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Research Article

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Modification of the Motorized Periwinkle Cracking Machine

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Abstract A modified periwinkle cracking machine consisting of a 2HP electric motor, hopper, serrated roll crusher which carries out size reduction by compression, impact and shear force was developed. This machine which was fabricated using locally sourced standard materials eliminate drudgery involved in the cracking of periwinkle. Performance analysis indicated that the machine perform best when the periwinkle is parboiled for about ten minutes at a cracking speed of 251rpm. The following results were obtained: 1.5% shell lost, 9.2% mechanical lost, 53.57Kg/hr throughput capacity and 92.01% cracking efficiency. Adoption of this innovation is recommended because it reduces the crushing of periwinkle meat, improved hygiene (as human contact with the meat during processing will be reduced) and also energy saving

Keywords cracking machine, periwinkle, periwinkle shell, periwinkle meat, drudgery

1. Introduction

Periwinkle in zoology refers to any small marine snail belonging to the family littorinidae (class Gastropoda, phylum mollusca).They are widely inhabited in sea and shore (littoral), chiefly herbivorous, usually found on rocks, stones or pilings between high and low tide marks however a few are found on mud flats and some tropical species are found on the prop roots or mangrove trees. Among the approximately 80 species in the world, ten (10) are known to inhibit the western Atlantic ocean [1]. Periwinkles are the most known of “snail like” mollusks found on Cornish shores of Africa and western areas of Nigeria are part of these regions where they are found, harvested and processed [2]. Periwinkle are estuarine snails found in the intertidal area of the mangrove edges and surfaces therefore could be handpicked, also reported is that the mud surfaces in west Africa mangrove swamps are littered with periwinkle which can easily be reached. Periwinkle make regular feedings excursions, trace paths back to their former ecological niches hence remain within a short distance for many weeks and can survive a long period in the absence of water while making use of their reserved food [3]. There are about 40.3 tons of periwinkle per year being harvested from 35 mangrove communities of delta and rivers state in Nigeria survey by the researchers of some riverside communities of itu, oron, issiet, okobo, ikotoffiong and uta-ewea in Akwaibom state showed abundance of periwinkle in these communities, massive periwinkle harvesting is also reported from some communities in Bayelsa, cross river and Edo states of Nigeria [4].

Other faunas found associating with periwinkles at the Niger delta mangrove swamp creek and mud flat include the fiddle crab catangeri, the Hermit Crab clibernarius spp which occupy the empty shells of periwinkles the blue or swimming crab callinectes latimanus and the hairy mangrove crab sesrmahuzardi found crawling around the mangrove trees are the bivalve or mangrove Anadara senillis and so many others [5]. Periwinkles processing has suffered lots of setbacks for centuries now owing to its continual local cracking methods which appear the most laborious tasks of the entire process. Cracking of periwinkle is currently done manually in Nigeria and most African countries. These has resulted to poor processing of periwinkle meat, proven to be time wasting, tedious, insufficient, uneconomical, involved high drudgery and in some cases have helped to introduce dirt and germs thereby reducing the quality of the sauce [6-7]. These has left majority of the customers with the choice of either to spend hours gushing out the meat with sharp object or suck out the meat during consumption [8].

Inadequate production of periwinkle meat due to poor level of mechanization has led to its small market; reduce its economic and industrial value [2].

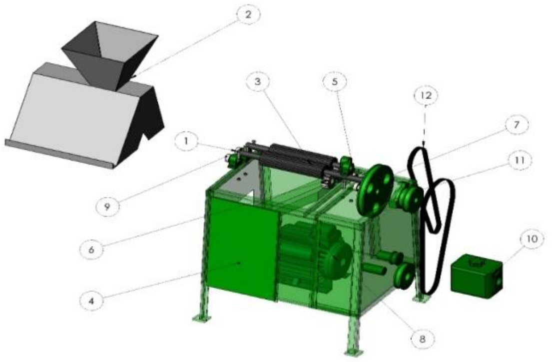
The periwinkle shell which current research work has proven to be of divers use ranging from its use in building to road construction is yet to be fully utilized due to its poor production yearly [9].

Nwachukwu Chris C [10] made the first attempt on design and fabrication of an automatic periwinkle cracking machine where he concentrated on achieving a very high cracking efficiency of about 95% although the high percentage efficiency was achieved but the whole meat was crushed in the process. The modification of this machine will not only achieve a high cracking efficiency but will also aimed at maintaining a high percentage whole meat efficiency which will in turn improve periwinkle production in Nigeria. Thus, the innovation of the improved motorized periwinkle cracking machine is beneficial to farmers especially now that the federal government is investing in agriculture and mechanization for food security and economy stability.

2. Materials and Methods

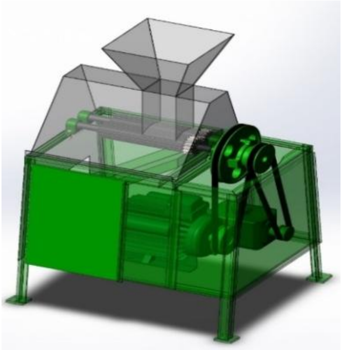
2.1. Manufacturing Procedure/Description of the Modified Motorized Periwinkle Cracking Machine

The materials used for the fabrication of the modified motorized periwinkle cracking machine include: mild steel angle iron, mild steel plate, stainless steel shaft, stainless steel plates for resistance of corrosion and strength, bolts and nuts, bearings, V-belts, single phase electric motor, cast iron pulleys. Samples of Tympanotonus fuscatus var radula were purchased from Ngwa road market, aba, Abia State and used to evaluate the produced modified motorized cracking machine. The developed motorized periwinkle cracking machine consists of the frame, feeding unit, cracking unit, driving and discharge unit. The hopper is calibrated and made from stainless flat plate of 3mm thickness in a square frustum pyramid shape; it forms the feeding chute through which periwinkles are metered into the cracking chamber of the machine. The cracking chamber consists of serrated-rolls crusher of 282×60×5mm dimensions made from stainless steel pipes which rotates in counter to each other. The driving mechanism consists of the v-belt, pulley, gears, speed reduction gear (1:10 ratio) and a single phase electric motor of 2hp and 1400 rpm speed power rating. The machine has the pulley to crack and discharge Tympanotonus fuscatus var radula specie of periwinkle with low damage to the meat and a high potential for cracking and discharge of other varieties of periwinkle and related materials. The cost of the machine is cheap enough for local farmers and is simple to operate and maintain.



Exploded view of the machine

S/N	Description
1	Screw
2	Hooper
3	Roll crushers
4	Frame
5	Thrust bearing
6	Gears
7	Driven pulley
8	Electric motor
9	Industrial bearing
10	Reduction gear
11	Reduction pulley
12	Belts



Isometric view of the machine

2.2. Design Analysis of the modified motorized periwinkle cracking Machine

2.2.1. Design considerations

In designing the periwinkle cracking machine, the following considerations were made;

- The design considered the comfort and safety of the operator in sizing and enclosure
- The optimal velocity of the roll-crusher was considered in the choice of motor, pulley and speed reducer.

2.2.2 Design and Selection of Transmission System

The machine is powered by a 2hp electric motor with a speed of 1400rpm mounted on a slotted and detachable base for ease of connection and adjustments. The power to roll-crusher is 251rpm while its transmission to the moving parts is by shafts, pulleys, speed reduction gear of 1:10 ratio and drive belts. The speed of the driving motor and the speed of the roller-shafts is computed as 251rpm using the equation (1).

$$VR = N_1 D_1 = N_2 D_2 \qquad (1)$$

Where N_1 and N_2 are the speed of the driving motor and speed of the roller shaft while D_1 and D_2 are the diameter of the driving pulley and diameter of the roller driven pulley. The Centre to center distance of the belt was computed as 257.5mm using the relationship of the equation (2) [11]

$$C = \frac{Dl + Ds}{2} + Ds \qquad (2)$$

The design length of the belts' drives were computed as 1210mm using the equation (3) [11], hence type A v-belts was used.

$$\mathrm{L} = \frac{\pi}{2}(d_1 - d_2) + 2\mathrm{x} + \frac{(d_1 - d_2)2}{4x} \qquad (3)$$

The angle of lap (Ɵ) of each of the drives was computed as 2.03rad using equation (4) [11]

$$\theta = (180° - 2 \propto) \frac{\pi}{180°} rad \qquad (4)$$

$$sin \propto = \left(\frac{Dl - Ds}{2c}\right) \qquad (5)$$

The velocity of the belt was computed as 4.4ms^{-1} using equation (6)

$$\mathrm{V} = \frac{\pi DN}{60} \qquad (6)$$

Tension on the tight and slack side of the belt was computed as 203.52N since the velocity of the belt is less than 10m^{-1}, centrifugal force is neglected and T_{max} will be equal to the tension on the tight side

$$T_{MAX} = T_1 \qquad (7)$$

$$T_{MAX} = \partial_b \times A_b \qquad (8)$$

Where σ_b is the maximum allowable shear stress of 2.4×10^{-6}mpa and A_b is the effective area of 8.48×10^{-5}m^2 [11]
Rotation of the tight side to the slack side of the belt tension in terms of co-efficient and angle of contact was computed as 25.28N using the equation (9).

$$2.3 log \frac{T_1}{T_2} = \mu\theta cosec\beta \qquad (9)$$

Where T_1 and T_2 are the tension in both the tight and slack side of the belt, μ is the coefficient of friction between belt and the pulley, θ is the angle of contact between the belt and the pulley, β is half of the pulley groove angle, for type A V- belt, pulley groove angle is 34^o =17^o.

2.2.3. Modified motorized periwinkle cracking machine shear force

Assuming that the torque acting at gears A and B is the same as that of the shaft, therefore the tangential force acting at gear B was computed as 806.49N using equations as obtained from khurmi and Gupta [11] was given as;

$$F_{tb} = \frac{T}{Rb} \qquad (10)$$

Where T is the torque transmitted by the shaft = 29.84N, R_b is the pitch radius of the gear = 0.037cm.
The total force (load) of the periwinkle cracking machine was computed as 806.49N using the equation

$$F_t = W_{TH} + W_{TV} \qquad (11)$$

Where WTH and WTV are the total horizontal load and total vertical load which are 806.49N and 372.4N.

2.2.4. Cracking shaft design of the periwinkle cracking machine

For a solid shaft having little or no axial load, the ASME code equation is given as (ASME 1995);

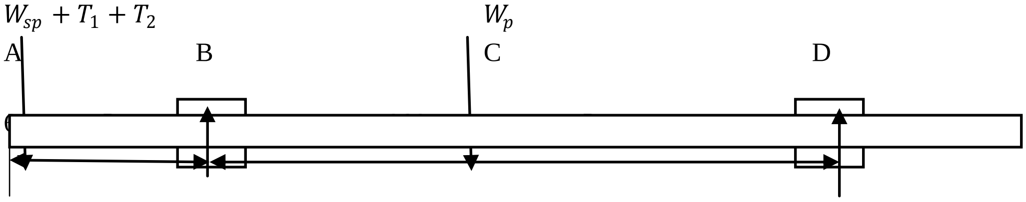
$$\mathrm{d}^3 = \left({}^{16}\!/_{\pi S_s}\right) \times [(K_b M_b)^2 + (K_t M_t)^2]^{1/2} \qquad (12)$$

Where D is the diameter of the shaft, M_t is the torsional moment, M_b is maximum bending moment, K_b is combined shock and fatigue factor applied to bending moment, K_t is combined shock and fatique factor applied to torsional bending moment, S_s is the allowable shear stress = 56Mpa = 56×10^6 N/m^2 [11]. While the respective maximum twisting moment on the shaft, m_t can be determined as 5.35 N-m using this equation

$$M_t = (T_1 - T_2)\frac{D_s}{2} \qquad (13)$$

Where T_1 and T_2 on the tight and slack side of the belt which are 203.52mm and 25.28mm and D_s is the diameter of the smaller pulley = 60mm.

The bending moment on the cracking shaft was determined using the figure below



Total force on point A was computed as 338.8N using the equation 14

$$W_{sp} + T_1 + T_2 \qquad (14)$$

Where W_p is the weight of un-cracked periwinkle =98.1N, W_{sp} is the weight of the cracking shaft pulley = 110N, T_1 and T_2 is the tension on the tight and slack side of the belt which are 203.52N and 25.56N. The reactions of bearing R_B and R_D were determined by taking the moment about B which were computed as 31594N and 120.96N Taking downward forces to be negative (-) and upward forces to be positive (+), the shear forces acting on this shaft are computed as follows:

$F_{A-B} = -338.8N$, $F_{B-C} = -22.86N$, $F_{C-D} = -120.96N$, $F_D = 0N$.

Thus the maximum bending moment on the shaft is 20328N-mm. The maximum twisting moment of the shaft is 29837.2N-mm. Since the feeding of the periwinkle is gradual and steady, K_b = 1.5, K_t = 1.0 [11] the shaft diameter was determined using equation as 15.7mm. Therefore a stainless steel rod of diameter 20mm was selected, giving considerations for bearings.

3. Machine Performance Procedure Evaluation

A 10kg samples of periwinkle was bought, washed, and per-boiled, a certain x-quantity of samples were taking once at time (unequal sampling), weighed and introduced into the developed modified motorized periwinkle cracking machine for cracking and discharge.

The products (shells and meat) were used to evaluate the performance of the designed and fabricated periwinkle cracking machine using equations adopted from Kute [12], and a design table was computed.

3.1. Machine Parameter Test

The percentage of the total shell lost was calculated using the expression below;

$$\%\, W_{sl} = \frac{Wsl}{Ws} \times 100 \qquad (15)$$

Where, $\%W_{sl}$ *is* the percentage shell lost (%), W_{sl} is the weight of shell lost (kg), W_s is the total weight of shell (kg).Cracking Efficiency, CEcompares the quantity of cracked periwinkle to the total quantity of periwinkle in a sample unit. It was calculated as;

$$CE = \frac{Qc}{Qt} \times 100 \qquad (16)$$

Where, CE is the cracking efficiency (%), Q_C is the quantity of cracked periwinkle (kg), Q_t is th ‘’ Ne total quantity of periwinkle in a sample (kg).Mechanical Damage, MD expresses the percentage of damaged meat to the total machine produced meat. It was calculated as shown below;

$$MD = \left(\frac{Q_u}{Q_{w+}Q_u}\right) \times 100 \qquad (17)$$

Where, MD is the mechanical damage (%), Q_U is the quantity of un-whole meat (kg), Q_W is the quantity of whole meat (kg), W_M = weight of meat produced (kg). Meat Efficiency, ME is a measure of the percentage of wholesomeness of produced meat to total machine produced meat. It forms the major parameter on which the machine test was evaluated, it was expressed as;

$$ME = \left(\frac{Q_w}{Q_{w+}Q_U}\right) \times 100 = \left(\frac{Q_w}{W_m}\right) \times 100 \qquad (18)$$

Where, ME is the material efficiency (%),$Q_U$is the quantity of un-whole meat (kg), Q_M is the quantity of whole meat (kg), W_M is the weight of meat produced (kg).Throughput Capacity; TC is defined as the rate at which the periwinkle is being cracked and discharged. This can be calculated using the relationship below;

$$TC = \frac{Qt}{Tc} \text{ (Kg/hr)} \qquad (19)$$

Where;$Q_T$is the total quantity of periwinkle (Kg), $T_C$is the time of cracking (hr).

4. Results and Discussions

Result of the cracking efficiency, mechanical damage, meat efficiency, throughput capacity and percentage shell lost is presented in the Table 1 below. The machine was tested at three different cracking speed of 251rpm, 539rpm, and 656rpm, the performance and the results are discussed below. From the determined results shown in table 1 below, it is noticed that the different in cracking speed has a significant changes and effect in the parameters discussed earlier as it is explained below;

Table 1: Performance Analysis of the periwinkle cracking machine

Cracking speed (rpm)	Quantity of periwinkle (kg)	Time taken (hr)	Percentage shell lost (%)	Cracking efficiency CE (%)	Meat efficiency ME (%)	Mechanical damage MD (%)	Throughput capacity TC (kg/hr)
251	3	0.108	1.5	92.01	90.80	9.20	27.69
539	3	0.08	1.59	94.63	84.30	15.70	37.5
656	3	0.056	1.58	97.66	78.20	21.80	53.57

The highest shell lost was recorded at a speed of 539rpm with a mean value of 1.59% followed by 1.58% recorded at the speed of 656rpm and the least was recorded as 1.50% at a speed of 251rpm. From the result, percentage shell lost increases with increase in cracking speed up to maximum and decline. The deviation from the expected trend of increase in percentage shell lost with increasing shaft speed as observed from increasing the shaft speed from 539rpm to 656rpm was as a result of fluctuation in power, unequal sample sizes and human factors.

In the cracking efficiency, the highest mean cracking efficiency was recorded at a speed of 656rpm with a mean value of 97.66% followed by 94.63% recorded at a speed of 539rpm while the least was recorded at 92.01% at a speed of 251rpm. From the result, it can be seen that cracking efficiency increases though slightly, with increase in speed.

The highest material or meat efficiency was recorded at a speed of 251rpm with the mean value of 92.80% followed by 84.30% recorded at a speed of 539rpm while the least was recorded as 78.20% at a speed of 656rpm. From the result, material efficiency decreases with increase in cracking shaft speed and can be said to be inversely proportional to the cracking speed. Decrease in mechanical damage leads to increase in meat efficiency and vice versa.

The highest material throughput capacity was recorded at a speed of 656rpm with the mean value of 53.57% followed by 37.50% recorded at a speed of 539rpm while the least was recorded as 27.69% at a speed of 251rpm. The result, shows that material throughput capacity increases with an increase in cracking speed and can be said to be directly proportional to cracking speed.

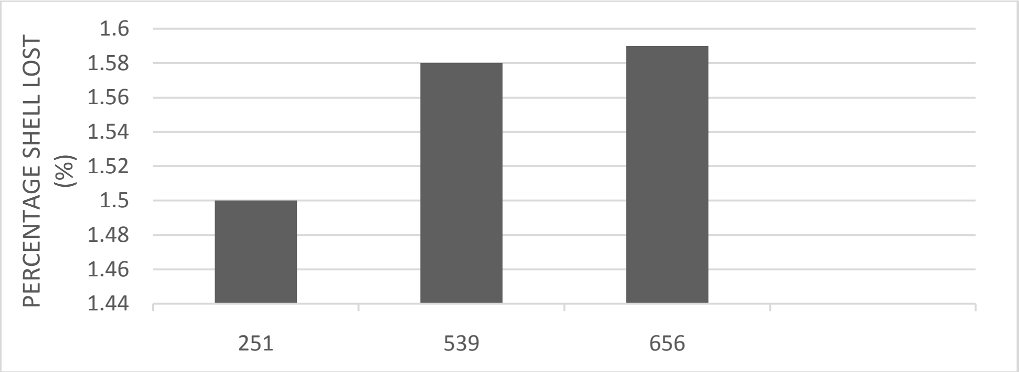


Chart 1: Percentage shell lost against cracking speed

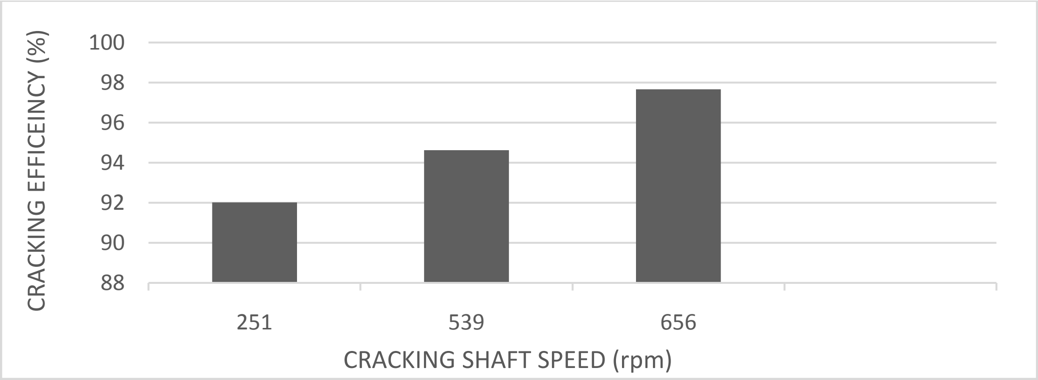


Chart 2: Cracking Efficiency against Cracking Speed

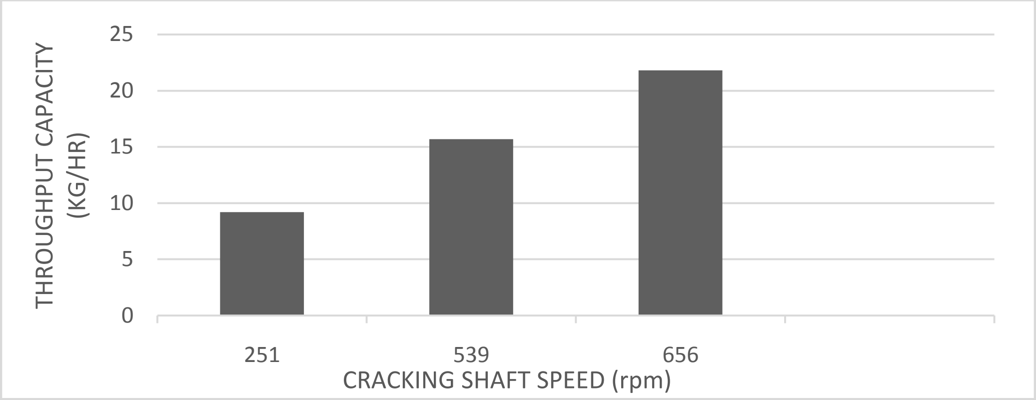


Chart 3: Mechanical Damage against Cracking Speed

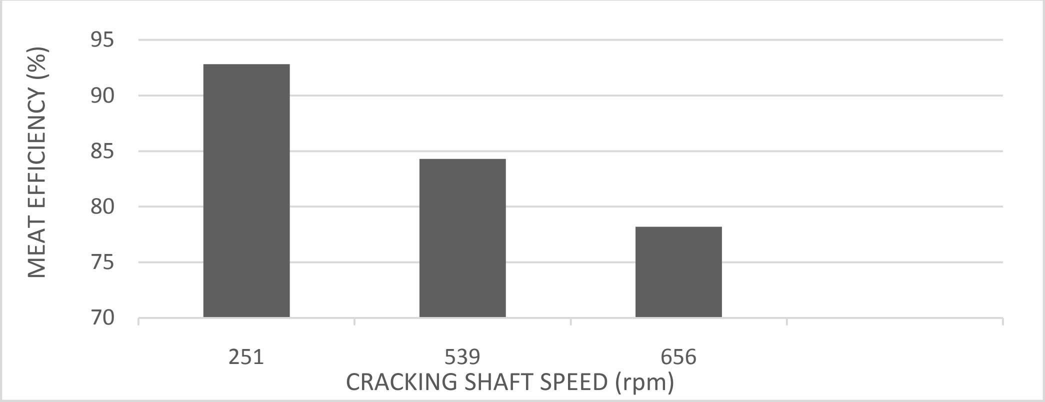


Chart 4: Material Efficiency against Cracking Speed

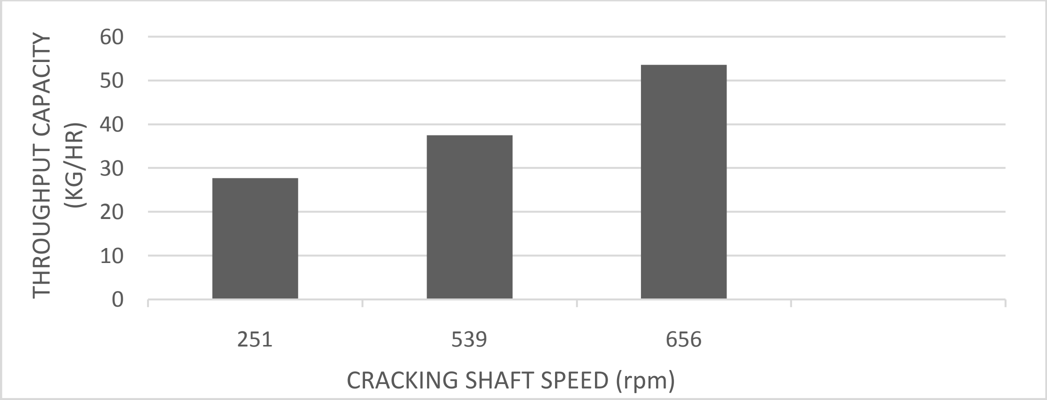


Chart 5: Throughput Capacity against Cracking Speed

5. Conclusion

The modified motorized periwinkle cracking machine for periwinkle processing, was designed and developed using locally sourced standard materials at Michael Okpara University of Agriculture, Umudike work shop. This machine performs with an average throughput capacity of 27.69kg/hr, meat efficiency of 92.80%, cracking efficiency of 92.01% and a minimum mechanical damage of 7.20%, when tested randomly at different speed rate. The development of this machine improved the whole meat efficiency and with minimum mechanical damage and also reduces time loss and drudgery associated with periwinkle processing. Thus, the innovation of the improved motorized periwinkle cracking machine is beneficial especially now that the federal government is investing in agriculture and mechanization for food security and economy stability.

References

[1]. Fayeoriferi, G and Bob – Manuel, A. (2012). The preliminary study on the population estimation of the Periwinkles Tympanotonousfuscatus (linnaus 1758) and Pachymelinia aurita (Muller) at Rumuolumeri mangrove swamp creek, Niger Delta, Nigeria. Agriculture and Biology Journal of North America 3 (6): 265-270.

[2]. Olorunje, G.S and Olalusi, O.C (2003): “Periwinkle shell as alternative to coarse aggregate in light weight concrete”, International Journal of Environmental Issues, 1(1): 231-236.

[3]. Dambo, W.B, (1993): Tolerance of the periwinkle P. aurita and T. fuscatus to refined oils. Environ. Pollution, 79:293-296.

[4]. Jambo N. and Chinda A. (2010). Aspect of the Ecology of Tympanotousfuscatus (Linneaus 1758) In the mangrove swamp of the upper bonny river, niger delta, Nigeria. Current research journal of biological sciences 2(1): 42-47.

[5]. Bob –Manuel, F.G (2006): Aquatic Ecology and Fisheries one book Company Rivers. pp. 276.

[6]. Powell, C.B. Hart, I. and Deekae, S.N. (1985). Market survey of the periwinkle Tympanotonus fuscatus in Rivers State. Sizes, prices, trade routes and exploitation levels. In proceedings of the 4th annual conference of the fisheries society of Nigeria (FISON). Ita, EO Ajayi, TO Ezenwa, B Olaniawo, AA Udolisa, REK Tagget, PA (Eds.), pp: 55-61.

[7]. FAO/FIDI, (1994). World Aquaculture production 1986-1997. Fisheries circular No. 815 (Review 6), FAO, Rome.

[8]. Ojiakor J.C (2010): Pakistan journal of nutrition 11(x): xx-xx, 2012 ISSN 1680-5194© Asian network for scientific information.

[9]. Micheal I.O and Munner, U. (2012): Effect filler content on the mechanical properties of Periwinkle shell reinforced (NSL resin composite. ARPN journal of engineering and applied sciences 7(2): 135-143.

[10]. Nwachukwu Chris (2015): Development and Performance Evaluation of a motorized periwinkle cracking machine. M.Sc. thesis Agriculture and Bio resource engineering department Michael Okpara University of Agriculture Umudike, Abia state. Nigeria.

[11]. Khurmi R.S and Gupta, J.K (2012): A textbook of machine design S. Chand and company ltd Rag Nager New Delhi.

[12]. Kutte M.T. (2001): Reactivation and Performance Evaluation of the Threshing Unit of a combine Harvester Scrap for stationary threshing of rice. An unpublished M. Eng. Thesis. Department of Agric Engr Futo, Yola- Nigeria Pp. 47-48.