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Prospects of Decortication Efficiency Improvement through Environmental Control in Selected Indigenous Varieties of Melon Seeds

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ABSTRACT

This study determined some properties of three indigenous melon seed varieties (Citrullus vulgaris, Citrullus lanatus and Lagenaria siceraria) as well as the best combination of treatment parameters that ensured optimal yield in relation to decortication. These were with a view to increasing the shelling efficiency of the melon seeds. The physical properties were determined using standard procedures after subjecting them to a combination of treatments involving seven levels of soaking time (5, 10, 15, 20, 25, 30 and 60 minutes) and four levels of freezing duration (30, 45, 60, and 75 minutes) after which the pretreated samples were then subjected to air-drying at ambient temperature. All three varieties of melon seeds exhibited maximum value of compressive stress at longitudinal orientation. C. vulgaris (Papa) at a combination of 10 minutes soaking time with 60 minutes freezing time was able to improve dehulling by 16.54% using the NCAM sheller. For C. lanatus variety the dehulling efficiency was increased by 28.15% when subjected to an optimum combination of 15 minutes soaking and 75 minutes freezing while L. siceraria variety was observed to have achieved 11.70% improvement in dehulling performance at an optimum combination of 60 minutes soaking and 45 minutes freezing time. The study concluded that pre-treatment of melon seeds could offer a better avenue for utilization of melon seeds in both domestic and industrial uses.

1. INTRODUCTION

Melon (local name: *Egusi*) is the English name for a wide variety of seeds obtainable from some plants in the *Cucurbitaceae* family which are found mainly in the warmer parts of the world. The plant consists of 118 genera with about 825 species. There are four types commonly found in West Africa, namely:

Cucumeropsis manii, *Citrullus lanatus, Lagenaria siceraria and Citrullus vulgaris*. The most popular among them are *C. lanatus* and *C. melus* while the common cultivars found in South Western Nigeria include *Bara, Serewe, Sofin* (Adekunle *et al.*, 2009). The seeds of *Bara* have a mean length of about 12 mm, width of 8 mm, thickness of 2.3 mm and weighs about 150 mg on the average.

Melon is popularly grown for its numerous dietary values and economic importance. According to Bankole *et al.* (2010) and Egbe *et al.* (2015), melon is an extensively cultivated and consumed oil seed crop in Nigeria and West Africa. The crop has also been reported as being the fourth most important in the world in terms of production (18 metric tons), after orange, banana and grape (Maduako *et al.,* 2006).

Studies have shown that there are several factors that affect the efficiency of decortication, threshing, shelling and de-hulling processes (Kabir and Fedele 2018). These can however be categorized into seed, operation and design parameters. Various authors have also established that the seed size is also an important factor to be considered as shelling efficiency tends to increase as seed sizes increase (Prashant, *et al.* 2013; Ogunsina and Bamgboye, 2014; Romuli, *et al.* 2015).

Melon is one of the valuable sources of vegetable protein and oil. Ground melon meals are commonly used in sauces, soups and condiments especially because it is rich in dietary proteins. A number of authors have investigated the nutritional composition of this seed and have discovered that it protein content is between 23.4 to 37.4, fibre content between 2.6-27% and ash content 3.6-3.7%. Ajibola *et al.* (1990) however reported a 50% fat content for the crop. According to Sobowale *et al.* (2015), the processing of melon is necessary to further diversify its use. Although this crop has a high potential especially for oil production, melon shelling has presented serious challenges to local processors. This has led to the under-utilization of the seeds. Many efforts have been made and many mechanical devices fabricated but the efforts hitherto have not been very encouraging. The highest recorded shelling efficiency for *C.lanatus* and *C. vulgaris* of the National Center for Agricultural Mechanization (NCAM) melon sheller at the optimum speed of 860 rpm were 92.44% and 79.69% respectively. The impact of moisture content on shelling effectiveness of a melon shelling machine as studied by Makanjuola (1975) revealed that the kernels could be separated more easily from the shells at low moisture contents and established that the most appropriate moisture content was 8.6% (wet basis).

From the reviewed literature, there is little information regarding the pretreatment of melon seeds prior to shelling. Studies carried out on the decortication of *Cucurbitaceae* seeds have shown that pretreatments can increase the shelling efficiency of such seeds (Idowu *et al.* 2019). This study was therefore undertaken to investigate the effect of pretreatments on the decortication of selected varieties of melon seeds to provide important data that may help optimize shelling using an existing melon shelling machine (NCAM Melon Sheller).

2. MATERIALS AND METHODS

2.1. Material Collection and Preparation of Samples

The three popular species of melon *Papa* (*Citrullus vulgaris*) (Plate 1), *Sofin (Citrullus lanatus*) (Plate 2) and *Igba* (*Lagenaria siceraria*) (Plate 3) were used for this study. Three varieties of melon seeds each weighing 20 kg were obtained from Sabo Market, Ile-Ife, Nigeria for the investigation. The seeds were physically inspected to ensure that all impurities such as stones, leaves etc. were adequately removed.


Plate 1: *Papa* (*C. vulgaris*)


Plate 2: *Sofin* (*C. lanatus*)


Plate 3: *Igba* (*L. siceraria*)

2.2. Determination of Physical Properties

A digital vernier caliper with a sensitivity of 0.001 µmm was used to obtain the length, width and thickness dimensions of a population of 120 seed from each of the varieties of the melon seeds. Geometric mean diameter was determined for each seed at specified soaking time from the average measurements of the length, width and thickness with the expression shown in Equation 1 while the sphericity (s) and aspect ratios were determined using equations 2 and 3 respectively presented by Mohsenin (1980):

$$D = (abc)^{1/3} \tag{1}$$

Where D is geometric mean diameter, a is length, b is width, c is thickness.

$$s = \frac{(abc)^{1/3}}{a} \tag{2}$$

Aspect ratio = b/a (3)

Mass was determined by weighing each unit seed of 100 seeds sampling in 3 replicates on an Electronic scale (Model Series) with an accuracy of 0.01g. The solid volume of the seeds, volume of circumscribed sphere and true density were determined as shown in equations 4-6 as presented by Mohsenin (1980)

$$Volume\ of\ Solid = (Sphericity)^3 X\ Volume\ of\ Circumscribed\ Sphere \tag{4}$$

Where:

$$Volume\ of\ Circumscribed\ Sphere = \frac{(\pi a^3)}{6} \tag{5}$$

True density of seeds was determined using Equation 6 as suggested by Mohsenin (1980)

$$True\ density = \frac{Mass\ of\ single\ seed}{Volume\ of\ that\ particular\ seed} \tag{6}$$

Bulk density was determined as a ratio of the mass of seeds in the cylinder to the volume of the cylinder. The porosity of the seeds was calculated from the values of the bulk and true densities by using the mathematical equation (Equation 7) suggested by Mohsenin (1980). Porosity, which is also referred to as the packing factor (PF), was also determined from the following relationship:

$$PF = \frac{Solid\ density\ of\ particles\ (TD) - density\ of\ packing\ (BD)}{Solid\ density\ of\ particles\ (TD)} \tag{7}$$

Where PF is the porosity, BD is the bulk density (g/mm^3) and TD is the true density (g/mm^3).

2.3. Determination of Mechanical Properties

Mechanical properties such as the compressive stress, strain, maximum loading at breaking of the seeds were determined using an Instron Universal Testing Machine (Model 3369, Norwood, USA, 50kN Max.) available at the Centre for Energy Research and Development, Obafemi Awolowo University, Ile–Ife, Nigeria. The melon seeds were inserted either longitudinally or axially with tip-up or down inside the machine. The compressive stress, strain and energy at impact were measured.

2.4. Pretreatments of Melon Seeds

The effect of freezing and soaking time on melon seeds were evaluated for three species of melon seeds. About 100 g of sample were soaked in water for 5, 10, 15, 20, 25, 30, and 60 mins duration. Samples (100 g) used for investigation into effect of freezing on each of the three varieties were weighed and placed in a deep freezer compartment and temperature monitored with the aid of a digital thermometer. The freezing time considered for the soaked samples were 30, 45, 60, 75 mins at -4 ^{o}C. The pretreated samples were sun-dried at ambient temperature to allow the frozen melon seed to thaw. The pretreated samples were then subjected to shelling under an available machine at National Centre for Agricultural Mechanization

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(NCAM), Idofian, Kwara State, Nigeria. The result of the 7 × 4 complete randomized design (CRD) with three replicates was then analyzed using analysis of variance (ANOVA).

2.5. The NCAM Melon Shelling Machine

The NCAM shelling Machine has an impeller type shelling unit, comprising a hopper, a rectangular shaped discharge chute, impeller blade, involute housing and powered by a 5 hp petrol engine (Plate 4). The prime mover rotates the shaft of the impeller blade and the collision against the involute housing brings about the shelling. The machine operates on the principle of kinetic energy absorbed by an object as a result of the impact of collision against a stationary wall. This cracks the seeds in a nut-shell and loosens the seed coat eases removal during separation.

Plate 4: NCAM melon sheller

2.6. Shelling of Pretreated Seeds

The pretreated melon seeds were decorticated using the NCAM melon sheller because it is a typical melon sheller available. Machine performance was evaluated by grading the melon seeds into: hulled and whole, hulled but broken, chaff and dehulled. The experiment was replicated thrice and recovery was determined by gravimetry. The speed of the machine was maintained within the range of 700-860 rpm as specified for efficient performance of the machine using the in-built speed regulator. The shelled seeds and the chaff were blown out by the impellers through the involutes housing unit which opens into the outlet end of the chute for easy discharge of products.

3. RESULTS AND DISCUSSION

3.1. Shape Indices of Whole and Dehulled Melon Seeds

A summary of experimental data as shown in Table 1 revealed that *Igba* (*L.siceraria*) seeds had the largest length, width and thickness for the seeds. *Sofin* (*C. lanatus*) seeds had the smallest dimensions and *papa* (*C. vulgaris*) seed was intermediate though with thicker shell hence the reason why it is also referred to as “thick edge melon”. Similarly, *Igba* (*L. siceraria*) kernels had the largest length and width hence called the long whitish melon. The volume-area properties of three melon varieties also showed that *Igba* had the largest seeds and kernels as discussed earlier on physical properties of melon. The observed results for the three varieties also correlates with observations made by Ige (1982).

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Table 1: Shape indices of whole and dehulled melon seeds in relation to shelling.

	Property	Whole seeds			Dehulled seeds		
		C. vulgaris	*C. lanatus*	*L. siceraria*	*C. vulgaris*	*C. lanatus*	*L. siceraria*
Axial dimensions	Length, a (mm)	15.13±1.0	14.10±0.83	20.85±1.71	12.54±0.90	12.50±0.91	16.14±1.31
	Width, b (mm)	9.46±0.77	8.62±0.63	8.65±0.61	7.07±0.58	7.20±0.54	7.26±0.65
	Thickness, c (mm)	1.83±0.25	1.64±0.02	2.44±0.59	1.66±0.23	1.62±0.24	1.59±0.59
	GMD (mm)	5.29±0.34	5.72±0.31	7.39±0.66	5.19±0.36	5.17±0.32	5.59±0.33
	AR	0.63±0.04	0.61±0.05	0.42±0.05	0.58±0.06	0.58±0.06	0.45±0.05
	Sphericity	0.35±0.02	0.41±0.02	0.36±0.04	0.41±0.02	0.41±0.03	0.35±0.03

Reported values are mean ± standard deviation; GMD: Geometric mean diameter; AS: Aspect ratio

3.2. Effect of Soaking and Freezing Time on the Shelling Efficiency for *C. vulgaris*

Results obtained from varying soaking and freezing time on the shelling efficiency of the NCAM melon sheller for *Citrullus vulgaris* as shown in Table 2 revealed that shelling efficiency for the machine increased as both parameters increased until the optimum level was observed at a combination of 10 minutes soaking time with 60 minutes freezing time which gave the highest shelling efficiency. This condition led to a 16.54% increase in shelling efficiency when compared with the control condition. After the optimum value was attained a decline in performance was observed, the shelling efficiency was lowest at a combination of 5 minutes soaking time combined with 30 minutes freezing time which also equated to a 75.80% reduction in efficiency of the shelling process. The observed reduction in the shelling efficiency could have been due to the effect of uneven expansion of imbibed water molecules during soaking brought about by the freezing stage of the pretreatment. This would have probably led to the formation of water crystals within the cells of the seed thereby causing structural deformation (hysteresis) when the thawing occurred before shelling of the *C. vulgaris* seeds.

Table 2: Effect of freezing and soaking time on shelling efficiency for *Citrullus vulgaris*

Soaking time (mins)	Freezing time (mins)			
	30	45	60	75
5	15.44	33.65	52.62	61.84
10	25.45	40.19	67.42	66.9
15	17.88	30.16	53.25	60.67
20	16.89	45.62	50.96	58.07
25	23.8	34.01	61.69	58.45
30	19.81	39.97	58.71	58.64
60	15.94	47.98	64.27	66.84
Control	57.85	57.85	57.85	57.85

3.3. Effect of Soaking and Freezing Time on the Shelling Efficiency for *C. lanatus*

Results from Table 3 shows that combining the different soaking and freezing times in conditioning the *Citrullus lanatus* variety before shelling with the NCAM melon sheller led to the highest shelling efficiency (60.67%) at a combination of 15 minutes soaking and 75 minutes freezing. This corresponds to a 28.15% increment in performance when compared to the values obtained from the control experiment. The machine was also observed to have had the lowest performance with a combination of 60 minutes soaking time and 60 minutes freezing time, this also translated to a 40.14% reduction in output when compared with control values. The observed reduction in the shelling efficiency of *C. lanatus* variety after 15 minutes soaking time and 75 minutes freezing time could also have been due to the effect of uneven expansion of imbibed water molecules during soaking brought about by the freezing stage of the pretreatment. This would have probably led to hysteresis and the consequent structural change in the *C. lanatus* seeds.

3.4. Effect of Soaking and Freezing Time on the Shelling Efficiency for *L. siceraria*

Pre-treatment of *Lagenaria siceraria* prior to shelling with the NCAM sheller as shown in the results on Table 4 revealed that combining the different soaking and freezing times lead to the highest shelling efficiency at a combination of 60 minutes soaking and 45 minutes freezing times. This treatment was observed to have led to 11.70% increment in performance when compared to the values obtained from the control experiment. The treatment also gave the lowest dehulling performance at a combination of 5 minutes soaking time and 30 minutes freezing time, this performance translated to a 35.74% reduction in when compared with results obtained under control condition. The relatively large length of soaking when compared with the other two varieties at optimum shelling condition shows that the seed coat had higher resistance to water penetration this must have also been responsible for the observed relatively lower freezing times. The observable reduction in the shelling efficiency of *L. siceraria* variety after 60 minutes soaking time and 45 minutes freezing time could also have been due to the effect of anomalous expansion of imbibed water molecules during freezing thereby leading to a hysteresis-like reaction causing structural change in the *L. siceraria* seeds.

Table 3: Effect of freezing and soaking time on shelling efficiency for *Citrullus lanatus*

Soaking time (mins)	Freezing time (mins)			
	30	45	60	75
5	58.39	63.09	58.71	63.22
10	57.17	52.68	53.14	74.44
15	58.30	58.67	81.18	89.49
20	57.42	55.18	63.54	73.85
25	58.73	61.00	64.06	69.06
30	58.20	56.53	54.12	67.49
60	58.59	55.55	41.80	67.23
Control	69.83	69.83	69.83	69.83

Table 4: Effect of freezing and soaking time on shelling efficiency for *Lagenaria siceraria*

Soaking time (mins)	Freezing time (mins)			
	30	45	60	75
5	44.87	44.89	56.91	58.39
10	50.01	61.00	56.56	57.17
15	48.89	61.55	50.45	58.30
20	45.56	58.08	45.49	57.42
25	49.30	54.37	57.40	58.73
30	34.12	53.87	61.88	58.20
60	45.52	78.00	64.40	58.59
Control	69.83	69.83	69.83	69.83

3.5. Summary of Statistical Analysis

Statistical analysis of results done by analysis of variance as displayed on Table 5 shows that the effect of the seed shape had a significant effect on the performance/efficiency of the sheller in the dehulling process of the three varieties of melon. Further investigation also revealed that the combined effect of soaking and freezing times also was significant in the shelling characteristics of *C. vulgaris* while all other interaction effects with the exception of combined effect of soaking and freezing times was significant for *L. siceraria.* This shows that *L. siceraria* variety is highly sensitive to changes in virtually all of the considered parameters and therefore extra care needs to the taken in conditioning of the *L. siceraria* seeds.

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Table 5: Comparison of critical values from analysis of variance for the effect of soaking time, freezing time and shape indices on shelling quality of melon seeds

Source	DF	*C.vulgaris*		*C. lanatus*		*L. siceraria*	
		F Value	Pr > F	F Value	Pr > F	F Value	Pr > F
Soaking time	6	1.18	0.319	1.41	0.2136	0.49	0.8149
Freezing time	3	0.31	0.8147	2.23	0.0867	0.26	0.8565
Shape indices	18	2,47	0.0001*	5,63	0.0001*	1,110.48	0.0001*
Soaking *freezing time	2	1.52	0.0873	1.93	0.0166*	0.68	0.8228
Soaking time*shape indices	12	0.64	0.8098	0.44	0.9450	3.33	0.0002*
Freezing time*shape indices	6	0.84	0.5371	1.17	0.3271	5.31	0.0001*
Soaking*freezing*shape indices	36	0.83	0.7393	0.82	0.7496	3.41	0.0001*

*ANOVA is significant at 0.05

4. CONCLUSION

Pretreatment of *Citrullus vulgaris* (*Papa*) at a combination of 10 minutes soaking time with 60 minutes freezing time was able to improve dehulling by 16.54% using the NCAM sheller. For *Citrullus lanatus (Igba*) variety however the dehulling efficiency was increased by 28.15% when subjected to an optimum combination of 15 minutes soaking and 75 minutes freezing while *Lagenaria siceraria* (*Sofin*) variety was observed to have achieved 11.70% improvement in dehulling performance at an optimum combination of 60 minutes soaking and 45 minutes freezing times. The study concludes that pre-treatment of melon seeds could offer a better chance of utilization of melon seeds for both domestic and industrial uses.

5. CONFLICT OF INTEREST

There is no conflict of interest associated with this work.

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