Progress in Agronomic, Nutritional and Engineering Development Research on Treculia africana Tree Crop*

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Abstract

African breadfruit (*Treculia africana* var. africana Decne) is an underutilised tree crop in the family Moraceae. An evergreen forest fruit tree in tropical Africa, it produces large round compound fruits which are covered with rough pointed outgrowths. The seeds are buried in spongy pulp of the fruits. It is an important food item in parts of tropical West Africa, and is variously cooked as pottage, or roasted and sold with palm kernel (*Elaeis guineensis* Jacq) or coconut as a roadside snack. The flour has high potential usage for pastries production. The seeds are very

*Paper presented at the 3^{rd} International Conference on Neglected and Underutilized Species (NUS): for a Food Secure Africa. Accra, Ghana, 25^{th}–27^{th} September 2013. Bioversity International, Rome, Italy nutritious and constitute a vital source of vitamins, minerals, proteins, carbohydrates and fats. This paper reports recent efforts to upgrade the value chains of some varieties of *Treculia Africana* found in parts of Ghana and Nigeria. Particular attention is paid to progress in agronomic, nutritional and engineering development research, as well as consumer preferences after alternative processing operations. The agronomic studies showed that seed sterilisation resulted in a lower proportion of deformed seedlings. About 63% of seedlings arising from seeds previously treated with 10% dilution of NaOCl had true leaves and each seedling thereof had more leaves. The nutritional studies determined the best methods of seed extraction and demucilagination for use in high-quality flour production. The production of pasta, breakfast meal and good-quality oil are also demonstrated. Design, construction and testing of a continuous flow machine for depulping the partially fermented fruits resulted in potential significant reduction in the drudgery associated with manual processing. The best conditions for dehulling the seeds after parboiling were determined. Consumer preferences for several derived products were very high. For more effective widespread introduction of the tree crop into the food chair, efforts to extend the mature technologies and full mechanization of the depulping and other post-harvest operations should be sustained.

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1 INTRODUCTION

1.1 Importance

1. African breadfruit (Treculia africana var. africana Decne) belongs to the family Moraceae. It is an evergreen forest fruit tree in tropical Africa.

2. As shown in figure 1, the plant produces large compound fruit, usually round, and covered with rough pointed outgrowths. The seeds are buried in spongy pulp of the fruits.

(a) Trunk flutting (b) Fruit attachment (c) Typical simple leaf

Figure 1: Treculia africana tree in Nigeria showing fruit attachment and leaf structure

Source: Mbah (2005)

3. Some varieties of *Treculia Africana* and *Artocarpus altilis* (also called breadfruit) are produced and used in Ghana, as shown in figure 2.

Figure 2: Breadfruit varieties in Ghana
Source: Oduro *et al* (2007)

4. The seed is an important food item, popularly known as ”Ukwa” by the Igbo tribal group of southeastern Nigeria. Three varieties of the seeds reported by Akubuo (2006), are shown in figure 3.

(a) Large sized (*Var africana*) (b) Medium sized (*Var inverse*) (c) Small sized (*Var molis*)

Figure 3: Different varieties of the breadfruit seeds
Source: Akubuo (2006)

5. The seed is variously cooked as pottage, or roasted and sold with palm kernel (Elaeis guineensis Jacq) as roadside snack, as shown in figure 4(a). The flour has high potential usage for pastries

6. Figure 4(b) shows samples of processed *Treculia Africana* on sale by peasant farmers.

7. Figure 4(c) shows cooked breadfruit on sale as pottage in a restaurant.

(a) Roasted

(b) Parboiled

(c) Cooked

Figure 4: Processed breadfruit on sale in Nigeria

8. The seeds are highly nutritious and constitute a vital source of vitamins, minerals, proteins, carbohydrates and fats (Okafor and Okolo, 1974).

9. African breadfruit is an important natural resource in parts of tropical West Africa, contributing significantly to the income and dietary intake of the people.

1.2 TARP

The Treculia Africana Research Project (TARP) was concieved to

1. Improve the widespread use and acceptability of the crop
2. Develop early maturing varieties of the crop to facilitate the development of commercial plantations and orchards
3. Develop mechanical equipment for its processing (especially depulping & dehulling)
4. Develop modern food and beverages from the crop
5. Upgrade the value chain of the crop.

The Project team comprises a number of scientists and engineers drawn from Universities in Nigeria and Ghana. The present report surmarises the most recent results obtained by members of the team facilitated by an initial funding from the African Forestry Research Network (AFORNET) of the African Academy of Sciences (AAS).

2 SEEDLING QUALITY

Baiyeri and Mbah(2006a) evaluated the effects of factorial combinations of four storage duration (in days after seed extraction) and surface sterilization with three dilution levels of sodium hypochlorite on seedling emergence and quality. The specific objective was to identify the after-ripening treatment that could boost seedling emergence percent and the quality of seedlings obtained thereof.

1. The experiment was conducted in a controlled environment in the Department of Crop Science, University of Nigeria, Nsukka, Nigeria, between July and September 2003. Seeds were extracted from a single ripe fruit of Treculia africana var. africana. Seeds were washed and only viable seeds, determined by floatation method, were used. The seeds were air-dried for a couple of hours and only properly filled seeds were sorted out for use. Six hundred well-filled seeds were finally se-

lected for the experiment.

2. The experiment was a factorial laid out in a completely randomized design. The factors were number of days in storage and sterilization with sodium hypochlorite (NaOCl, 3.5% active ingredient). Storage durations were 0, 3, 6, and 9 days, while levels of sterilization were 100% water (control), 90% water plus 10% NaOCl (10% dilution) and 95% water plus 5% NaOCl (5% dilution). There were therefore, 12 treatment combinations, each replicated five times, and each replicate were sown with ten seeds.

3. Parameters measured included number of days to seedling emergence, percent cumulative emergence, total number of true leaves produced by emerged seedlings per treatment combination, percent emerged seedlings that had produced true leaves and percent deformed seedlings.

4. Data were analyzed following factorial in a completely randomized de-

sign procedure. Means separation to detect the effects of storage, sterilization and storage by sterilization interaction were by Least Significant Difference (LSD) at 5% probability level.

5. Seeds stored for three or six days before planting emerged earlier than those planted immediately after extraction from the fruit pulp or those stored for nine days. Cumulative percent seedling emergence was statistically similar if seed planting was not delayed beyond six days of extraction (Table 1).

Table 1: The main effect of number of days of seed storage on seedling emergence and seedling quality.

Days in storage	DFSE	PTE	PDS	PSTL	NTL
0	14.5	94.0	44.4	68.4	14.1
3	13.0	90.0	27.5	71.4	14.1
6	12.6	90.0	47.4	38.7	7.4
9	19.0	76.7	0.0	30.9	5.3
$LSD_{(0.05)}$	1.7	8.7	13.3	15.5	3.3

DFSE: Number of days to first seedling emergence; PTE: Percent total seedling emergence; PDS: Percent deformed seedling; PSTL: Percent seedling with true leaf; NTL: Number of leaves per treatment.

6. Seed sterilization resulted into lower proportion of deformed seedlings. About 63% of seedlings arising from seeds previously treated with 10% dilution of NaOCl had true leaves and each seedling thereof had more leaves (Table 2).

Table 2: The main effect of surface sterilization of seed with various dilution of sodium hypochlorite on seedling emergence and seedling quality.

Sterilization	DFSE	PTE	PDS	PSTL	NTL
10% dilution	15.5	88.0	19.9	62.5	12.5
5% dilution	14.5	84.5	23.7	49.6	9.7
Control (Water)	14.4	90.5	45.8	44.9	8.6
$LSD_{(0.05)}$	ns	Ns	12.1	13.4	2.9

DFSE: Number of days to first seedling emergence; PTE: Percent total seedling emergence; PDS: Percent deformed seedling; PSTL: Percent seedling with true leaf; NTL: Number of leaves per treatment.

7. The combined effects of storage and sterilization on days to seedling emergence and percent cumulative seedling emergence are shown in Figure 5

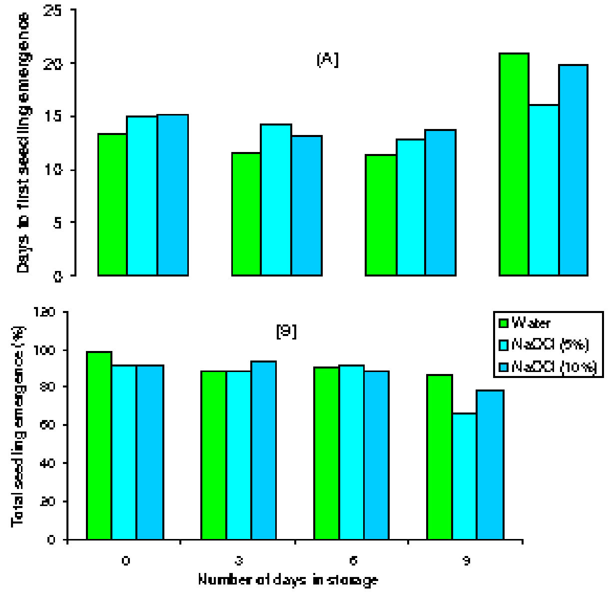


Figure 5: The effects of number of days of seed storage and surface sterilization with sodium hypochlorite at different dilutions on (A) days to first seedling emergence and (B) percent total seedling emergence.

8. Higher proportion of seedlings arising from seeds earlier sterilized with 10% dilution of NaOCl and planted within six days of extraction, produced true leaves (Figure 6(a)).

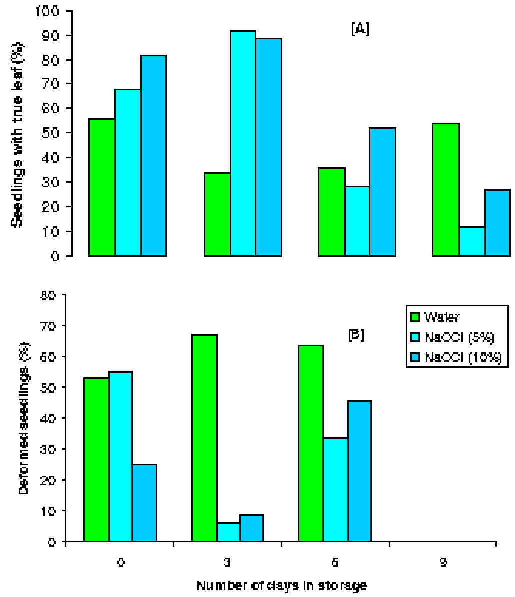


Figure 6: The effects of number of days of seed storage and surface sterilization with sodium hypochlorite at different dilutions on (A) percent seedlings with true leaves and (B) percent deformed seedling.

9. Seeds planted three days after extraction showed distinctively the effect of sterilization on foliage development. Deformity is unwanted. It results into seedlings unfit for field establishment.

10. Figure 6(b) showed that there were no deformed seedlings arising from seeds stored for nine days.

3 NURSERY MEDIA

The effects of soilless and soil-based nursery media on seedling emergence, growth and response to water stress of African breadfruit (Treculia africana Decne) was investigated (see Baiyeri and Mbah, 2006b).

1. **Experiments:** Two experiments were conducted in the research land of the Department of Crop Science, University of Nigeria, Nsukka, Nige-

ria, between November 2002 and August 2003. The seedling emergence and growth experiment was set up under blue polyethylene-shade, while the water stress experiment was conducted at the corridor of the departmental building to avoid rain water reaching the plants. Treatments were four nursery potting media. The media were formulated on volume ratios of ricehull, poultry manure and river sand; the control treatment was a soilbased medium.

2. **Seedling Growth** Seedling growth parameters and dry matter yield and distribution were measured at the 24^{th} and 26^{th} weeks after planting, respectively. Leaf samples were analyzed for mineral elements. Data were analyzed following completely randomized design procedure. Means separation to detect the effects of potting media was by Least Significant Difference (LSD) at 5% probability level.

3. **Potting media** There were some slight variations in both physical and chemical composition of the potting media (Table 3). Water holding

capacity ranged between 28% (for medium 1:2:3 RHB) to 74% (for medium 2:3:1 RHB). The percent organic matter was lowest (1.8%) for the soil based medium and highest (6.88%) for medium 2:3:1 RHB. Elemental composition was relatively similar.

Table 3: Physicochemical properties of nursery potting media evaluated for African breadfruit seedlings.

	Potting media*			
Properties	1:2:3 SB	1:2:3 RHB	1:4:3 RHB	2:3:1 RHB
Physical				
Total sand (%)	86.0	90.0	88.0	92.0
Silt (%)	4.0	2.0	4.0	2.0
Clay (%)	10.0	8.0	8.0	6.0
Water holding capacity (%)	36.0	28.0	48.0	74.0
Chemical				
Organic carbon (%)	1.12	1.16	1.60	3.99
Organic matter (%)	1.98	2.00	2.76	6.88
Total nitrogen (%)	0.30	0.28	0.48	0.16
Potassium (%)	0.18	0.16	0.16	0.24
Phosphorus (%)	0.22	0.24	0.20	0.26
Calcium (%)	0.26	0.12	0.28	0.30
Magnesium (%)	0.13	0.06	0.10	0.21
Sodium (%)	0.19	0.20	0.20	0.32
pH (H_2O)	5.8	6.9	6.3	5.4
Correlation matrix showing the relationship between the physicochemical properties				
	1:2:3 SB	1:2:3 RHB	1:4:3 RHB	2:3:1 RHB
1:2:3 SB	1.00	0.994**	0.993**	0.949**
1:2:3 RHB		1.00	0.977**	0.915**
1:4:3 RHB			1.00	0.979**
2:3:1 RHB				1.00

Potting media*: SB: Soil-based; RHB: Ricehull-based. Media were formulated as v/v/v ratios. First ratio in the formulation is topsoil (SB medium), and ricehull (for RHB media). The second and third ratios are poultry manure and river sand, respectively.

4. **Seedling emergence** The percent emergence was generally low and spanned through eight weeks (Table 4).

Table 4: Effect of potting media and weeks after planting on African breadfruit seedling emergence.

	Weeks after planting						
Media*	2	3	4	5	6	7	8
1:2:3 SB	0.0	8.0[¥]	13.0	14.0	17.0	18.0	18.0
1:2:3 RHB	3.0	37.0	45.0	53.0	56.0	57.0	57.0
1:4:3 RHB	0.0	11.0	30.0	34.0	38.0	39.0	41.0
2:3:1 RHB	1.0	26.0	39.0	42.0	46.0	51.0	52.0
LSD(0.05)	ns	15.5	13.6	13.0	13.8	13.3	13.4

¥Seedling emergence (%).

5. **Percent emergence** However, percent seedling emergence was consistently highest in medium 1:2:3 RHB and lowest in medium 1:2:3 SB. There was no more appreciable increase in percent emergence after the sixth week of planting.

6. Onset of seedling emergence

Figure 7 shows apparent variability in days to onset of seedling emergence as influenced by potting media. The soil-based medium which had the poorest total emergence similarly had the longest days to first seedling emergence. The earliest days to seedling emergence was obtained in medium 1:2:3 RHB.

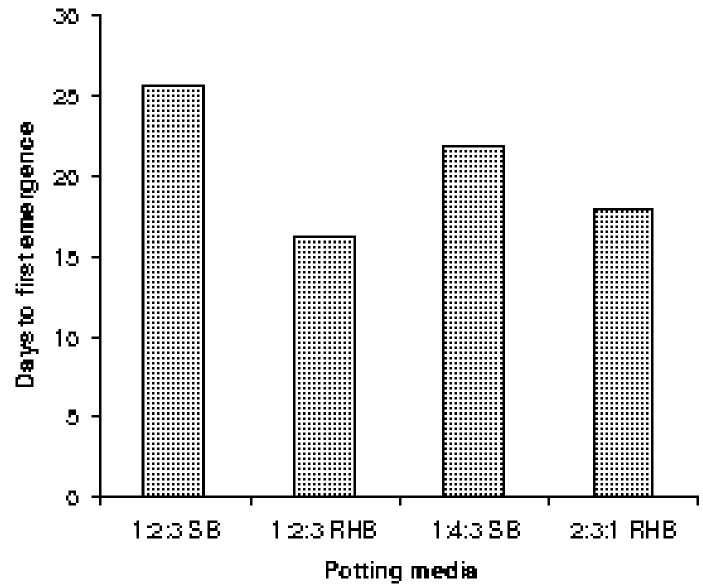


Figure 7: Variations in number of days to onset of African breadfruit seedling emergence as influenced by potting media.

7. Seedlings raised in medium 1:4:3 RHB had more leaves, longer stem and thicker stem girth at 24 week after planting (WAP). However, seedlings that grew in the soilbased medium had longer roots (Table 5).

Table 5: Variations in African breadfruit seedling growth parameters at 24 weeks after planting as influenced by potting media.

Media*	Number of leaves	Stem length (cm)	Stem girth (cm)	Root length (cm)
1:2:3 SB	13.0	20.4	0.84	25.8
1:2:3 RHB	10.9	21.4	0.98	17.6
1:4:3 RHB	12.8	26.9	1.24	20.8
2:3:1 RHB	12.5	24.8	1.12	18.8
LSD(0.05)	ns	ns	0.23	ns

8. Total dry matter was higher in soil-based medium followed by those grown in 1:4:3 RHB (Table 6).

Table 6: The effect of potting media on African breadfruit seedling total dry matter yield, dry matter distribution, and dry matter content at 26 weeks after planting.

		Dry matter distribution (%)		
Media*	**Total dry matter (g)**	**Leaves**	**Stem**	**Root**
1:2:3 SB	16.0	35.2	28.8	36.0
1:2:3 RHB	8.1	30.8	34.2	35.0
1:4:3 RHB	11.6	26.2	35.4	38.4
2:3:1 RHB	9.9	27.0	34.6	38.3
LSD(0.05)	ns	3.0	3.1	Ns
		Dry matter content (%)		
Media*	**Whole plant**	**Leaves**	**Stem**	**Root**
1:2:3 SB	31.3	30.8	33.8	30.2
1:2:3 RHB	41.0	38.1	49.2	40.9
1:4:3 RHB	34.1	33.9	37.2	31.9
2:3:1 RHB	36.3	34.8	37.7	36.3
LSD(0.05)	3.9	2.4	Ns	2.9

9. **Mineral compositions** Mineral compositions of the leaves were, in most cases, statistically similar (Table 7).

Table 7: Macronutrient contents of African breadfruit leaves at 26 weeks after planting.

	Nutrients (%)				
Media*	N	P	K	Ca	Mg
1:2:3 SB	1.20	0.28	0.27	1.20	0.63
1:2:3 RHB	1.16	0.29	0.27	1.40	0.72
1:4:3 RHB	1.23	0.31	0.25	1.40	0.84
2:3:1 RHB	1.31	0.29	0.24	1.20	0.72
LSD(0.05)	ns	0.01	ns	ns	ns

10. However, seedlings that grew in medium 1:4:3 RHB had higher values for leaf mineral elements except percent nitrogen.

11. Seedlings used for the water stress were statistically similar in height and they produced similar number of leaves during the stress period (Table 8).

Table 8: Variability in African breadfruit seedling responses to water stress as influenced by potting media.

Media*	PHTonset	DLT1	DLT5	DLYL1	NL3WAS
1:2:3 SB	30.6	21.4	25.4	25.1	1.8
1:2:3 RHB	26.8	32.4	47.1	36.1	1.8
1:4:3 RHB	29.8	35.5	42.1	36.9	1.9
2:3:1 RHB	27.1	42.2	57.5	45.4	1.6
LSD(0.05)	ns	5.6	11.7	11.5	ns

12. Loss of turgidity

The duration between the onset of loss of turgidity and when all leaves have drooped as influenced by potting media is shown on Figure 8. All leaves on seedlings raised in the soil-based medium lost turgidity within four days. Whereas, it took about 15 days between onset and complete loss of turgidity by all leaves for seedlings raised in media 1:2:3 RHB and 2:3:1 RHB. Leaf yellowing followed a similar trend of loss of turgidity.

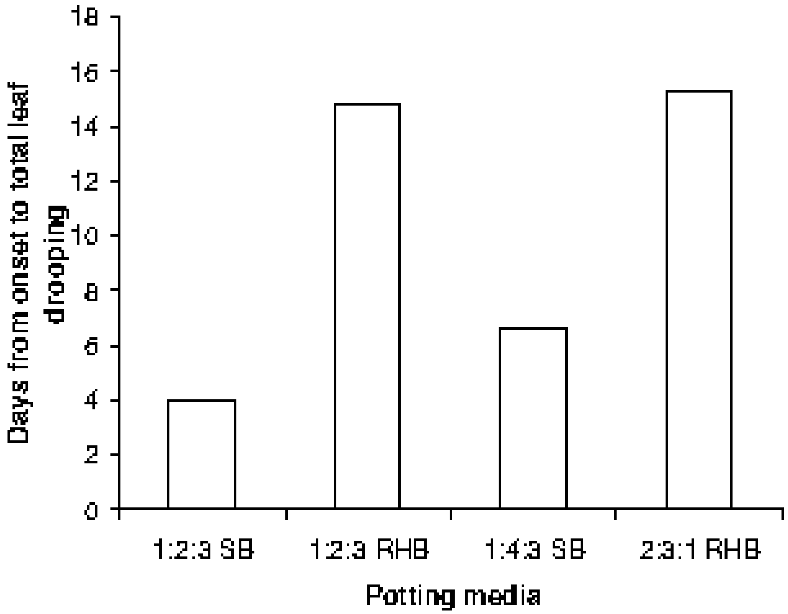


Figure 8: The effect of potting media on number of days between commencement of loss of turgidity by the oldest leaf and loss of turgidity by all leaves on each African breadfruit seedling.

13. Evidences from the seedling emergence, seedling growth, and seedling dry matter content and distribution, and seedling responses to water stress suggested that media 1:2:3 RHB and 2:3:1 RHB were adjudged the best soilless media. Seedling grown in these media had delayed water stress symptom expression suggest a better water economy.

4 DEPULPING

Depulping is the most labour-intensive and least mechanized post-harvest processing operations for *Treculia Africana*. This necessitated the development of a manual depulping machine as reported in Enibe (2001). Improvements on this initial version resulted in the continous-flow version reported in Enibe *et al* (2011).

1. The machine consists of four main units, namely the hopper/depulping chamber, the connector-pipe, the separation chamber and power system.

2. The present machine was designed to achieve the following objectives:

    (a) Low Cost: The machine was conceived to be cheap to fabricate, operate and maintain, and this was achieved by the use of readily available materials in constructing the machine.

(b) Ease of Fabrication, Operation, Assembly and De-assembly for maintenance: This was achieved by the extensive use of screw fasteners to hold different components together.

(c) Durability: The various components were designed to be durable in order to eliminate frequent breakdown of the machine.

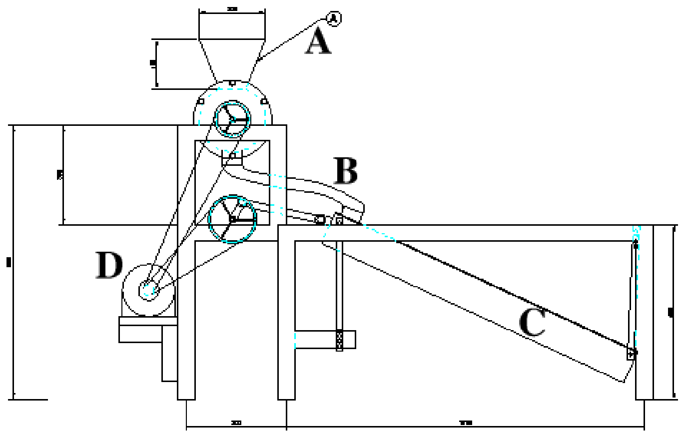
(d) Minimal water consumption.

(e) Minimal manual handling: This was in order eliminate the messy nature of the traditional processing method, and this was achieved by the continuous flow process of operation.

3. Drawing from the experiences gained in developing the version reported in Enibe (2001), a continuous flow machine with the general appearance shown in figure 9(b) was concieved.

A: Hopper/depulping chamber; **B:** Connector; **C:** Separator; **D:** power transmission system

(a) key



(b) Schematic diagram

(c) Hopper/depulping chamber

Figure 9: General view of the continuous flow depulping machine

4. A computer program for the sequence, "SIXBAR" reported in Norton (1999) was used to analyze the system and obtain values of linear and angular positions, velocities, accelerations and forces in the links in the system. Kinematic and dynamic analysis were also carried out.

5. To construct the hopper, 20 gauge galvanized steel was cut into the shape of the development of the frustum of a cone, and rolled mechanically to form the hopper's shape and joined at the ends. A photograph of the unit integrated with the depulping chamber is shown in figure 9(c).

6. The separation chamber tray was also fabricated from gauge 20 galvanized steel sheets.

7. It was formed into the desired shape mechanically and covered beneath with a metal mesh. Baffles were welded to the inner sides of the tray and attached to the metal mesh base using copper wires.

8. A water spray tank cover was fabricated from gauge 22 galvanized steel sheets. Holes were punched into the base to create outlets for jets of water. A plastic back-nut was screwed to the top of the tank to create an inlet for water. Holes were drilled into the sides of the tray using a hand drill to allow for the attachment of the rockers by means of M12 bolts and nuts.

9. An inside view of the separation chamber is shown in figure 10(a), while top and bottom views of the water tank constituting the cover are shown in figure 10(b) and (c). The baffles may be clearly seen inclined at an angle to the tray axis.


(a) Separator tray (b) Top View (c) Bottom View

Figure 10: Separator tray and Water tank doubling as separation chamber cover

10. As a preliminary evaluation of the machine performance, the effect of the level of fermentation and the method of feeding were investigated for the de-pulping chamber only and for a shaft speed of 316.7 rpm.

11. In order to determine the effectiveness of the de-pulping chamber, 2042 cm^3 (2 litres) of well fermented fruit was introduced into the hopper, the machine was started and water supplied. The machine was kept running until all the fruit introduced had passed through the de-pulping chamber and collected at the chamber outlet. The machine was turned off. The quantity of water consumed as well as the time taken to complete the operation was determined.

12. The seeds in the slurry collected at the outlet were sorted to obtained the number of seed completely de-pulped, N_1, the number of seeds partially de-pulped, N_2 and the number of broken seeds, N_3. Fractions of completely de-pulped seeds N_1/N_0, partially de-pulped seeds N_2/N_0, and broken seeds N_3/N_0, were computed and expressed as percentages.

The effectiveness was given by the first expression N_1/N_0 and the ineffectiveness by [100 - effectiveness]. Where the total number of seeds collected was $N_0 = N_1 + N_2 + N_3$.

13. the effect of the level of fermentation and method of feeding on the machine performance is shown in figure 11. It may be seen that the effectiveness of the machine improved with intermittent feeding of the fruit into machine as opposed to choke/batch feeding. Also, the effectiveness improved when processing partially fermented fruit against well fermented fruit.

A = batch feeding of completely fermented fruit; B = intermittent feeding of completely fermented fruit; C = intermittent feeding of partially fermented fruit.

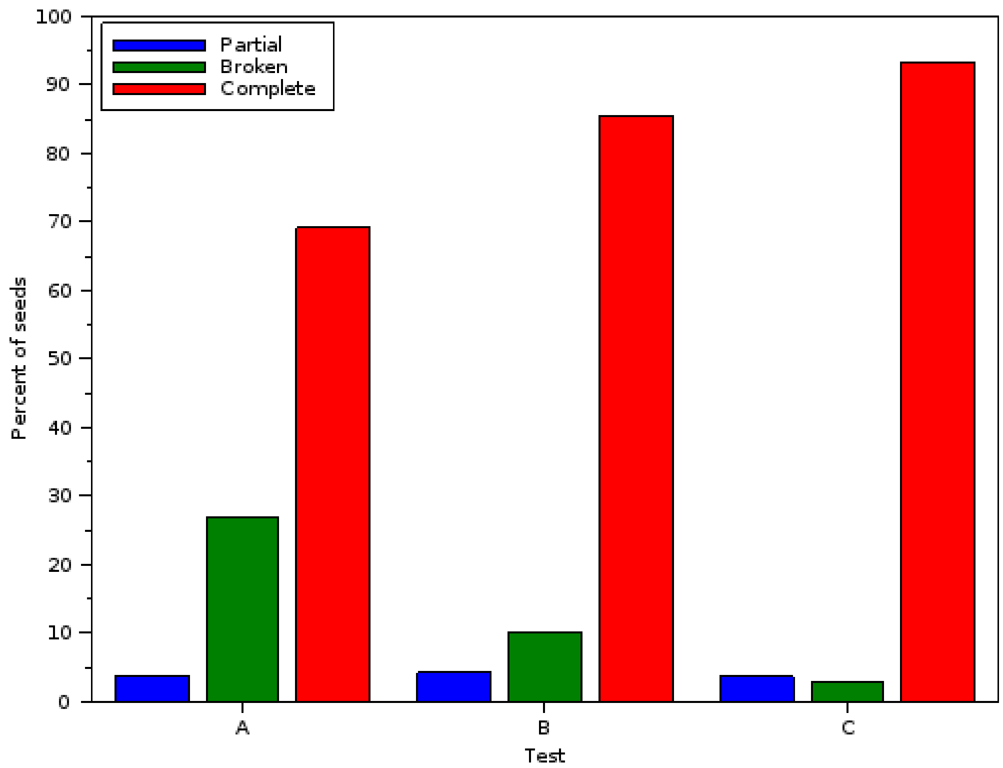


Figure 11: Depulper performance vs feed method and fermentation level

14. It was observed during the tests that the wire mesh fixed to the outlet of the de-pulping chamber for controlling the flow of the de-pulped fruit out of the chamber tended to prevent the flow of the slurry altogether, thus no conclusive deductions can be made of the times indicated as taken for the tests. The same also applies for the measured volume of water used up for the processes.

15. Further work

Further work is underway to develop an improved version of the depulping machine which is suitable for commercialization. The proposed version is shown in figure 12.

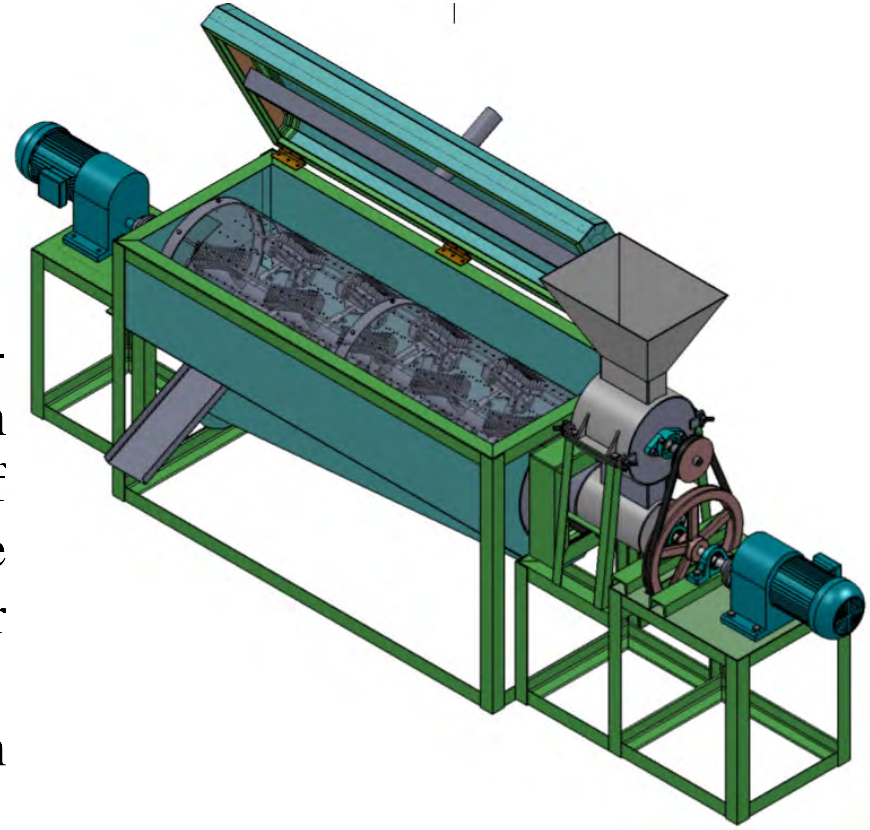


Figure 12: Proposed commercializable depulping machine

5 DEHULLING

Dehulling of parboiled seeds is now routinely achieved using domestic grinding machines, as shown in figure 13, but engineering studies of the mechanical processes involved received attention only recently.

Figure 13: Domestic grinding machine used as dehuller
Source: Enibe D. O. (2013)

A detailed study on the development of a customized dehulling machine for *Treculia Africana* seeds has been reported by Akubuo (2006).

1. Three varieties of the African breadfruit seeds as identified were collected separately: these were the var *africana* – large sized seeds; var *inverse* – medium sized seeds and the var *molis* – small sized seeds.

2. Figure 3 shows the three different varieties.

3. The physical properties for which data were collected are: moisture content, seed characteristic dimensions, gravimetric composition, density characteristies and shape factor.

4. The samples used were parboiled for 5, 7 and 10 minutes respectively.

5. The terminal velocities for the kernel and hull (chaff) were determined using the experimental set-up by Emah (2006).

6. Table 9 shows data for the physical properties of the African breadfruit seeds.

Table 9: Selected Physical Properties of African Breadfruit (Treculia afriacan) Seeds

Property	Large sized (Var africana) parboiling time (min)			Medium sized seeds (var inverse) parboiling time (min)			Small sized seeds (var molis) Parboiling time (min)		
	5	7	10	5	7	10	5	7	10
Moisture content (%wb)	38.22±0.15++	41.98±0.77	45.81±0.35	38.90±0.21	39.90±0.34	40.44±0.11	25.0±0.24	26.94±0.09	28.29±0.15
Axial dimensions (cm)									
Major (a)	9.38±1.0	8.63±0.77	8.59±0.53	1.05±0.042	1.05±0.055	1.05±0.026	0.94±0.029	0.95±0.036	0.93±0.035
Intermediate (b)	5.75±0.93	5.29±0.67	5.15±0.48	0.58±0.034	0.58±0.061	0.59±0.037	0.54±0.025	0.53±0.026	0.54±0.031
Minor(c)	4.64±0.99	4.36±0.77	4.18±0.48	0.57±0.052	0.53±0.043	0.53±0.027	0.46±0.036	0.45±0.032	0.46±0.017
Geometric mean	6.59±0.97	6.09±072	5.97±0.50	0.73±0.04	0.72±0.017	0.72±0.03	0.65±0.03	0.64±0.03	0.64±0.028
Seed gravimetric composition									
Average seed mass (g)	0.281±0.12	0.290±0.50	0.289±0.84	0.219±0.019	0.225±0.017	0.219±0.04	0.150±0.026	0.151±0.025	0.163±0.037
Density characteristics	881.40±15	891.47±20	896.48±24	1090±13	1125±16	1095±14	1071±18	1126±22	1160±20
Mass density(kg/m3)	992.10±10	990.50±13	998.61±16	1103±9.0	1132.8±12	1124±11	1081±10	1139±8	1260±6
Bulk density (kg/m3)	88.82	90.00	89.77	98.82	99.36	97.42	99.07	98.86	92.06
Density ratio (%)									
Shape indices (%)	67±1.0	68±0.9	66±1.2	69.5±0.8	65.7±0.9	65.7±0.8	66.0±1.3	64.2±1.4	65.6±0.91
Sphericity index	61±0.80	61±0.7	59±0.91	55.2±1.4	55.2±1.1	56.2±0.91	57.4±1.12	55.8±8.15	58.1±0.9
Aspect ratio	54.5±0.62	54.5±0.74	54.5±0.8	62.0±0.7	62.0±0.9	62±0.81	47.1±0.74	47.1±0.84	47.1±0.8
Roundness									

\+ Mean values

++ Standard deviation

7. The seed axial dimensions show that there is little or no difference between the intermediate and minor diameters of the three groups from each of the three varieties.

8. For the major diameters, there is a significant difference, which is indicative of their size difference. The average major, intermediate and minor axial dimensions of the large sized seeds at the three different parboiling times were (9.38, 5.75, 4.64cm); (8.63, 5.29, 4.36); (8.59, 5.15, 4.18cm) respectively.

9. The average major, intermediate and minor axial dimensions of the medium sized seeds were (1.05, 0.58, 0.57cm); (1.05, 0.58, 0.53cm); and (1.05, 0.59, 0.53cm) respectively for the three different parboiling times.

10. The data for the small sized seeds were (0.94, 0.54, 0.46cm); (0.97,

0.53, 0.45cm); (0.93, 0.54, 0.46cm) respectively for the major, intermediate and small seed axial dimensions for the different parboiling times.

11. Result of the mechanical properties of the African breadfruit seeds are reported in table 10. During compressive loading, all seeds tested after parboiling at different times exhibited force-deformation curves similar to those obtained by previous researchers on different agricultural products

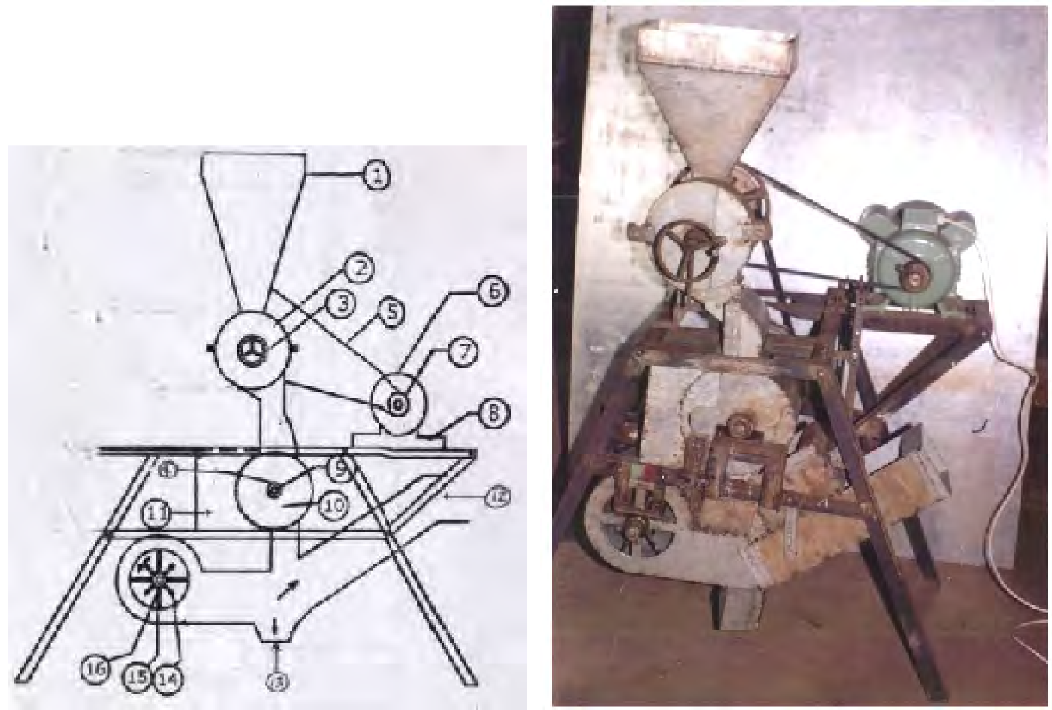
Table 10: Selected Mechanical Properties of *Treculia africana* seeds++

Property	Large sized seeds (Var africana)			Medium sized seeds (Var inverse)			Small sized seeds (var molis)		
Parboiling time (min)	5	7	10	5	7	10	5	7	10
Rupture force N	48.07±8.8	43.5±7.0	38.35±5.2	46.82±1.8	36.40±0.32	30.48±0.94	30.41±1.4	25.51±0.35	22.56±0.80
Dynamic angle of repose(deg)									
Unpolished wood	50.73±0.55	55.57±0.53	60.75±0.73	40.74±0.44	44.40±0.47	52.50±0.74	33.54±0.73	37.7±0.54	45.80±0.91
Formica	48.28±0.52	52.88±0.90	55.90±0.82	38.54±0.42	42.40±0.54	50.86±0.94	30.50±0.58	33.90±0.78	40.33±0.77
Mild steel sheet	47.82±0.84	52.70±0.21	54.89±0.61	36.84±0.50	42.80±0.70	46.81±0.64	27.61±0.74	34.88±0.81	38.74±0.54
Coefficient of static friction									
Unpolished wood	0.68±0.07	0.70±0.06	0.75±0.5	0.34±0.05	0.35±0.03	0.34±0.02	0.33±0.02	0.32±0.04	0.33±0.03
Formica	0.50±0.01	0.40±0.02	0.60±0.04	0.30±0.01	0.30±0.03	0.30±0.04	0.28±0.07	0.27±0.02	0.25±0.04
Mild steel sheet	0.58±0.08	0.61±0.04	0.64±0.06	0.32±0.04	0.34±0.04	0.34±0.01	0.33±0.06	0.31±0.05	0.32±0.06
Terminal Velocity(m/s)									
Kernel (endosperm)	4.75±0.81	5.56±0.46	5.84±0.12	4.50±0.65	5.0±0.12	6.50±0.51	4.80±0.71	6.42±0.01	2.90±0.51
Hall(chaff)	1.5±0.64	1.72±0.20	1.80±0.01	1.6±0.02	1.75±0.28	1.9±0.52	2.0±0.35	2.5±0.61	2.90±0.51

++ Mean value ± standard deviation

12. Figure 14 shows the schematic diagram and photograph of the improved breadfruit dehuller.

1 feed hopper, 2 dehulling chamber casing, 3 handle for disk adjustment, 4 roller shaft, 5 motor disk belt drive, 6 electric motor, 7 electric motor pulley, 8 electric motor stand, 9 roller, 10 roller shaft bearing, 11 concave plate, 12 hull outlet chute, 13 seed outlet chute, 14 fan blade, 15 fan casing, 16 fan shaft bearing



(a) Key (b) Schematic diagram (c) Photograph

Figure 14: Schematic diagram and photograph of the breadfruit dehuller

13. The seed is introduced through the feed hopper and dehulling is achieved in stages as the seed passes through the three major units of the machine

14. At the time of completion of the construction of the breadfruit seed dehuller, only large sized breadfruit seeds could be obtained locally. The preliminary tests were conducted with the large sized seeds.

15. About 850g of the seeds were parboiled separately for 5, 7 and 10 minutes, and used for the tests. Each test run lasted for about 45s. The samples were spread out for about 3 minutes and allowed to dry in order to remove the surface water before using them for the tests. Their moisture contents were determined using the oven dry method. The dehuller was run at the speed of 200rpm for each test. Calculations were made to determine the percentages of completely dehulled, partially dehulled, undehulled, breakages and dehulling efficiency which are measures of the effectiveness of the dehuller.

16. Results are shown in Table 11. The result at present indicate that dehulling is best after parboiling the seeds for 7 minutes followed by the 10 minutes parboiling result.

Table 11: Preliminary performance result of the breadfruit seed dehuller using large sized breadfruit seeds (Var africana)

	Parboiling time (min)		
	5	7	10
Moisture content % wb	28.4	33.3	37.5
Completely dehulled, %	67.73	74.92	70.71
Partially dehulled, %	10.27	3.70	5.02
Undehulled, %	28.0	18.38	24.42
Breakages, %	21.6	12.48	15.65
Dehulling efficiency, %	53.0	75.46	65.46
Throughput, kg/h	66.23	69.70	74.20

6 PASTA PRODUCTION

The production of pasta from *Artocarpus altilis* was investigated by Oduro *et al* (2006).

1. *Artocarpus altilis*, which is also commonly called *breadfruit*, are very useful plants in the world. Seedless breadfruit is very rich in carbohydrate, minerals and vitamins, and breadfruit flour is very rich in lysine. It has been known and used by many especially in rural Ghana (see figure 2).

The composite flours, produced as shown in table 12 were evaluated for physiochemical properties and proximate composition.

Table 12: Flour composition of blends (composite flour)

BLEND	WHEAT FLOUR (%)	BREADFRUIT FLOUR (%)
711	100	0
721	90	10
731	80	20
741	70	30
751	60	40
761	50	50

Table 13: Nutritional composition of the various blends of Wheat-Breadfruit flour

Sample	Moisture (%)	Crude fat (%)	Crude fiber (%)	Crude protein (%)	Ash (%)	Carbohydrate (%)
721	9.48 (0.04)	1.65 (0.03)	2.28 (0.01)	13.84 (0.05)	0.78 (0.03)	71.97
731	9.13 (0.07)	1.76 (0.10)	2.23 (0.02)	12.65 (0.03)	0.84 (0.30)	73.39
741	8.58 (0.03)	1.80 (0.30)	2.56 (0.03)	11.80 (0.02)	0.88 (0.10)	74.38
751	8.05 (0.05)	2.10 (0.03)	2.86 (0.01)	10.57 (0.02)	1.07 (0.07)	75.35
761	7.53 (0.01)	2.16 (0.20)	3.08 (0.01)	9.40 (0.04)	1.18 (0.03)	76.65
Wheat flour 711	10.08 (0.01)	1.50 (0.70)	2.00 (0.03)	14.50 (0.03)	0.58 (0.10)	71.34
Breadfruit flour	5.04 (0.05)	2.82 (0.04)	4.06 (0.05)	3.23 (0.02)	1.96 (0.03)	82.84

Standard deviations are given in parenthesis and values are means of duplicate determinations.

The proximate composition of the wheat flour and breadfruit flour are shown in the Table 13. Moisture content of the breadfruit flour was low (5.04%) relative to the wheat flour (10.08%).

Table 14: Functional characteristics of wheat flour, breadfruit flour and the various blends of Wheat-Breadfruit flour

Sample	Swelling power (%)	Water binding Capacity (g/g)	Solubility (%)	Bulk density (g/cm3)	Least gel Concentration (%)
721	7.14 (0.01)	76.44 (0.05)	10.18 (0.01)	0.68 (0.01)	15
731	7.53 (0.02)	82.79 (0.05)	10.28 (0.02)	0.66 (0.02)	15
741	7.83 (0.30)	104.78 (0.07)	10.48 (0.30)	0.63 (0.10)	15
751	8.08 (0.02)	123.13 (0.03)	10.65 (0.02)	0.62 (0.05)	15
761	8.64 (0.03)	139.41 (0.02)	10.83 (0.03)	0.60 (0.03)	15
Wheat flour 711	6.75 (0.01)	79.36 (0.04)	9.97 (0.20)	0.72 (0.03)	20
Breadfruit flour	12.98 (0.20)	4.97 (0.02)	9.54 (0.04)	0.55 (0.02)	-

Standard deviations are in the parenthesis and values are the means in duplicate determinations

Swelling power, water binding capacity and solubility increased from 10-50% bread-fruit substitutions (Table 14).

2. Sensory evaluation results of the pasta product (Table 15) indicate that for the composite flours sample 731 had the most preferred appearance, colour and firmness by hand. Sample 721 was the most preferred in terms of aftertaste and firmness by teeth whilst sample 741 was the most preferred overall. The overall evaluation showed that pasta from 100% wheat was the most preferred relative to the other products.

Table 15: Mean values of steamed wheat: breadfruit pasta products

SAMPLE	711	721	731	741	751	761
APP	1.40	2.00	1.50	2.15	3.35	4.60
COL	1.60	2.70	1.20	1.61	2.25	2.15
AR	2.70	2.05	3.35	2.95	3.95	3.20
FBT	1.15	1.40	1.75	2.05	2.60	2.80
FBH	1.05	2.25	1.35	2.25	2.85	2.05
OA	1.10	3.60	3.85	1.30	4.05	3.95
Mean	1.50	2.33	2.17	2.05	3.18	3.13

3. Results showed that there was significance difference among composite samples $(P < 0.05)$ for all the variables.

4. There was increase in crude fat, crude fiber, ash and carbohydrate content with increase in percentage substitution of non-wheat flour. The same trend was observed in swelling power, solubility and water binding capacity for flour composites.

5. A decrease in moisture content, protein content, LGC and bulk density was observed for flour samples from 10% to 50% substitution of non-wheat flour. Pasta made from 70% wheat and 30% breadfruit was the most preferred.

6. Therefore Breadfruit can be used in composite as an alternative source for pasta production.

7 BREAKFAST MEAL

The use of blends of breadfruit and soybean composite for breakfast meal production is reported in Oduro *et al* (2006b).

1. This study investigated the quality and acceptability of breakfast meals produced from various breadfruit-soybean composite flours.

2. Blends were formulated with a soybean substitution of 10%, 30%, 50%, 70%, and 90%., as shown in table 16.

Table 16: Flour composition of blends

BLEND	BREADFRUIT FLOUR (%)	SOYBEAN FLOUR (%)
	0	100
	100	0
101	90	10
102	70	30
103	50	50
104	30	70
105	10	90
106	CONTROL	-

3. The proximate composition of the blends and the acceptability of the formulated products were determined. The results showed the blends to have crude protein content between 6.85-36.59%, crude fat content of 4.44-18.12%, carbohydrate content of 33.15-77.84%, ash content of 2.325.06%, and energy value of 378.72-442.04 Kcal/100g.

Table 17: Nutritional composition of soybean, breadfruit, and composite flours.

Sample	Moisture (%)	Ash (%)	Crude protein (%)	Crude fat (%)	Crude fiber (%)	Carbohydrate (%)	Energy (Kcal/100g)	Fe mg/100 g	Ca mg/100 g
Soybean flour	0.94 (0.02)	5.05 (0.03)	40.46 (0.10)	22.02 (0.06)	5.70 (0.02)	25.83(0.62)	463.34	42	426
Breadfruit flour	5.04 (0.05)	1.96 (0.03)	3.28 (0.02)	2.82 (0.04)	4.06 (0.05)	82.84(0.86)	369.86	12	123
101	4.23 (0.026)	2.32 (0.148)	6.85 (0.148)	4.44 (0.163)	4.32 (0.045)	77.84(1.61)	378.72	15.45	136.33
102	3.84 (0.113)	3.51 (0.665)	15.54 (0.170)	7.32 (0.049)	4.52 (0.021)	65.27(0.92)	389.12	18.16	147.44
103	2.58 (0.127)	3.80 (0.021)	20.99 (0.219)	11.24 (0.156)	4.98 (0.021)	56.41(0.06)	410.76	25.28	160.94
104	2.05 (0.092)	4.33 (0.156)	30.21 (0.028)	14.99 (0.064)	5.12 (0.028)	43.3(0.13)	428.95	31.94	243.85
105	1.77 (0.035)	5.06 (0.035)	36.59 (0.085)	18.12 (0.134)	5.31 (0.028)	33.15(0.26)	442.04	38.33	333.54
106	9.7	2.98	17.73	9	3.02	57.57	382.2		

Values are means of triplicate determinations, standard deviations are in parenthesis

4. The sensory analysis showed that the formulated products were acceptable with preference more tilted towards blends with higher soybean content.

Table 18: Preference Mean Scores for the Formulated breakfast Meal

Blend	Taste	Aftertaste	Mouth feel	Colour	Flavor
101	2.300	2.900	2.700	1.400	2.600
102	1.700	2.100	2.300	1.600	2.400
103	1.600	2.300	1.700	1.500	2.000
104	2.000	2.000	2.200	1.600	1.900
105	1.800	1.600	1.800	1.700	1.900
106	2.400	1.500	2.400	2.400	1.700
LSD (5%)	0.238	0.000	0.012	0.000	0.008

5. The response for the overall acceptability (Fig 15) showed no significant difference $(p > 0.05)$ and had this order of preference 104 and 105, 102, 103, and 101. This implies that for overall acceptance, with the exception of blend 102, preference was higher for those blends with higher levels of soybean flour relative to those with higher breadfruit flour.

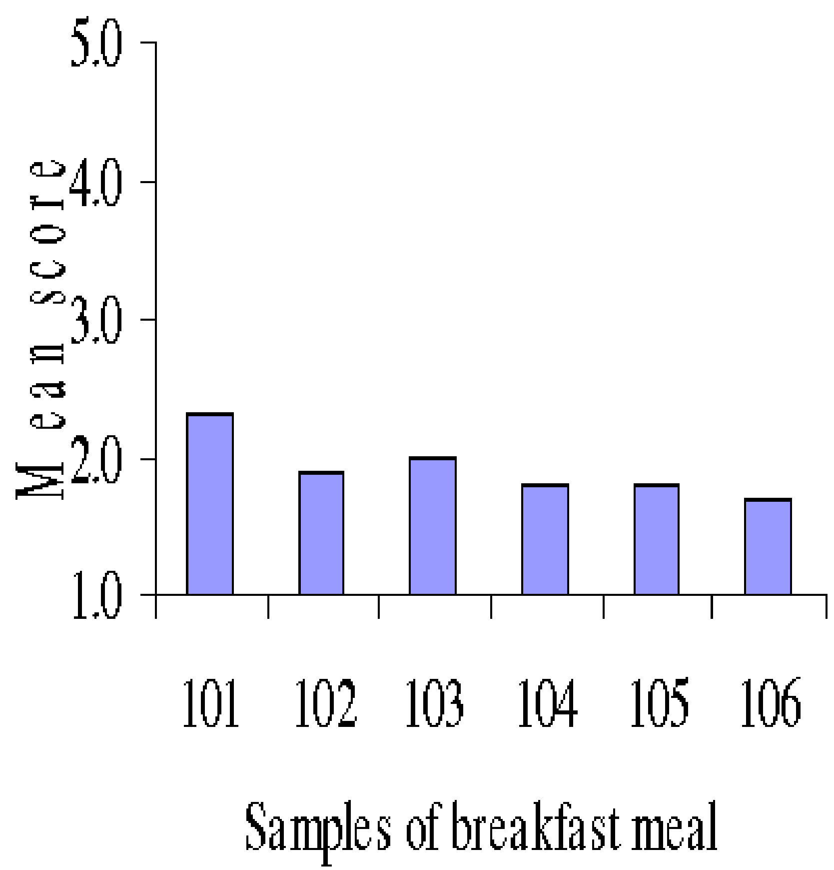


Figure 15: Mean Score for the overall acceptability of breakfast meal

8 OIL QUALITY

Ellis *et al* (2006) carried out studies to assess the quality of oil from *T. africana* seeds.

1. Fresh dried seeds were dehusked and milled.

2. Oil was extracted using the Soxhlet extraction procedure and the yield and quality characteristics of the oil evaluated.

3. Parameters assessed included specific gravity, acid value, saponification value, peroxide value, iodine value, refractive index and free fatty acid content among others.

4. The solubility of the oil in selected organic solvents and the presence of lipid soluble phytochemicals were determined. The nutritional quality of the seeds was also evaluated.

5. The results showed the seeds were high in carbohydrate and proteins with appreciable levels of ash and oil and low fibre content. Potassium and Phosphorus levels were relatively high with low calcium and iron levels. (see table 19).

Table 19: Proximate composition of *Treculia africana* seeds

Parameter	
Husks of seeds (%)	23.40 (0.40)
Moisture (%)	9.72 (0.05)
Crude Protein (%)	13.35 (0.02)
Crude Fat (%)	10.12 (0.02)
Ash (%)	1.96 (0.05)
Crude Fibre (%)	2.83 (0.005)
Carbohydrate (%)	62.01
Energy (kcal/100mg)	392.49
Fe (mg/100mg)	8.70
Ca (mg/100mg)	93.90
K (mg/100mg)	464.60
P (mg/100mg)	1300.00

6. The oil yield was low (11.82%) below the level for commercial sources of oil. The oil had a high specific gravity (0.89), good refractive index (1.47) and an iodine value of less than 100 (35.66). The peroxide value was also low (2.67) but within the range for fats and oils with a relatively high FFA (7.26%). The saponification value relative to other oils was low (128.33). (see table 20).

Table 20: Physicochemical properties of *Treculia africana* seed oil

Parameter	Value
Yield (%)	11.82 (1.82)
Refractive index	1.46 (0.14)
Free fatty acid (%)	3.27 (0.02)
Specific gravity	0.89 (0.02)
Peroxide value	2.67 (0.27)
Iodine value	36.55 (0.36)
Acid value	7.29
Saponification value	128.33 (0.33)
Colour	Yellow
Taste	Harsh
Odour	Pleasant

7. Identified lipid-soluble phytochemicals were carotenoids, terpenes, and saponins. Tannins were absent. Even though the yield was low, the quality of the oil from Treculia africana seeds was good and can be used as a supplement with other oils in the food sector.

9 DEMUCILAGINATION

Onweluzo and Odume (2006) report recent studies on the effects of method of extraction and demucilagination of *T. Africana* on its composition.

1. Mature fresh fruit heads of Treculia africana were procured and divided into four treatment groups using randomized complete block design (RCBD).

2. The first group was allowed to ferment naturally for 8 days before the seeds were extracted and washed (fermented control).

3. The second group was quartered, after which the seeds were extracted fresh from the pulp, demucilaginated by brushing with fine sea sand and subsequently rinsed with water (unfermented control).

4. Groups 3 and 4 were also quartered and the seeds were extracted fresh as in group 2 but the seeds were divided into 10 portions and treated with graded concentrations (1% - 5%) of trona and wood ash for times varying from 5 to 25 min.

5. Following the alkaline treatments the seeds were washed with water and the effectiveness of the treatments in removing the seed mucilage was determined by weight differences.

6. The demucilaginated seeds were dried in a hot air oven at 85^0C for 48h, dehulled and milled into flour to pass through 40mm mesh (British Standard Sieves) in an attrition mill. The flours were packed in polyethylene bags, heat sealed and stored at between 0 and 4^oC until used for analysis.

7. Proximate analyses for percentage moisture, crude fat, protein (N x 6.25), crude fibre and ash were done according to the standard method

of the AOAC (1990).

8. The nitrogen free extract (total carbohydrate) was calculated by difference.

9. The ether extract was analysed for peroxide value and free fatty acid content using the standard method of Pearson (1991).

10. Trace elements were estimated after wet oxidation of samples (2g) using concentrated Nitric acid and Perchloric acid as described by Osborne and Voogt (1978).

11. The concentration of the minerals, Calcium, Magnesium, Copper and Zinc in the digested sample were determined with the Pye Unicam Atomic Absorption Spectrophotometer.

12. Potassium and Sodium were determined with the Flame Photometer.

13. Figure 16 and 17 show the effectiveness of the different concentrations of trona (1% - 5%) and wood ash (1% - 5%) in demucilaginating freshly extracted Treculia africana seeds. Mucilage constitutes about 30 + 2% of the whole *T. africana* seeds used in the study on wet basis.

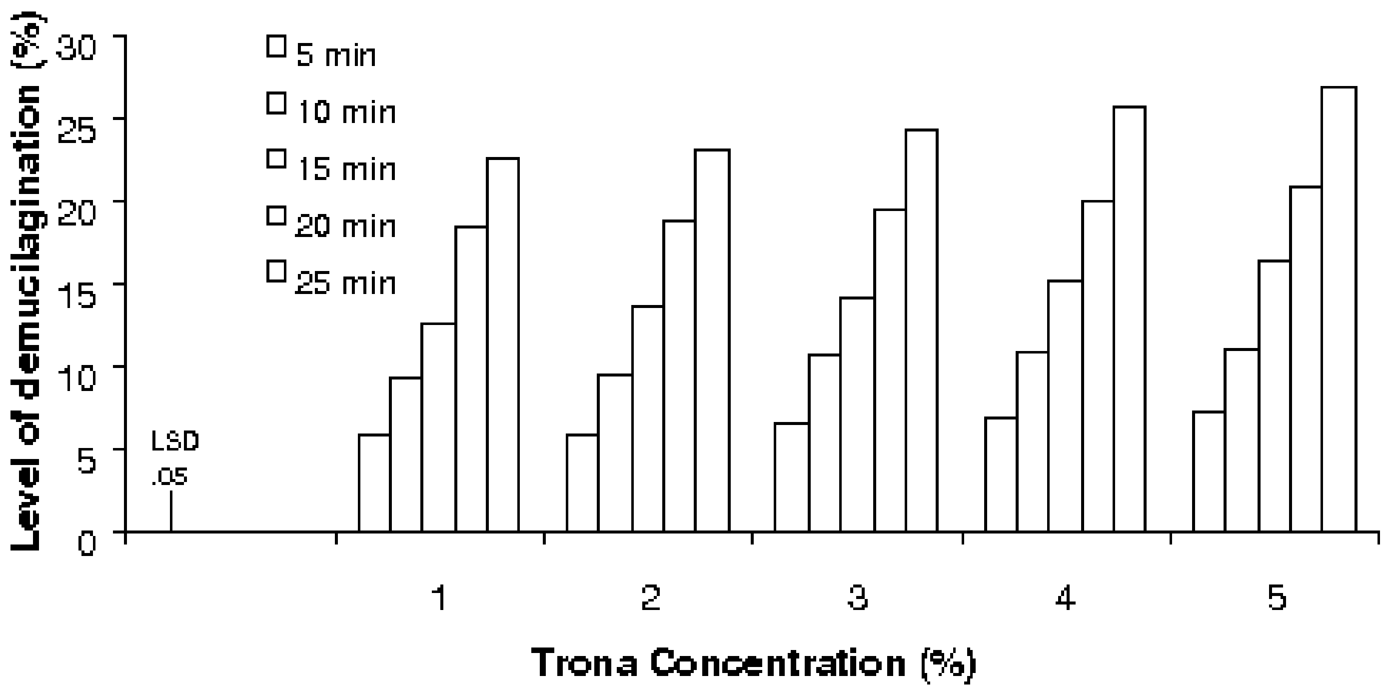


Figure 16: Effect of concentration of Trona and treatment time on the demucilagination of *Treculia africana* endocarp

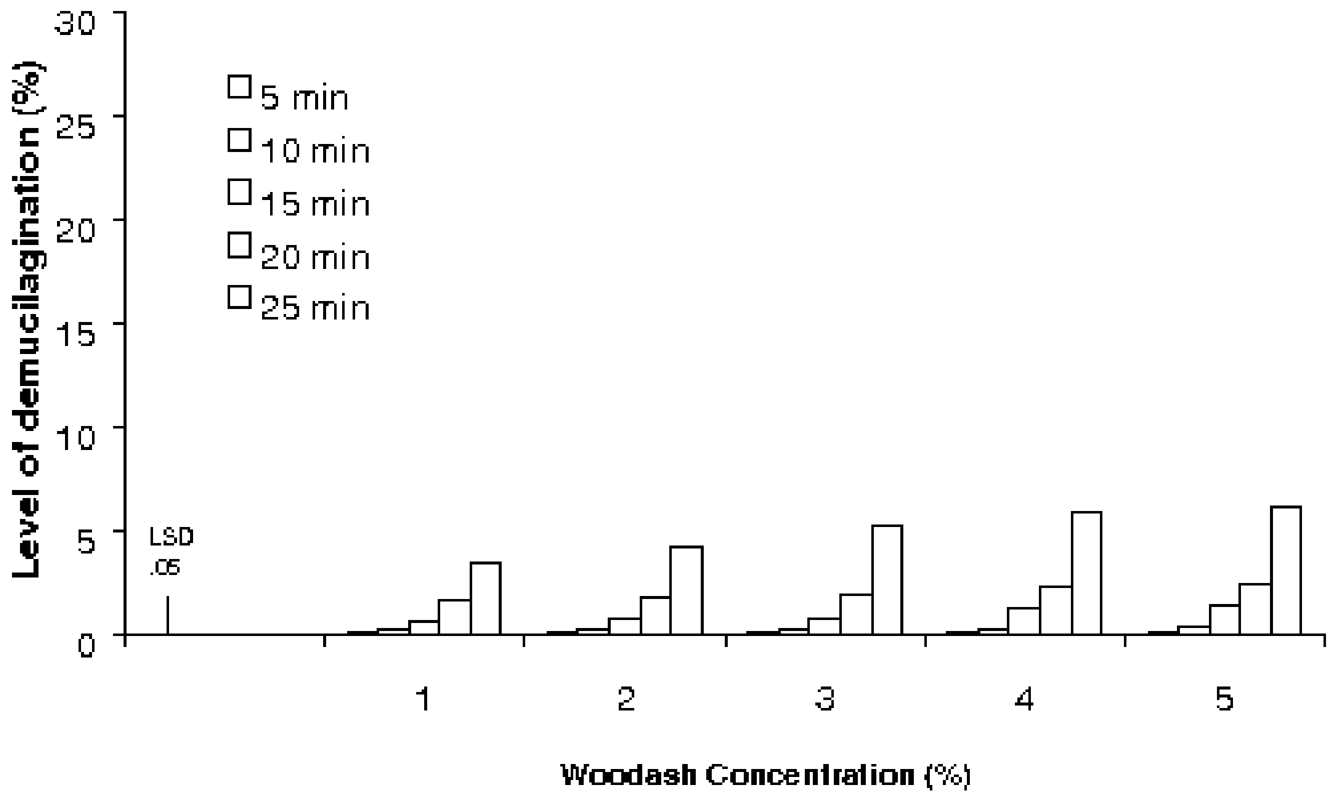


Figure 17: Effect of concentration of woodash and treatment time on the demucilagination of *Treculia africana* endocarp

14. Table 21 shows the effect of the demucilaginating treatments on the colour, bulk density and water absorption capacity of the dehulled T. africana seed flour.

Table 21: Effect of demucilaginating treatment on the colour, bulk density (g/cm^3) and water absorption capacity (g/g) of Treculia africana seed flour

Conc. (%)	Time (min)	Colour (A450nm)	Bulk Density (g/cm^3)	Water absorption capacity (g/g)
		Trona		
3	15	0.15±0.02	0.34±0.06	1.53^{a}±0.62
	20	0.16±0.02	0.36±0.10	2.49^{ab}±0.08
	25	0.22±0.01	0.35±0.06	2.72^{ab}±0.07
4	15	0.15±0.01	0.35±0.10	1.67^{a}±0.61
	20	0.17±0.03	0.35±0.20	2.54^{ab}±0.06
	25	0.23±0.01	0.37±0.10	2.71^{ab}±0.11
5	15	0.21±0.02	0.35±0.06	1.72^{a}±0.55
	20	0.25±0.01	0.35±0.20	2.75^{ab}±0.02
	25	0.25±0.01	0.35±0.10	2.77^{ab}±0.02
LSD		0.15	0.05	1.12
		Wood ash		
3	15	0.15±0.02	0.35±0.03	2.51±0.21
	20	0.15±0.01	0.36±0.02	2.62±0.03
	25	0.16±0.01	0.35±0.02	2.44±0.27
4	15	0.16±0.01	0.35±0.20	2.47±0.20
	20	0.16±0.02	0.36±0.20	2.63±0.09
	25	0.16±0.02	0.35±0.10	2.69±0.07
5	15	0.16±0.01	0.36±0.10	2.51±0.25
	20	0.25±0.01	0.35±0.10	2.56±0.28
	25	0.25±0.01	0.35±0.20	2.56±0.28
LSD		0.12	0.03	0.46
		Control		
Control (fermented)		0.22±0.01	0.38±0.04	1.67^{a}±0.12
Control (unfermented)		0.28±0.02	0.39±0.02	2.87^{b}±0.15
LSD		0.09	0.02	1.02

Mean ± SD, n =3

Means on the same column and treatment block bearing different super-script differ significantly ($P \leq 0.05$)

15. Samples from all the treatments showed marginal variations in proximate composition (Table 22).

Table 22: Effect of demucilaginating treatment on the proximate composition of *Treculia africana* seed flour.

Conc. (%)	Time min.	Moisture (%)	Protein (Nx6.25)	Crude Fat (%)	Crude fibre (%)	Total Ash (%)	Nitrogen Free extract (%)
				Trona			
	15	1.70±0.09	14.61±0.12	8.00±04	4.73±0.02	5.80±0.02	65.16±0.12
3	20	1.60±0.11	14.63±0.09	8.10±0.08	4.75±0.05	5.70±0.04	65.22±0.15
	25	1.50±0.06	14.65±0.08	8.30±0.06	4.76±0.04	5.60±0.07	65.19±0.13
4	15	1.30±0.11	14.62±0.11	9.00±0.07	4.81±0.05	5.60±0.09	64.67±0.11
	20	1.20±0.02	14.64±0.12	9.20±0.10	4.84±0.07	5.50±0.01	64.62±0.12
	25	1.10±0.01	14.68±0.07	9.50±0.11	4.87±0.09	5.40±0.12	64.45±0.13
5	15	1.10±0.01	15.01±0.09	10.10±0.09	4.15±0.10	5.40±0.08	64.24±0.11
	20	1.10±0.01	15.04±0.11	10.20±0.07	4.15±0.11	5.30±0.09	64.21±0.14
	25	1.10±0.01	15.56±0.12	10.40±0.10	4.81±0.12	5.60±0.08	62.53±0.12
LSD		0.32	1.43	2.54	0.98	0.65	3.04
				Wood ash			
3	15	1.40±0.07	14.0±0.02	8.80±0.13	4.70±0.03	5.50±0.09	65.60±0.14
	20	1.60±0.02	14.01±0.04	8.90±0.09	4.72±0.02	5.50±0.01	65.27±0.11
	25	1.80±0.05	14.03±0.07	8.90±0.07	4.74±0.03	5.60±0.09	64.93±0.12
4	15	1.50±0.03	14.02±0.10	9.30±0.08	4.75±0.04	5.60±0.12	64.83±0.15
	20	1.80±0.09	14.04±0.11	9.30±0.06	4.77±0.03	5.70±0.11	64.38±0.13
	25	1.80±0.07	14.01±0.09	9.40±0.01	4.74±0.02	5.80±0.00	64.25±0.11
5	15	1.60±0.04	14.03±0.07	9.40±0.08	4.79±0.03	5.80±0.08	64.68±0.16
	20	1.90±0.10	14.05±0.09	9.40±0.10	4.76±0.03	5.90±0.06	63.99±0.14
	25	1.90±0.09	14.01±0.09	9.60±0.11	4.87±0.05	5.90±0.09	63.68±0.12
LSD		0.62	0.25	0.96	0.34	0.56	2.23
				Control			
Control (fermented)		1.96±0.21	13.83a±0.13	9.46±0.05	4.21±0.02	5.24±0.04	65.30^b±0.14
Control (unfermented)		1.28±0.41	15.20^b±0.12	10.61±0.13	4.64±0.03	6.30±0.11	61.97^a±0.11
LSD		0.96	1.2	1.24	0.52	1.10	2.53

Mean ± SD, n= 3

Means on the same column and treatment block bearing different super-script differ significantly ($P \leq 0.05$)

16. Figure 18 shows the effect of treatment on the peroxide value (PV) and free fatty acid (FFA) content of the T. africana seed ether extract.

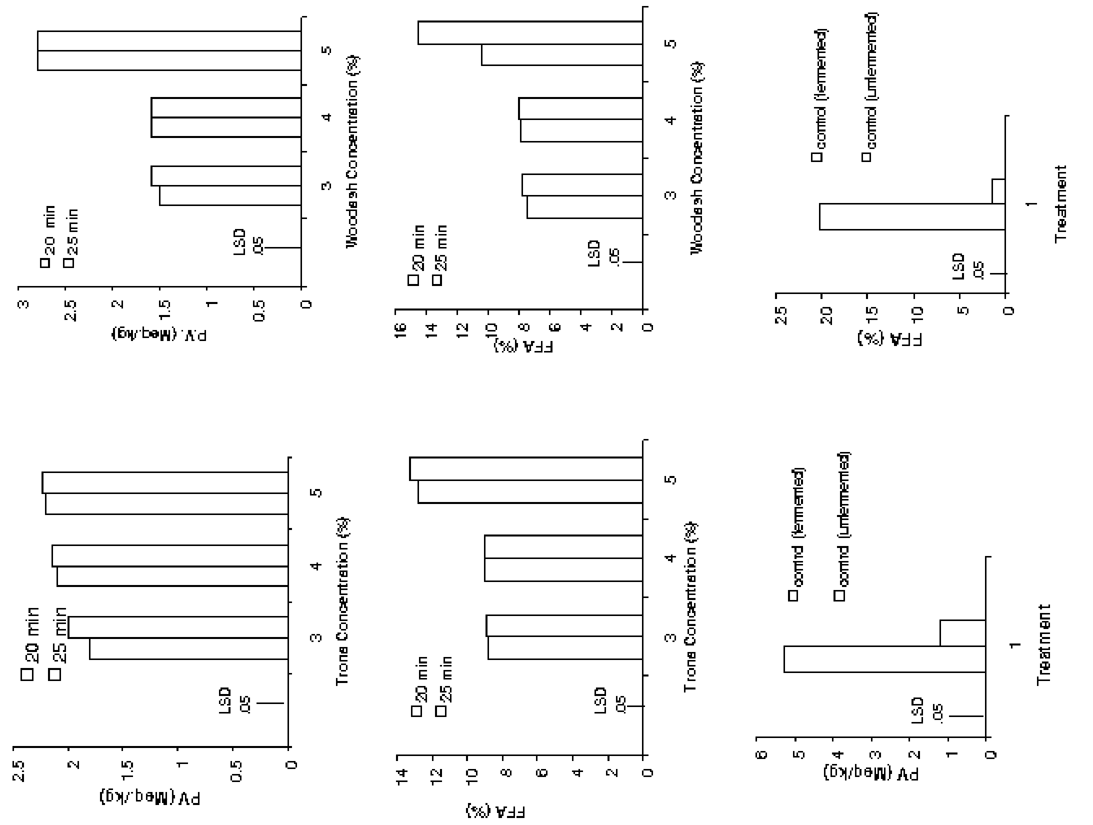


Figure 18: Effect of demucilaginating treatments on the peroxide value (PV) and Free Fatty Acid (FFA) content of *Treculia africana* seed ether extract

17. Table 23 shows the effect of demucilaginating treatment on the mineral content of *T. africana* seed flour.

Table 23: Effect of demucilaginating treatment on the mineral content of *Treculia africana* seed flour.

Conc. (%)	Time min.	Ca	Mg	K	Na	Cu	Zn
		Minerals (mg/100g)					
				Trona			
3	20	15.6±0.02	7.97±0.01	14.42±0.01	28.5±0.01	0.01±0.00	0.16±0.01
	25	15.1±0.02	80.6±0.01	142.4±0.01	28.6±0.01	0.01±0.00	0.22±0.02
4	20	16.0±0.01	81.7±0.03	132.4±0.02	34.8±0.02	0.08±0.00	0.37±0.01
	25	15.0±0.01	81.9±0.02	133.6±0.03	39.1±0.02	0.08±0.01	0.37±0.01
5	20	15.1±0.01	81.2±0.01	134.1±0.02	45.2±0.03	0.01±0.00	0.43±0.01
	25	15.8±0.02	81.3±0.01	130.4±0.02	49.1±0.01	0.02±0.00	0.38±0.02
				Wood ash			
3	20	15.0±0.02	80.4±0.02	141.51±0.01	28.4±0.02	0.01±0.00	0.24±0.02
	25	15.7±0.01	81.7±0.02	141.0±0.01	28.3±0.02	0.01±0.00	0.22±0.02
4	20	14.6±0.03	81.5±0.01	132.6±0.03	38.1±0.02	0.08±0.01	0.32±0.02
	25	16.0±0.02	81.3±0.02	1.34.6±0.02	39.8±0.03	0.08±0.01	0.33±0.02
5	20	15.1±0.02	81.6±0.02	131.0±0.02	47.0±0.02	0.01±0.00	0.35±0.02
	25	16.1±0.03	81.4±0.02	1.34.0±0.03	48.1±0.02	0.01±0.00	0.36±0.01
				Control			
Control (fermented)		16.8±0.01	81.36±0.04	131.6±0.04	43.64±0.03	0.02±0.00	0.45±0.01
Control (unfermented)		23.6±0.02	82.2±0.05	146.4±0.03	46.3±0.03	0.16±0.00	0.13±0.02

Values are means of duplicate determinations ± S.D.

10 CONSUMER ACCEPTABILITY

Consumer acceptability studies for *Treculia africana* conducted in Anambra State of Nigeria were reported by Enibe(2007).

1. Four rural communities in Anambra State were randomly selected for the study.

2. In each community, thirty (30) households were randomly selected and interviewd, yielding a total of 120 households.

3. About 60% of the respondents gave first preference to *Treculia africana* meals in place of other foods made from cassava, rice or yam.

Further work on consumer acceptability and marketing of *Treculia Africana* in Nigeria is ongoing, as shown in Enibe D. O. (2013)

11 Recommendations

Sustained funding of research and development efforts are required to

1. Improve the widespread use and acceptability of the crop
2. Develop early maturing varieties of the crop to facilitate the development of commercial plantations and orchards
3. Commercialise mechanical equipment for its processing (especially depul ing & dehulling)
4. Develop modern food and beverages from the crop
5. Upgrade the value chain of the crop.

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THANK YOU!
GOD BLESS YOU!