Empirical Survey of Postharvest Operations Constraining Bambara Nut Utilization

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Abstract

Postharvest bambara nut processing operations were assessed in this study to address all factors constraining effective utilization of this unique crop. It involved review of existing records and empirical observations of its native and present day semi-mechanized processing systems. Results revealed milling and sieving as the postharvest operations that are yet to be successfully addressed by the existing mechanized systems. This is caused by lack of inherent crack in seed coat of bambara grain and high binding force between its coat and endosperm due to its 205.92mg/100g (2.06g/Kg) phenolic compound content. The binding strength of this grain was deduced from records as 1.51 Mpa and used to determine the minimum pressure required for effective separation of the endosperm (food flour) and coat (chaff) of ground bambara grain as 7812.5Pa. These findings were applied in the development of a viable single flow milling-sieving machine for bambara flour production which improved hygiene, reduced drudgery and food loss in this sector.

Keywords
Bambara nut, constrain, flour, milling, sieving

1.Introduction
Bambara ground nut is a crop with a high potential for the attainment of food security and poverty alleviation in Nigeria and Africa at large, as it shows considerable drought resistance and potentially high nutritional qualities (Yusuf *et al*.,2008; Atoyebi *et al*., 2017). Its seed shown in figure 1 is a complete balanced food because of adequate iron, protein, ash, fat, fibre, potassium, sodium, calcium, carbohydrate, oil and energy content (Atoyebi *et al*., 2017). It has superlative best worth protein content plus lysine which complements cereals in diets unlike other grains. According to Jagdev (2018), the seed is rich in beneficial bacteria known also as probiotics, milk from bambara seed is used for therapeutic purposes in diarrhoea and irritable bowel syndrome.

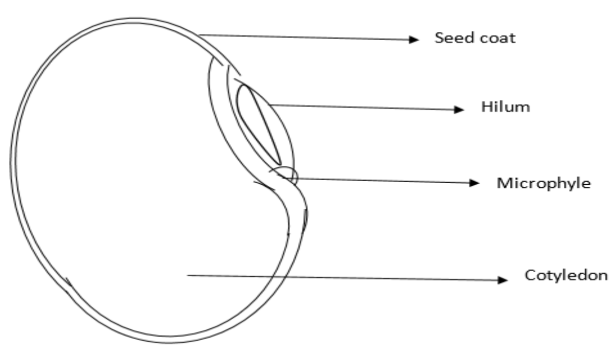

Figure. 1: Structure of bambara seed

Although bambara seed can be eaten as vegetable in its freshly raw green grains form, as snack when boiled with salt and pepper or roasted dry seeds, processing of the bambara grain to flour is vital for its diverse applications in diets/beverages preparation such as fufu, relish, soup/stew, Moi–Moi (Okpa), water yam pudding (Ojojo), milk, biscuit, bread, pastries and food thickener (Kaptso *et al.,* 2007; Okpuzor *et al.,* 2010; Aviara, 2013). Hillock *et al.* (2011) revealed high demand and cost of these bambara flour prone food diets due to their unique taste, flavour and enhanced minerals content level than other legumes based diets. However, Uvere *et al.* (2015) revealed gross underutilization of this crop and subsistence level of its cultivation in sub-Saharan region due to inadequate postharvest processing system. Hence, the ever increasing quest for full mechanized bambara flour processing system to curb scarcity and high cost of these food recipes and also improves the utilization of this unique crops. Consequently, the objectives of this study includes to:

- Carry out empirical survey on the post-harvest operational constrain of Bambara groundnut utilization
- Proffer solution to the postharvest operational constrain of Bambara ground nut utilization

2. Literature Review

Bambara flour production from its dry nut involves milling and sieving operations. The dry bambara nuts are crushed into fine particle as much as possible to weaken the bond between its endosperm and coat while the sieving separates them. The sieved bambara endosperm granules constitute the recipe for its diverse human diet/beverage application while that of the seed coat (chaff) is not good for human consumption but highly suitable for livestock feed production. The milling process is partially mechanized with the latest version of hammer mill while manual sieving operation still prevails in this sector because unsuccessful fitting/matching of other grain flour sieving machineries for bambara flour production (Ikechukwu, 2021). Multiple milling operations with hammer mills which dominates this sector presently in order to reduce excessive loss of bambara cotyledon flour to chaff also adds in making bambara flour production in this region strenuous and unhygienic. The present condition of ineffective mechanized system for these two critical sequential operations in bambara flour production constitute the basic cause of persistence underutilization of this crop and subsistence level of its cultivation in sub-Saharan region.

Apart from tedium and drudgery, Fayose (2008) also stress that manual technique in sieving flour and slurry food is time wasting and unhygienic because hand stirring of the flour (human contact with the food material) involved in this process introduces germs and impurities in the product. This, result in excessive time lost to sieving and low production in terms of quantity. Several sieving methods have been in practice for both wet and dry grain processing. Vibratory and sifting methods of sieving as designed by Radhika (2016) and Adetunji (2013) although highly employed in the production of wheat flour, garri and soybeans flour, consumes high energy, are expensive, extremely complicated, difficult to replicate and operate by unskilled operators, low sieving rate, inability to totally release the chaff after sieving affected general adoption of this machines for bambara flour processing. Horizontal sieving machine and mechanical shaker as designed by Nachimuthu*,* et al, (2016) and Nwigbo et al, (2017) on the other hand are fully appreciated but this methods are largely characterized by large vibration, dust generation which pose health risk to the operator, noise and particle size of the sieved bambara flour which is above 35μm also marred it's adoption for bambara flour sieving.

Noticeably, in the aforementioned systems, sieving is done in batches and multiple milling practiced, as their sieving efficiency depend on the particle size of the ground grain. In an attempt to eliminate drudgery of loading/re-loading during multiple milling before sieving operation, Adekomaya and Samuel, (2014) developed a petrol- powered hammer milling machine for processing ultra-fine ground grain in one flow. Existing sieving techniques and the subsequent modification encourages drudgery in transporting the ground flour from the mill to the sieving machine also human contact with the flour which is unhygienic and exposes the flour to contamination. These existing systems were not found suitable for bambara flour processing because it's separation efficiency is poor as a result of strong binding properties of bambara seed. The existing sieving technologies processes flour in batches just like the traditional technique and other mechanized flour sieving systems before it. The unique properties of high bonding strength of bambara seed coat and endosperm which was not considered in the design of these existing machines constituted its poor sieving efficiency and hence a breach in the adoption of this machines for bambara flour processing. As a result bambara flour sieving machine have recorded limited success in Nigeria thus, the preference for the manual technique among bambara flour producers. Manual bambara flour sieving employs a chiffon wrapped bowl upon which the ground flour is hand-stirred until fine flour is separated, leaving its chaff behind on the chiffon surface after the stirring. Apart from drudgery Uvere etal, (2015) stressed that manual sieving of bambara flour is time consuming and unhygienic because hand-stirring introduces germs into the product. It further revealed that loss of flour with high chaff content is witnessed during manual sieving operation especially as large seized mesh sieves are increasingly being adopted in order to spend less time with this discomfort. No record of article directed to design and development of bambara flour sieving machine has been cited. Bottleneck in the growing bambara flour market is to develop an efficient sieving system in accordance with bambara ground nut properties and end users particle size specification and its integration with a milling system for continuous flow. This will totally eliminate drudgery associated with existing sieving technique and manual method adopted in this sector. Human contact with the flour will also phase off as well as batch processing of the flour. Therefore, the need for integrated milling and sieving system in order to reduce excessive loss of flour to chaff and encourage continuous flow and improve hygiene in this sector in line with end users prescription. This is in line with FAO (2005) that revealed processors preference to integrated system for easy operation and maintenance.

3. Methodology

This study was carried out by investigative processes which comprise;

1. Paying visits to bambara flour processors in Eastern Nigeria where bambara flour market thrives but absolute traditional processing is still in practice to thoroughly study the various steps involved in each unit operation of this technique.
2. Paying visit to places where various scales of semi mechanized systems are used for bambara flour processing to observe the operation and functioning of their machine/equipment to be acquainted with the problems the processors encounter in the course of using the semi-mechanized systems
3. Relevant pioneer and other available records on bambara flour processing were also analysed and compared with practical observations.
4. The matching activities of each unit operation of both the traditional, proximate composition of the seed and mechanized methods were thoroughly compared in other to make certain the problems of the traditional techniques that have not been properly addressed by the present day mechanical methods in order to come up with a system the will appropriately address the problem of multiple milling and manual sieving in this sector.

4. Result and Discussion

4.1 Analysis of empirical observations and existing records

Practical evaluation of semi-mechanized bambara flour processing showed that thirty minutes to one hour is usually required to cool the temperature of the ground flour discharged from the mill which is over 60^0C to decrease to about 40^0C, beforehand stirring of the flour could be done. This is to prevent inflicting injury on the operator since the operator is the source of power (human hands). The human hands in manual sieving operation serve two purposes which include; compressing and shearing of the ground bambara flour against the sieve. This results in fine flour sipping through the sieve apertures to the receptacle while retaining the coarse unwanted particles which will be discarded after each batch of sieving. This compressing and shearing is done with about 50 moves per minutes in an anti-clockwise and corresponding clockwise rotational movement of the right to left hand followed by regular tapping on the sieving surface. This is done in order to overcome the binding force by physical process. Survey of processing equipment/machinery and their product indicated that milling, sieving/separation of fibrous content from milled flour is the only unit operation of the traditional technique that has not been properly addressed in the existing mechanized processing. The milling of the flour is obtained by multiple grinding of the nut complemented by manual separation of chaff from milled bambara groundnut flour. This practice is witnessed among bambara groundnut flour processors all over Eastern Nigeria where bambara flour market thrives, such places as: Ogige market in Nsukka, Ogbete market in Enugu, Nkwo Ngwa market Aba, Ubani Ultra morden market Umuahia, Owerri relief market, Eke Onunwa market, Obowo relief market etc. This practice is associated with loss of raw material, delay, undesired exposure of the flour and human contact with the food material which exposes the flour to microbial attack. Thus, the need for an integrated continuous process milling and sieving system, that will address these ugly phenomena.

Existing records revealed mechanization of the sieving process of bambara flour extraction from its seed as a holdup for the processor because the seed has a unique contents of lipid and crude lipid similar with soybean seed resulting in difficulty in their seed coat separation from the cotyledon after milling. However, the seed coat of soybean according to Suqin et al. (2007) can be separate by soaking in water, roasting or by dipping in $CHCL_3$ before milling. This is because soybean contains hydroxyl fatty acids and anatomical study also revealed that the only features consistently correlating with the seed permeability to water is inherent small cuticle cracks on the surface of the seed coat as stated by Suqin et al. (2007). This is not so with bambara seed coat. Bambara seed coat is impermeable to water, heat and chemical because it does not contain inherent cracks like the soybean seed (Suqin et al., 2007). In addition, Mubaiwa et al. (2017) showed that bambara seed contains phenolic compound such as lignin, tannin and hydroxycinnamic acid as well as phytase-phytate-pectin unlike other grains. This is therefore a justification for the high strength of binding force witnessed between the coat and the cotyledon of the seed. Lignin which is contained in bambara seed according to Neeraj etal. (2017) serves as coatings, agricultural chemicals, micronutrients, natural binders, adhesives, resins and in the manufacturing of vanillin and textile dyes. Owing to its huge chemical structure, lignin can as well provide additional functionality such as filler, reinforcing agent, compatibilizer, stabilizer as well as fire retardant (Neeraj et al., 2017). Tannin acts as grout or extender to participate in the formation of adhesive bond and stiffness (Hussein et al., 2011). Also phytase-phytate-pectin when heated in the presence of liquid expands and turns into gel, making it a great thickener for jams and jelly (Savanna and Adda, 2019). Thus, these combined binding characteristics of bambara seed content, resistance to water and heat, increases the strength of the bond when subjected to destructive process like heating. As a result, manual sieving is predominant in this sector as the only method of separating chaff from the fineness flour. Diolla et al. (2015) showed 205.92mg/100g (2.06g/Kg) as phenolic content of bambara grain and binding force of the bambara seed coat and nutritive tissue (endosperm) as 1.51 per MPa. Therefore, a mechanism that can process continuous and adequate pressure in overcoming this bond is vital in this sector to improve bambara nuts utilization.

4.2 Advancement of bambara nuts utilization with innovative milling-sieving machines integration

The centrifugal force and pressure required to separate the endosperm (flour) and coat (chaff) of ground bambara grain without inflicting any damage on the chiffon material was determined as 42.554KN and 7812.5Pa respectively from the following relations given by Khurmi and Ghupta (2006) as given in equations (1) to (8).

$$F_h = N_H m_H \, r_h \omega_h \qquad (1)$$

Where mass of hammer, m_H is 0.83kg, distance of hammer, r_h 0.15mm, number of hammer, N_H 4, using equation (1) from (Khurmi and Ghupta 2006)

Assuming inelastic impact between the hammers and material, the velocity of material was determined as

12.8175m|s from equation (2) from Ndirikal (2016) as

$$v_m = \sqrt{\frac{2N_m M_m r_h}{N_m m_h}} \qquad (2)$$

V_m, M_m, N_m Represent, velocity of material being milled, mass of material being milled and number of material impacted respectively,

But speed of the cross beater hammer blade was determined as 902.4rpm. The distances between the successive arms of the cross-beaters were designed at 150mm apart from each other in accordance with (Adekomaya and Samuel, 2014). The blade length of the beater selected, 130mm, thickness of blade.15mm. $Area, 6400mm^2$, D_1, D_2 which represent the diameters of electric motor pulley and diameter of the beaters 170mm,300mm respectively by (Adekomaya and Samuel, 2014).

But the angular velocity, ω was determined as 85.45rad|sec, power transmitted by the cross beaters, C_P was determined as 640.875watts from equation (3) by (Hannah and Stephens, 2004)

$$C_P = \frac{2\pi N_2 T}{60} = T\omega \qquad (3)$$

C_P and ω represent, power transmitted by the cross beaters and angular velocity respectively. Torque, T was determined as 7.5N-m from equation (4) Khurmi and Gupta 2007).

$$T = Fr \qquad (4)$$

Volume of air generated, A_V was determined as 0.082032m^3|s and area of the hammer $0.0064mm$ deduced from equation (5)

$$Q = av \qquad (5)$$

Velocity pressure of the flour from the milling chamber to the sieving chamber was determined as 98.95Pa, density of air, ρ as 1.2046kg|m^3 from equation (6)

$$V_P = \frac{1}{2}\rho v^2 \qquad (6)$$

Total pressure, P_T was determined as 7812.5Pa, air volume, A_V as 0.082032m^3|s from equation (7) by (Rajput, 2014)

$$P_T = \frac{C_P}{A_V} \quad (7)$$

The maximum allowable pressure of the sieving barrel after reinforcing with aluminium net, P_b as shown in figure 8 was determined as 7900Pa, the thickness of the barrel, *t as* 3mm inside diameter of the barrel, *di* as 0.08203mm and maximum yield stress of steel, δ as 505 N/mm^2 from the equation (8) given by Khurmi and Gupta (2006) as;

$$P_b = \frac{0.54t\delta}{di} \quad (8)$$

Thus the pressure generated from the cross beater hammer, P_T (7812.5Pa) was able to over the binding force of Bambara nut enabling also the expelling of the flour through the aluminium coated net (37µm-screen openings) with the aid of the paddle because its pressure bearing capacity of 7900Pa is greater than the pressure 7812.5Pa developed by the cross beater hammer.

The integrated milling and sieving machine for processing bambara flour from it dry seed was designed and fabricated with locally sourced standard materials and its components were assembled such that the process materials flow is gravity driven in order to improve hygiene and ensure low cost of its production/maintenance. The maximum size of starch granules from white bambara nut is 35µm while normal size of crushed seed coat of this grain is above 40µm and this impelled the selection of a standard 400-messh (37µm-screen openings) for the sieving operation (Kuaté et al., 2015; ASTM - E 11). Its hammer beaters were structured for dual function as crusher in the milling unit and blower for generating the required air pressure for sieving operation of this system. The distances between its successive arms were designed at 150mm apart from each other in line with (Adekomaya and Samuel, 2014) specifications for hammer arms. The major components of the machine include an electric motor, milling and sieving units. These components are assembled on a frame as shown in figure 2.

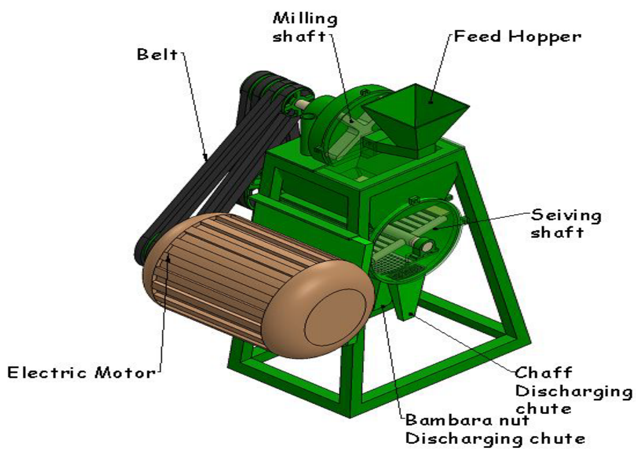

Figure 2. Bambara flour milling/sieving machine

Grinding of the seed and discharging of the ground flour into the sieving unit is actualized as it flows from the hopper into the gap between the rotating and fixed hammer of the grater. The particle size of the ground flour is regulated as desired by adjusting the gap between the hammers using a mesh. The milled flour discharges directly into the sieve through a 0.0026mm apertures of mesh to the sieve barrel. The sieve separates the fine flour and chaff from ground grain by turbo-pneumatic process. The pressurizes air generated from the cross beater hammer in the milling chamber with the aid of the paddles slacks and stirs the fairly compacted milled bambara flour and wipe out the pressed flour which tend to clog on the eye of the chiffon. The chiffon was fixed between aluminum net and interior surface of the barrel. The barrel is perforated (3mm diameter holes at equal spacing of 5mm) 3mm thick stainless steel pipe with inter diameter of 178mm. The fineness flour oozes out of its fibrous content and discharges through the chiffon and barrel perforations as the pressurized air transports and presses the ground seed flour on the sieve aperture. The chaff is discharged as soon as the fine flour is properly separated from the chaff with the aid of the pressurized air and the paddle as the discharge chute is opened.

Comparative performance analysis of the bambara nut milling-sieving machine with the semi-mechanized system as shown in table 1 gives the throughput and the extraction efficiency for the bambara nut milling-sieving machine and the semi- mechanized system at a given bambara nut feed rate. At an average feed rate of 4.8kg, throughput and extraction efficiency of the bambara nut milling-sieving machine gives an average result of 117.8kg/h and 98.45% respectively while the semi-mechanized method gives 41.15kg/h and 83.7% as the average throughput and efficiency respectively. From the table it can be deduced that increase in feed rate also means increase in throughput and extraction efficiency for fully mechanized system while increase in feed rate means decrease in throughput and unstable extraction efficiency for semi-mechanized system this is because as human drudgery and fatigue comes to play after working for a giving time it tends to reduce the efficiency of the output as the feed rate is increased. But for the bambara nut milling-sieving machine, drudgery and fatigue is not witnessed at any time. Therefore the integrated bambara nut milling- sieving machine is seen to have the capacity to improve proper milling and sieving as well as revenue generation in the sector. It also reduces drudgery and eliminates time wastage and excessive loss of bambara flour associated with the semi-mechanized method. Bambara nut milling-sieving machine boost efficient production and recovery of quality bambara flour which in turn will eliminate the major problem of drudgery, fatigue, time wastage, poor efficiency and effectiveness of processing of bambara seed into fine flour for poverty alleviation and food security (Table 1)

Table 1: Comparative performance analysis of the novel integrated milling-sieving machine and existing semi-mechanized system for bambara flour production.

S/No	Feed Rate (kg)	Throughput (kg/hr)		Extraction Efficiency,(%)	
		Semi-Mechanized System	Fully-Mechanized System	Semi-Mechanized System	Fully-Mechanized System
1	2.00	43.37	118.00	88.50	98.60
2	4.00	41.38	117.43	84.80	98.00
3	5.00	40.44	117.68	83.00	98.80
4	6.00	39.42	117.89	82.50	98.70
5	7.00	41.15	117.79	84.70	98.50
Average	4.80	41.15	117.76	85.00	98.45

5. Conclusion

The bambara grain contain phenolic compounds amounting to 205.92mg/100g (2.06g/Kg) which bonds its nutritive tissue (endosperm) and seed coat with a maximum strength of 1.51 per MPa. Thus the binding force of the bambara seed was determined as 7284.38Pa per unit mass as a result a higher separating force is required to overcome the bond. Therefore 7812.5Pa which represent the total pressure of the cross beaters that is the pressure required to overcome the binding force of the seed and separate these two materials (flour content and chaff) is capable of overcoming the binding force of the seed coat and the cotyledon Thus, the bambara nut milling-sieving machine enables effective processing and utilization of bambara groundnut. Thereby, reducing drudgery and fostering mass production of quality bambara flour which also will reposition this world most underutilized legume for mitigating future food shortage in sub-Saharan region.

References

Andrianto, Tomy, and Gima Sugiama. *The Analysis of Potential 4A's Tourism Component in the Selasari Rural Tourism,Pangandaran, West Java*. no. January, 2016.

Adekomaya S and Samuel O. Design and Development of a Petrol-powered Hammer mill for rural Nigerian Farmers. Journal of Energy Technologies and Policy. Vol.4, No.4. 2014.

Adetunji O and. Osunlana A. Development of an Improved Garri Sifting Machine. The Pacific Journal of Science and Technology 14 (2), 54-61. 2013

Atoyebi J, Olaniyi O, O, Olugbenga A, Michael A. Morphological Characterisation of Selected Africa Accession of Bambara Groundnut. International Journal of plant research p-ISSN 2163-2596 7.2. .2017.

Aviara N. Bambara Groundnut Processing, Storage and Utilization in North Eastern Nigeria. Continental Journal of Engineering Science, 8, 28-36, 213.8.1.28.36..2013.

Diallo K, Kone K, Soro D, Assidjo N. Caracterisation Biochimique Et Fonctionnelle Des Graines De Sept Cultivars

De Voandzou (vigna subterranean (L.) Verdc. Fabaceae) Cultives En Cote D,ivoire. European Scietific Journal Vol. 11 No. 27. 2015.

FAO. Small-scale Palm Oil Processing in Africa. Food and agricultural organization agricultural Series 148. pp. 1-55.2005

Fayose, F. The Development of a Multi-Purpose Wet Food Sieving Machine. The CIGR E-journal. Manuscript FB 08006, Vol. X, 2008.

Hanna R. Steven, Stephen A. Konz. Facility Design and Engineering, 3rd Edition on line version. Scottsdale, Ariz Holcom Hathaway, 2004.

Hillocks R, Bennett .C and Mponda O. Bambara nut: A review of utilization, market potential and crop improvement. African crop science journal, vol. 20, no. 1,pp. 1-16. 2011.

Hussein A, Ibrahim K., Abdulla K.. Tannin-phenol formaldehyde resin as binders for cellulosic fibers: mechanical properties. Natural resources 02(02), 2011

Ikechukwu I. Development and parametric analysis of bambara flour processing machine using response surface methodology. Ph.D. dissertation submitted to Mechanical Engineering Department, Michael Okpara University of Agriculture Umudike Abia State Nigeria. 2021.

Jagdave .S. Origin and ecology of bambara groundnut (vigna subterranean (L,.) Verdc. Journal of ecology and natural resources 2578-4994. 2018.

.

kaptso G, Njintang N, Hounhouigan J, Scher J,and Mbofung C. Production of bambara groundnut (Voandzeia subterranean) four for use in the preparation of koki (a steamed cooked paste): efect of ph and salt concentration on the physicochemical properties of four. Int J Food Eng. https://doi. org/10.2202/1556-3758.1076, 2007

Khurmi R, Gupta J. A Textbook of Machine Design (Vols. Seventh Multi-color edition). Ram Nagar, New Delhi, India: Eurasia Publishing House (PVT) Ltd. Pp. 509-557, 2005.

Khurmi R, Gupta J. A Textbook of Machine Design (Vols. Seventh Multi-colour edition). Ram Nagar, New Delhi, India: Eurasia Publishing House (PVT) Ltd. , 2006.

Kuate G, Yanou N, Mbouga M, Joel S, Joseph H, Carl. Physicochemical and micro-structural properties of flours, starch and proteins from two varieties of legumes: bambara groundnut (vigna subterranean). Journal of food science technology 52(8):4915-4924,,2014.

Mayes, S, Ho, W. Chai, H. Gao, X., Kundy, A, Mateva, K., Zahrulakmal, M. Hahiree, M, Kendabie, P.; Licea, L.. Bambara groundnut: An exemplar underutilized legume for resilience under climate change. Planta, 250, 803–820. 2019.

Mubaiwa J, Fogliano V, Chidewe C, Linnemann A. Hard-to-cook phenomenon in bambara groundnut (Vigna subterranea (L.) Verdc.) processing: options to improve its role in providing food security. Food reviews international vol. 33, no. 2 167-194. 2017

Nachimuthu A, Ragunath S, Mohanavelan P, Nabhan P. Design and fabrication of horizontal sand sieving machine. International Research Journal of multidisciplinary science & Technology, 1(3), 17-20. Retrieved from www.irjmrs.com, 2016

Ndirika V, Onwualu A, Onu O. Design principles for postharvest machines. Text book on the design principles for postharvest machines; Maiden edition, publisher; Naphtalin publication Nigeria, 2016..

Neeraj M, Aurelie C, Francois.R, Fabine. S, Giulio .M, and Jin-Ping .G. An overview on the use of lignin and its derivatives in fire retardant polymer systems. Doi:10.5772/intechopen.72963. Nigeria Sudan Savannah. Agricultural Engineering International. The CIGR Journal . No 11 vol.ix pp1- 2017

Nwigbo M., Beredam J., Dan-Orawari G, Ayodele A. and Itekena H . Fabrication and Performance Evaluation of a Mechanical Shaker. International Journal of Engineering and Modern Technology ISSN 2504-8856 Vol. 3 No.2, 2017

Radhika S. Russel finex showcased their innovative food separation solutions at profood propack.and Agbiz beverage processing and packaging exhibition 2017.

Savanna S, Adda B. What is pectin ? a unique fiber explained. Natural resources 02(02) doi:10,4236/nr,2019, 22013, 2019.

Suqin S, Chris.J., Fengshan M, Carol. A. and Mark. A. The outermost cuticle of soybean seeds: chemical composition and function during imbibition. Journal of experimental botany, vol. 58, no.5.pp.1071-1082. 2007.

Uvere P, Uwaegbute A. and Adedeji E. Effect of malting on the milling performance and acceptability of bambara groundnut (Voandzeia subterranean Thouars) seed and product. Plant foods for human nutrition 54; 49-57. 1999.

Yusuf M, Hassan S, Barket A, Shamsul H. Effect of salicyclic acid on salinity induced changes in Brassica juncea. Journal of integrative plant biology volume 50, issue 9,2008.

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