs}) g	272.90	242.20	264 .30	269.50	244 .60
Weight of sample after shelling (W_{sas}) g	350.90	305.80	343.30	346.10	314.60
Weight of moisture added (W_m) g	78.00	63 .60	79.00	76.60	70.00
Moisture content (%) $M_s = \frac{W_m}{W_{abs}} \times 100$ (d.b)	28.60	26.30	29.30	28.40	28.60
Weight kernels $W_{kc,}$ g	70.20	53.30	58.00	58.90	45.00
Weight of unshelling seed, W_{us} g	64.30	65.50	54.60	70.70	68.10
Weight of chaff, W_c, g	88.10	103.20	113.90	97.50	95.70
Weight of broken kernels in the chaff, W_{kc}g	12.00	10.20	8.00	10.70	18.60
Coefficient of performance C_p (%)	20.00	17.10	16.90	20.42	14.30
% purity	44.35	33.63	33.74	42.03	32.00
% impurity	55.65	66.37	66.26	57.97	68.00
Material discharge efficient (%) E_m	45.11	50.85	50.07	45.19	44.72
Wastage % (W_{st})	14.60	16.32	12.12	15.37	29.25
Throughput (kg/h)	7.04	6.94	7.04	7.07	6.82

APPENDIX 4:

Shelling Analysis For 60 Minutes At Storage M.C. Soaking Period

Descriptions	CAN A	CAN B	CAN C	CAN D	CAN E
Weight of sample before shelling (W_{sbs}) g	69.40	92.50	74.80	84.50	68.70
Weight of sample after shelling (W_{sas}) g	109.60	121.90	114.00	117.10	91.20
Weight of moisture added (W_m) g	40.20	29.40	39.20	32.60	22.50
Moisture content (%) $M_s = \frac{W_m}{W_{abs}} x100$	57.93	31.80	52.41	38.60	22.50
Weight kernels $W_{kc,}$ g	23.50	25.10	27.40	24.30	23.80
Weight of unshelling seed, W_{us} g	18.70	21.50	25.20	24.40	23.20
Weight of chaff, W_c, g	30.70	30.20	34.00	34.00	31.20
Weight of broken kernels in the chaff, W_{kc}g	4.40	7.50	6.10	7.80	5.20
Coefficient of performance C_p (%)	21.44	20.6o	24.04	20.80	20.61
% purity	43.36	45.39	44.68	41.68	43.27
% impurity	56.674.	54.61	55.37	58.32	56.73
Material discharge efficient (%) E_m	49.45	45.37	53.86	49.79	50.31
Wastage % (W_{st}) (%)	15.77	23.01	18.21	24.30	17.93
Throughput (kg/h)	22.32	2.53	2.78	2.72	2.50

APPENDIX 5:

Shelling Analysis for 60 Minutes at Storage M.C. Soaking Period

Descriptions	CAN A	CAN B	CAN C	CAN D	CAN E
Weight of sample before shelling (W_{sbs}) g	65.20	88.20	62.90	71.40	83.40
Weight of sample after shelling (W_{sas}) g	101.30	113.90	104.10	107.30	106.60
Weight of moisture added (W_m) g	36.64	22.56	39.58	35.46	23.20
Moisture content (%) $M_s = \frac{W_m}{W_{abs}} \times 100$	35.64	22.56	39.58	33.46	23.20
Weight kernels $W_{kc,}$ g	2050	22.20	20.70	21.20	21.60
Weight of unshelling seed, W_{us} g	17.80	20.20	18.00	18.70	18.90
Weight of chaff, W_c, g	28.60	30.30	29.00	30.40	30.70
Weight of broken kernels in the chaff, W_{kc}g	5.00	6.20	5.60	5.90	6.00
Coefficient of performance C_p (%)	20.24	19.50	19.88	19.76	19.89
% purity	41.75	57.71	58.35	58.91	58.70
% impurity	58.25.	57.71	58.35	58.91	58.70
Material discharge efficient (%) E_m	48.47	46.10	47.74	48.10	48.16
Wastage % (W_{st}) (%)	19.61	21.83	21.29	21.77	21.74
Throughput (kg/h)	2.61	2.37	2.20	2.29	2.32

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