Development and Performance Evaluation of a Roasted Groundnut (*Arachis hypogaea*) Blanching Machine

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***Abstract*—A roasted groundnut blanching machine was designed with the aim of reducing drudgery associated with manual blanching of roasted groundnuts. Fabrication and performance evaluation were carried out at the Department of Agricultural and Environmental Engineering, Federal University of Technology, Akure, Nigeria. Roasted groundnuts purchased at a local market in Akure were used for performance evaluation. Three operating parameters: blanch clearance, blanch speed and feed rate, were considered for the purpose of this research. Three levels each of feed rate, brush speed and blanch clearance were compared. Blanch clearances were varied from 10mm to 20mm at an increment of 5mm for three different feed rates of 0.2kg/hr, 0.4kg/hr and 0.6kg/hr respectively, while blanch speed was varied from 100rpm to 200rpm with an increment of 50rpm. The machine blanching capacity was found to be 36.91kg/hr. Changes in blanch clearance, feed rate and blanch speed affected the blanching efficiency, cleaning efficiency, and mechanical damage. Maximum values of blanching efficiency of 89.46% and cleaning efficiency of 91.39%, and maximum mechanical damage of 53.02% were obtained at blanch clearance of 10mm and blanch speed of 200rpm. Minimum values of blanching efficiency of 44.56%, cleaning efficiency of 41.70% and mechanical damage of 9.90% were also obtained. Results show that the feed rate has effects on the evaluation parameters, with blanch speed having a positive relationship with evaluation parameters. It was concluded that roasted groundnut blanching could be best achieved with the machine when the feed rate, blanch clearance and blanch speed were regulated to 0.2kg/hr, 0.8mm and 200rpm, respectively.**

***Keywords*—roasted groundnut, blanching, blanching efficiency, cleaning efficiency, mechanical damage**

I. INTRODUCTION

Blanching is the removal of the outer red skin from groundnuts with mild pressure, and it plays an important role in the storage and marketing of groundnuts. Manual blanching has been noted as one of the problems militating against the appreciable market value of roasted groundnuts. However, local manufacture of groundnut blanching machines can proffer a solution to this challenge and many other associated problems.

The groundnut (*Arachis hypogaea*), also called the peanut, is one of the most important food crops in the world. It is the world's fourth most important source of edible oil and third most important source of vegetable protein [1]. In 2004 groundnuts were grown on 24 million hectares worldwide with a total production of 36 million metric tons. It is estimated that around 65% of the crop produced in the world is crushed to extract groundnut oil and the rest is used in making other edible products [3].

Blanching provides substantial value addition to groundnuts [6], ensuring that they can be eaten without further processing. The groundnut blanching machine removes the skins from shelled groundnuts [2]. The skin of a groundnut after roasting is ordinarily loose and removable by manual manipulation; such blanching however becomes a tedious and laborious process when performed commercially on large quantities of kernels. The blanch invention provides for manipulation of the kernels between opposing tenacious yielding surfaces with which the kernels come in contact, and the outer coat is removed as the kernel is thrust through. The loosened skins are withdrawn by air blast while the denuded kernels are distributed over a sorting table for removal of kernels unsuitable for sale, after which they are graded by separation of pieces and halves from the whole kernels.

Groundnut kernel processing is highly mechanized in developed countries. However, in the developing countries of the world (including Nigeria), the traditional method of processing is the norm [5]. This is very cumbersome and labour-intensive. Traditional blanching of roasted groundnuts is done manually by constant rubbing the groundnuts in between two palms at mild pressure [4], after which air is blown over them by mouth to separate the removed skins from the skinned kernels.

In Nigeria, roasting is usually done on large trays with sandy soil as the heating medium, making it necessary to do some more cleaning after. Cleaning, sorting and grading are done manually, and packaging is either in transparent polyethylene bags or in bottles of various sizes. The groundnut blanching machine is necessary to reduce drudgery, save cost and enhance production capacity through easily accessible energy resource input. Traditionally, blanching is a physically demanding job as it is usually carried out in direct air in an open environment or from the mouth for a long duration. Not only is this method physically exhausting but also substantial amounts of roasted groundnuts are usually lost in the process of operation. Hence, traditional operation is characterized by backbreaking work with low productivity. With the development of the machine, the work will be done with better efficiency and a reduction in the difficulty associated with manual blanching of the product. Moreover, the groundnut loss in the manual blanching process may be significantly reduced.

Large quantities of groundnuts are lost annually due to lack of storage facilities and local method of processing the groundnuts [6]. In order to improve on various ways in which the husk or rind of roasted groundnuts are removed, there is need to develop simple machines to address this problem and this brought about the design and fabrication of the roasted groundnut blanching machine. This machine will solve problems such as blowing air through roasted groundnuts in order to remove chaff, reducing loss of groundnuts during winnowing, and reduce the stress and time involved in peeling the chaff off roasted groundnut during winnowing. The cleanness of the finished product will also be improved.

The work was carried out to:

- design and fabricate a roasted groundnut blanching machine,
- carry out a performance evaluation of the developed machine, and
- determine the operating conditions that optimize the roasted groundnut blanching machine, making it easily adaptable for use by low and medium scale farmers.

II. MATERIALS AND METHODS

The groundnuts used to carry out the performance evaluation of the blanching machine were roasted groundnuts obtained from Oja-Oba Market, Akure, Nigeria. All individual components were designed and fabricated in the Department of Agricultural and Environmental Engineering of the Federal University of Technology, Akure, Nigeria.

A. *Design Calculations*

The following design calculations were made.

Conveyor belt capacity, c (kg/s)

$$c = C_S \text{ x } v \text{ x } M_s \qquad (1)$$

Where:

C_s = Load cross section area perpendicular to conveyor (m^2)

v = Belt speed (m/s)

M_s = Material density (kg/m^3)

Live load, L_L (kg/m)

$$L_L = \frac{c}{3.6 \text{ x } v} \qquad (2)$$

Total live load, T_{LL} (kg)

$$T_{LL} = L_L \text{ x } C_L \qquad (3)$$

Where:

C_L= Conveyor length (m)

Dead load, D_L (kg)

$$D_L = M_R + M_b + M_p \qquad (4)$$

Where:

M_R = Mass of roller (kg)

M_b = Mass of belt conveyor (kg)

M_p = Mass of pulley (kg)

Belt pull, B_{PP} (N)

$$B_{PP} = (T_{LL} \text{ x } D_L) \text{ x } C_f \qquad (5)$$

Where:

C_f = Coefficient factor, 0.005

Effective belt pull, E_b (N)

$$E_b = (B_{PP} + A_b + A_{b1}) \text{ x } 1.25 \qquad (6)$$

Where:

A_b = mass of material conveyed on upper side (kg)

A_{b1} = mass of material conveyed on return side (kg)

Total effective belt pull, T_1 (N)

$$T_1 = E_b \text{ x } k \qquad (7)$$

Where:

E_b = Effective belt pull (N)

k = 1.5

Total weight of belt conveyor, W (kg)

$$W = W_m + W_b \qquad (8)$$

Where:

W_m = Weight of material (kg)

W_b = Weight of belt conveyor (kg)

Return side tension, R (N)

$$R = Fe \text{ x } W \text{ x } L_s \text{ x } 0.4 \text{ x } g \qquad (9)$$

Where:

Fe = 0.03

L_s = Length of belt of conveyor (m)

g = 9.81N

Total empty friction, Z (N)

$$Z = Fe + (L_s + t_f) \text{ x } W \text{ x } g \qquad (10)$$

Where:

t_f (terminal factor) = 10m

Load friction, F (N)

$$F = F_j \text{ x } (L_s + t_f) \text{ x } \frac{c}{3.6 \text{ x } v} \text{ x } g \quad (11)$$

Where:

F_j = 0.025 for horizontal conveyor

Load slope tension, S_T (N)

$$S_T = \frac{\text{c x H}}{\text{3.6 x v}} \quad (12)$$

Where:

H = Height of conveyor (m)

Effective tension, T_e (N)

$$T_e = Z + F + S_T \quad (13)$$

Power required to drive the conveyor, P (kW)

$$P = \frac{T_e \text{ x } v}{33000} \quad (14)$$

Diameter of shaft, d (m)

According to ASME standards,

$$d = \sqrt[3]{\frac{16}{\pi \text{ x } \tau} \text{x} \sqrt[2]{(Kb \text{ x } Mb)^2 + (Kt \text{ x } Mt)^2}} \quad (15)$$

Where:

π = 3.142

τ = Shear stress (Nm)

Kb = Combined shock and fatigue factor applied to bending moment in load

Kt = Combined shock and fatigue factor applied to torsional moment

Mb = Bending moment (Nm)

Mt = Torsional moment (Nm)

B. Machine Construction

The hopper (Fig. 1a, element 1) was fabricated using four welded galvanized plates slanting downwards to form a trapezoidal cross section with two openings. The larger (upper) opening is for introducing the roasted groundnut kernels into the blanching unit while the smaller (lower) opening connects the blanching unit to blowing unit. The fabrication procedure involved marking out 150mm^2 dimensions for the upper opening and 70mm x 50mm dimensions for the lower opening, with a height of 120mm. The marked sheet plates were cut and welded to form the trapezoidal shape. The outer surfaces were then smoothened with an electric grinding machine.

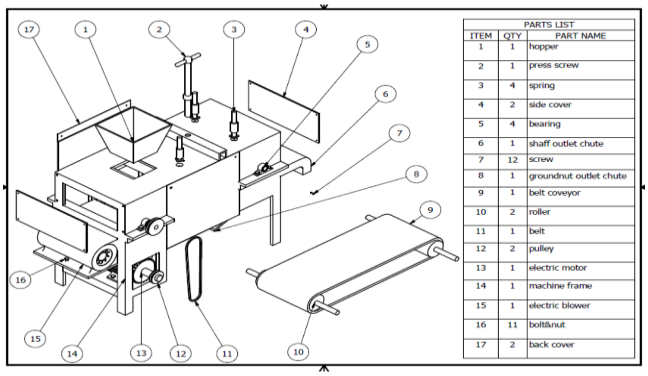

Fig. 1(a): Exploded view drawing of the groundnut blanching machine

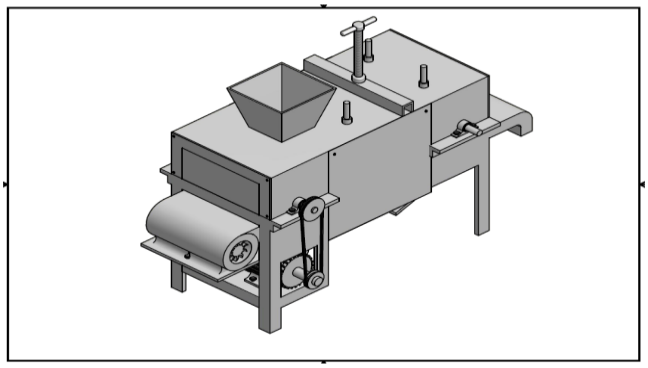

Fig. 1(b): Isometric drawing of the roasted groundnut blanching machine

The blanch drum which houses the inner drum with the brush-like projections where the blanching occurs was made from a 1.5mm thick iron sheet. It was 450mm^2 to give a 110mm diameter. Cutting was carried out in conformity with the marked dimensions. The iron plate was rolled to shape by a rolling machine and then welded to form the cylindrical shape. The drum and the hopper were joined together using bolts and nuts.

The support frame was fabricated from eight square bars (mild steel), four of length 600mm and four of length 150mm. The components were welded to form the support frames. The electric motor (3 horsepower by Atlas) transmits power to the blower and the prime mover that supplies power to the inner drum by belt drives. The blower is at the outlet of the blanching unit.

The exploded and isometric views are shown in Fig. 1(a) and (b).

C. Performance Evaluation

Performance evaluation was conducted using three levels of feed rate (0.2kg/hr, 0.4kg/hr and 0.6kg/hr), three levels of brush speed (100rpm, 150rpm and 200rpm) and three levels of brush clearance (10mm, 15mm and 20mm). The three independent variable levels were pre-selected based on the results of the preliminary tests.

The performance criteria considered were the product Mechanical damage, Blanching efficiency, and Cleaning efficiency. The performance variables include

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the constant variables (mass of roasted groundnuts and air velocity) while the running variables are as given above.

III. RESULTS AND DISCUSSION

The results of this experiment revealed the effect of operating parameters on the blanching of roasted groundnuts. The evaluating performance parameters were recorded using different tests to actually determine the optimum operating parameters of the machine. The results showed that blanch speed has the highest effect on efficiency of the machine. Moreover, other operating parameters also depend on blanch speed for real processing operation to be carried out.

During the experiments, machine operating parameters were adjusted (blanch clearance from 10mm to 20mm, feed rate from 0.4kg/hr to 0.8kg/hr and brush speed from 10rpm to 200rpm) in order to get the best results from the machine during blanching process of roasted groundnuts.

A. Effects of Variable Parameters on Mechanical Efficiency

Fig. 2 shows the effect of blanch clearance on mechanical efficiency of the machine. As the blanch clearance increased, the mechanical efficiency also increased. This signifies that the smaller the blanch clearance between blanch brush and chamber of the roasted groundnut blanching machine, the higher the damage of the groundnuts. Increase in clearance between blanch brush and chamber lowers the damage to groundnuts during blanching processes but also decreases the blanching efficiency of the machine.

Fig. 3 shows the effect of blanch speed on mechanical efficiency of the machine. It can be seen that the maximum mechanical efficiency (53.016%) was obtained at the blanch speed of 100rpm which implies that decreasing blanch speed increases the mechanical efficiency within the blanching drum.

Fig. 4 shows that a mechanical efficiency 43.456% was obtained at the feed rate of 0.8kg/hr. Feed rate was found to have a significant effect on mechanical efficiency of the machine.

Fig. 5 shows the result that was obtained at the optimum operating parameters. The highest mechanical efficiency of 53.016 % was obtained at the blanch clearance of 10mm when the machine was operated with the three parameters at the same time. For the machine to blanch without breaking the roasted groundnuts and carry out maximum blanching, the blanch clearance must be properly set.

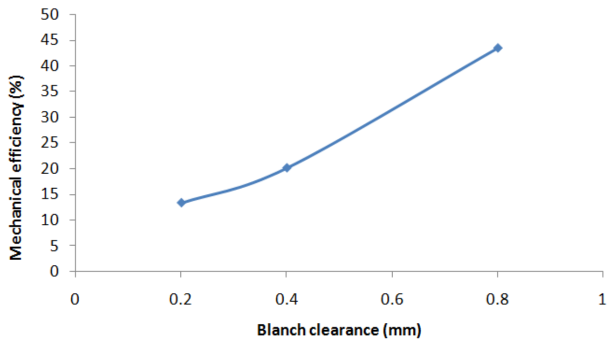

Fig. 2: Effect of blanch clearance on mechanical efficiency of the machine

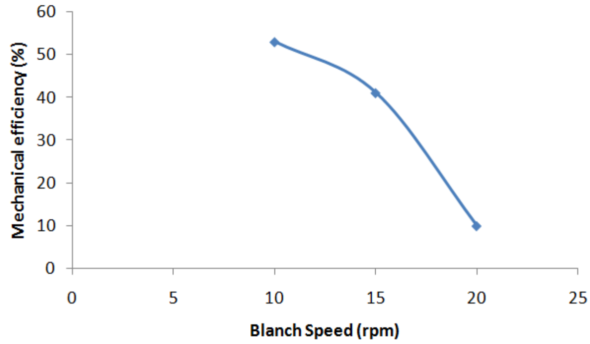

Fig. 3: Effect of blanch clearance on mechanical efficiency of the machine

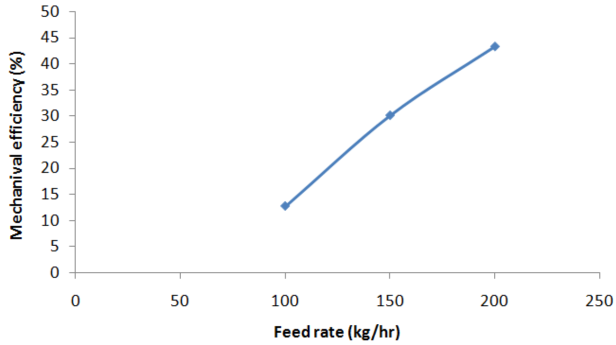

Fig. 4: Effect of feed rate on mechanical efficiency of the machine

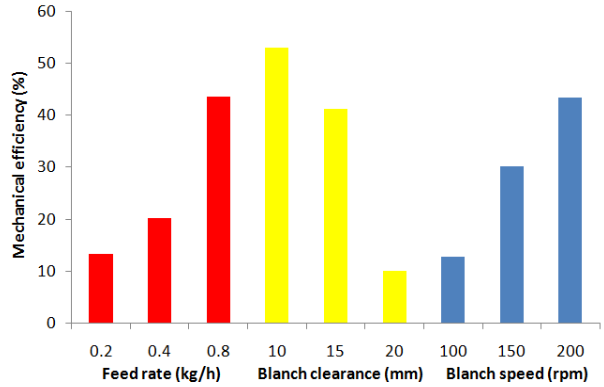

Fig. 5: Effect of variable parameters on mechanical efficiency of the machine

From Fig. 5, blanch clearance of 10mm shows the highest efficiency above other operating parameters.

B. Effects of Variable Parameters on Blanching Efficiency

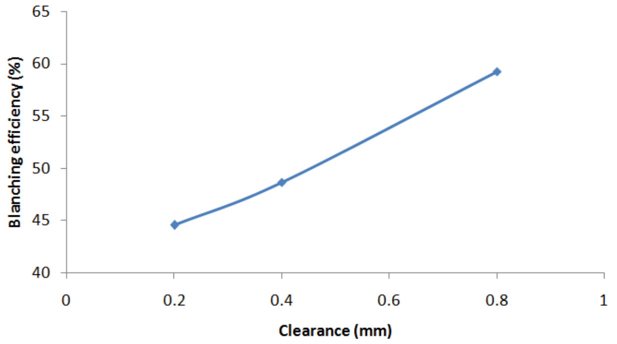

Fig. 6: Effect of blanch clearance on blanch efficiency of the machine

Fig. 6 shows that the highest blanching efficiency of 59.26 % was obtained at blanch clearance of 0.8mm. Any increase in blanch clearance will decrease the blanching efficiency, as the blanch clearance is directly proportional to the size of groundnut kernel. If the diameter of the groundnut kernel to be blanched is equal to the blanch clearance between the blanching brush and chamber, therefore, blanching will not take place [8].

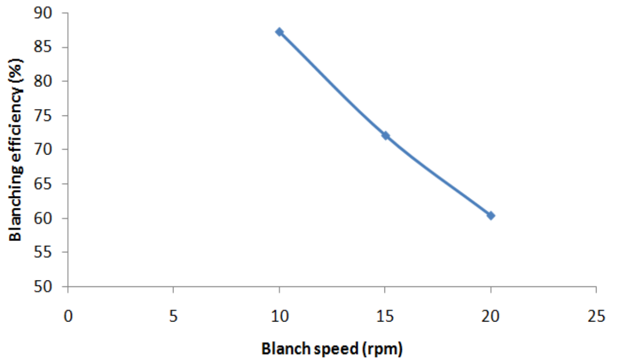

Fig. 7: Effect of blanch speed on machine blanching efficiency

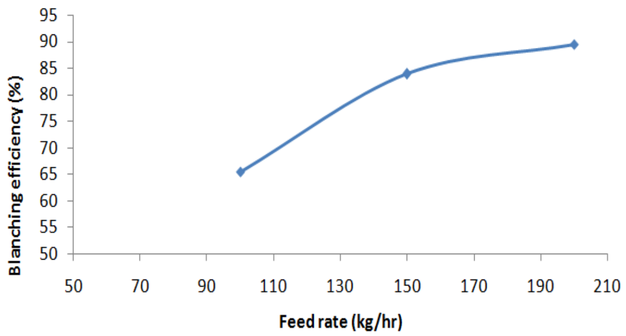

Fig. 8: Effect of feed rate on blanching efficiency of the machine

Fig. 9 shows that blanch clearance 10mm, blanch speed 200rpm and feed rate 0.8kg/hr were the best operating parameters to operate the machine.

C. Effects of Variable Parameters on Cleaning Efficiency

Results obtained for cleaning efficiency are in agreement with the findings of [4]

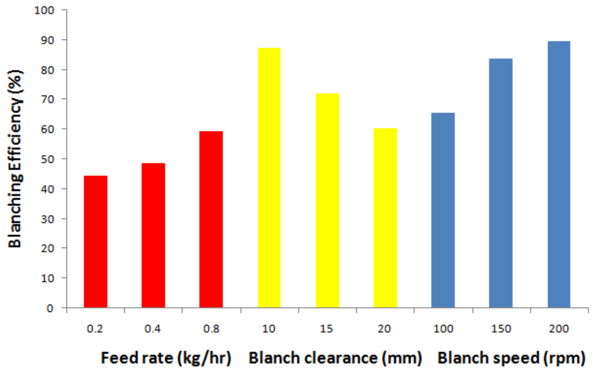

Fig. 9: Effect of variable parameters on machine blanching efficiency

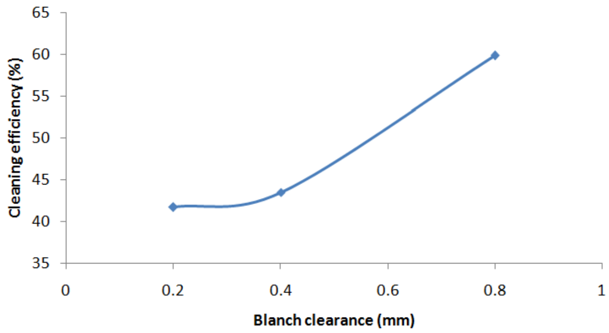

Fig. 10: Effect of blanch clearance on cleaning efficiency of the machine and [9] that cleaning efficiency increases with increase in blanch speed, which affects the quality of groundnuts blanched.

Fig. 13 shows that blanch clearance of 20mm, blanch speed 100rpm and feed rate 0.2kg/hr were the operating parameters at which the highest cleaning efficiency was obtained.

Comparing Fig.s 5, 9 and 13 show that the roasted groundnut blanching machine had highest overall efficiencies when the feed rate, blanch clearance and blanch speed were regulated to 0.2kg/hr, 0.8mm and 200rpm respectively.

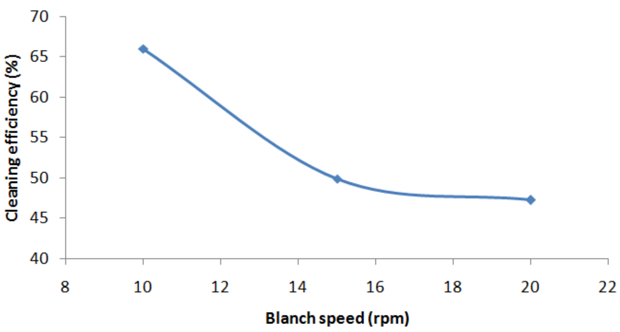

Fig. 11: Effect of blanch speed on the machine cleaning efficiency

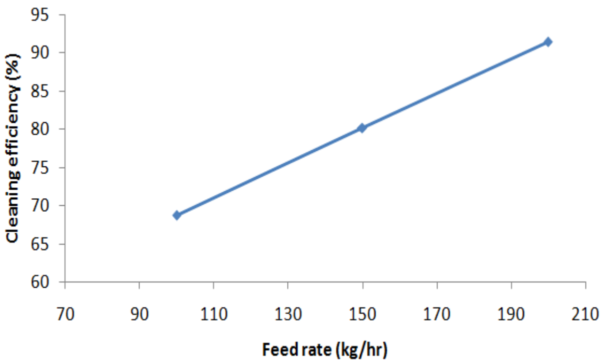

Fig. 12: Effect of feed rate on cleaning efficiency of the machine

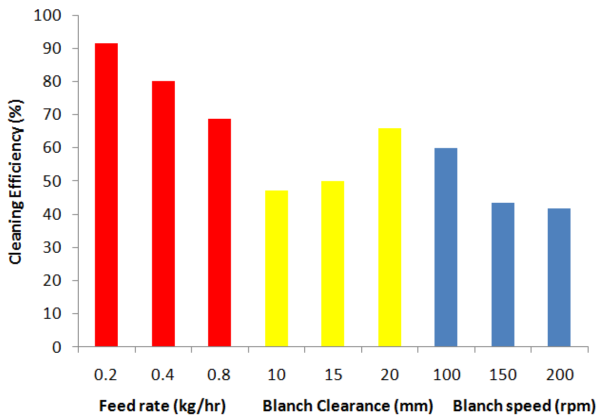

Fig. 13: Effect of variable parameters on machine cleaning efficiency

CONCLUSION

The design and performance evaluation of a roasted groundnut blanching machine was carried out with the aim of reducing the drudgery associated with the manual blanching of roasted groundnuts. Blanching efficiency of the roasted groundnut machine at different blanch speeds of 100rpm, 150rpm and 200rpm were 63.01%, 84.30 % and 89.46 % respectively, and mechanical damages were 91.39 %, 80.00 % and 68.45 % respectively. Nevertheless, the machine has overcome the limitations of roasted groundnuts blanching. The machine has many comparatively favourable attributes and is to be preferred to the traditional method of blanching of roasted groundnuts. The roasted groundnut blanching machine has economic advantages over manual method of blanching roasted groundnuts and further enhances its suitability for small-scale groundnuts processors.

REFERENCES

[1] Y.S. Ademiluyi, “Performance test for improvement of IAR groundnut sheller/decorticator,” unpublished.

[2] S. Afonja, “Planning of the technology needs of women in agriculture,” Workshop on the Promotion of the Adoption of Appropriate Agro Processing Technologies Proceedings, Post Harvest Technology Research Group, Obafemi Awolowo University, Ile - Ife, Nigeria, p. 7.

[3] P. Barry and P. Alex, “Longitudinal impact assessment study of groundnut producers in Malawi,” 2010, Natural Resources Institute, University of Greenwich paper 1.

[4] H.U. Kabri, B.A. Ankidawa, and J. Elson, “Modification and performance evaluation of a manually operated drum groundnut roaster,” Savannah Journal of Agriculture, **1**(2), 2006, 88 – 93.

[5] E.N. Norde, C. Jensen and J.D. Helsel, “Priority and strategies for groundnut research,” NIAR National Workshop for Groundnut Production and Processing, 1982, Zaria, Nigeria, pp.

[6] A.O. Ogunwole, “Design, fabrication and testing of a (manually and electrically operated) roasted groundnut decorticating machine,” Food Science and Quality Management, Vol.14, 2013, pp. 1 –11.

[7] S.E. Shiv, “Blanched and roasted peanuts”, 2009, Buhler (India) Ltd, 13D, KAIDB Industrial area, Attibele, Bangalore-562107.

[8] H. Thaddius, ”Design, construction and testing of a groundnut seed drum roaster”, unpublished.

[9] J.G. Woodrof, “Peanuts: production, processing, products”, 3rd Edition, Avi Publishing Company, Westport, Connecticut: Avi, 1983.