International Journal of Engineering Innovation & Research
Volume 4, Issue 5, ISSN: 2277 – 5668

A Tiltable Discharge Paddy Parboiling System

Gbabo Agidi
Engineering Department, National Cereals Research Institute, Badeggi-Bida, Niger State, Nigeria
Email: agidides@yahoo.com

J. T. Liberty
Department of Crop Production and Protection, Federal University Dutsin-Ma, Katsina State Nigeria

Adamu Jibrin
Department of Agricultural & Bioresources Engineering, Federal University of Technology Minna, Niger State Nigeria

T. M. Alhassan
Department of Agricultural & Bioresources Engineering, Federal University of Technology Minna, Niger State Nigeria

***Abstract* – The design and development of tiltable discharge of rice parboiling equipment has been carried out in this study. The machine was fabricated to take a capacity of 100kg of paddy rice for soaking and steaming par batch. The equipment is made up of three basic units which are: boiling unit; which consist of heat generating chamber, drainage valve and pressure valve regulator, steaming unit; which consist of false bottom, metal screen, steam stand, and transfer unit: which made of two different sizes of pipes (35mm and 75mm), consist of water valve and steam valve and it connected to both boiler and steamer for free flow of water and steam in the system. The result showed that the introduction of tiltable discharge of paddy rice parboiling equipment had made the soaking and steaming of rice easy and low cost. The machine soaking paddy rice at 70°C for 6hours to 12hours and steaming for 40 minutes, this method was found to be easier, faster and also gave better results as far as recovery of rice is concerned.**

***Keywords* – Tiltable Discharge, Parboiling Equipment, Paddy, Soaking, Steaming.**

I. Introduction

The quality of locally processed rice still remains a major concern for the future of Nigerian rice sector. Previous rice sector studies have identified poor physical appearance and cleanliness as major problems of rice delivered to the Nigerian market. In consequence, the demand for better quality imported rice had been increasing steadily over the last two decades, creating rice supply-demand gap, which has to be filled through official and unofficial import.

Rice parboiling is a significant step in rice processing. It involves temperature and hydration conditioning of the paddy before removing the husk and polishing the final product through dehusking and milling. This is an energy intensive process that requires manual and thermal energy. The thermal energy for this process comes exclusively from firewood, particularly in the northern part of Nigerian and one of the preferred sources is prosopis Africana. Kiriya the Hausa name is very important for farming and pastoralist communities in West Africa. Sustainability of the parboiling process is determined by the processing technique used and the energy source adopted. The scale of processing affects energy efficiency and capacity. The desire temperature is usually close to but below the gelatinization temperature of the rice. Bhattacharya (2001) proposed that soaking should start at 70-75^{0}C allowing for cooling. After soaking, the rice is steamed for a certain period of time to completely gelatinise the starch. After steaming, the rice is dried, de-husked and milled. (weber et., 2008)

During parboiling, various physio-chemical changes occur due to gelatinization of starch granules in the rice. These changes play an important role in the next processing operation. Therefore parboiling requires a specific amount of energy for the starch granules in the rice to be completely gelatinised, any excess energy supplied during the process is released to the surroundings. The parboiling help to reduce breakage on milling, change the cooking characteristics and achieve desirable flavour, impact different eating characteristics, reduces losses of nutrient during milling.

The knowledge of how much energy is required in rice parboiling process is important for optimization of the process, especially in rural communities where the process is based on traditional method without consideration given to the exact temperature for gelatinization heat loss to the atmosphere and the potential energy of the fuel used for this thermal process (weber et al, 2008). Therefore, this work is aimed at:

i) Design a tiltable discharge paddy rice parboiling equipment.
ii) Fabricate equipment that will parboiling up to 100 Kg of paddy rice.
iii) Construct the equipment using locally available material.
iv) Test and assess the performance of the parboiling equipment.

II. Materials and Methods

2.1 Materials Selection

The following factors were considered in designing the tiltable discharge rice parboiling equipment.

Cost: Cost has always been the major factor of consideration while designing the machine elements or machine and in this age of competition it has become more important. The best machine design is the one which helps get the finished product with all the major functionalities and highest possible quality at the lowest possible cost.

High Output and Efficiency: Earlier machines used to be very heavy and consume lots of power. Now the trend is of full functional machines consuming low power and giving high output in terms of the number of the of products manufactured. Some computer controlled

International Journal of Engineering Innovation & Research
Volume 4, Issue 5, ISSN: 2277 – 5668

machines can manufacture the components very fast and are highly efficient.

Strength: The machine elements or the machine should be strong enough to sustain all the forces it is designed for so that it is not damaged or permanently deformed during its life time. Right at the time of the designing the machine the designer should consider the force machine can be applied to and consider all the relevant factors that could affects its life.

Stiffness or Rigidity: The machine should be rigid enough so that under the effect of applied forces for which it is designed there is no deformation of the machine or machine elements beyond the specified limits. If there is excessive deformation, there are chances the failure of the machine elements and the whole machine.

Wear Resistance: Wear is the removal of the material from the metallic surface when two surfaces rub with each other. If there is more removal of the material, the component will become weaker and eventually break. The wear of the contacting surfaces can be reduced by the lubrication of the surfaces, increasing the strength or the hardness of the working surfaces. The effect of wear can also be reduce by increasing the surface, so that during the lifetime of the mating machine elements they will not fail even if there is some wearing between them.

Heat Resistance: the material selected should be the type of material that will withstand high resistance of heat.

Product Life Cycle: this is predictable stage at which every product or equipment/machine goes through from induction to the withdrawal from the market or at working place.

Lubrication: Lubrication between the two mating surfaces of the elements of the machine help reducing friction between them and wearing of the two surfaces, which results in the increase in life of the components of the machine.

Operational Safety: For the safety of the operator of the machine, the hazard producing things from machine should be eliminated and the design should confirm to the safety codes. (Gbabo 2001)

2.2 Design Calculation

The following data were used in the design calculation for the development of the rice parboiler;

Quantity of rice to be steamed per batch = 100Kg

Bulk density of paddy (Champ and Highly, 1986) =571Kg/m^3

Density of mild steel (hyper text book. Com) = 7.85kg/m^3

Quantity of water required for 1000Kg of paddy (Wimberly, 1983) = 1300kg

Assumed the diameter of steamer = 0.6m

Clearance for the steam circulation below false bottom (Gbabo 2001) = 0.075m

Assumed the diameter of the boiler = 0.7m

Required soak duration = 4-5hrs

Required soaking temperature = 65-70^{o}C

Assumed excess volume of boiler required for steam generation = 150 % of actual volume of water required to soak 100Kg of rice. assumed 50% of excess water is required for parboiling rice

2.2.1 Steaming Unit

i) Volume of Tank Required: The volume of the steaming tank is the sum of the volume of paddy required for steaming per batch and the excess volume allowed for steamed rice expansion and steam circulation assumed to be 10 of the paddy volume

$$V_T = Vr + 10Vr \quad (1)$$

$$V_T = \frac{Mr}{\rho_r} + \frac{10\%\,(Vr)}{\rho_r} \quad (2)$$

Where;

V_r is the volume of rice.

ρ_r is the density of rice.

V_T is the volume of steaming tank.

M_r is the mass of rice required for steaming per batch.

$$V_T = \frac{100\,Kg}{571\,Kg/m^3} + \frac{10\%(100)}{571\,Kg/m^3} = 0.17513 + 0.017513$$

$$V_{T\,=}\, 0.19264m^3$$

10% 0f V_r is the excess volume of the steaming tank to accommodate expansion volume of
rice after steaming and also to allow steam circulation.

ii) Height of Steaming Tank

$$H_T = \frac{V_T}{\pi R_s^2} + H_f \quad (3)$$

$$H_T = \frac{0.19264\,m^3}{3.142 \times (0.3)^2} + 0.075m$$

$$= 0.68124 + 0.075$$

$$H_T = 0.756m$$

$$H_T = 0.76m$$

Where;

H_s is the height of steaming tank.

R_s is the radius of the steaming tank.

D_s is the diameter of the steaming tank.

2.2.1 Boiler

In order to compute the required volume of boiler, the volume of water that would be
sufficient to soak 1Kg of rice is calculated first.

i) Volume of Boiler

$$V_w = \frac{m_w}{\rho_w} \quad (4)$$

Where;

M_w is the mass of water required to soak 1kg of rice.

ρ_w is the density of water = 1000kg/m^3. But 1000kg rice requires 1300kg of water
(Wimberly, 1983)

i.e 1kg of water requires $\frac{1300\,kg}{1000\,kg} \times 1kg = 1.3kg$ of water.

$$V_w = \frac{1.3kg}{1000\,kg/m^3}$$

$$V_w = 0.0013m^3$$

Assumed volume of water in the boiler required for soaking 1kg of rice

$$V_{sw} = V_w + (150\% \text{ of } V_w) \quad (5)$$

Where;

V_{sw} is the volume of water in the boiler required for soaking.

150% of V_w is the volume of boiler expected to accommodate steam required within the Boiler.

$V_{sw} = 0.0013 + 1.5\ (0.0013)$

$= 0.00325m^3$

Since a maximum of 100kg of rice required to be soaked as laid out in the experimental design, the actual required volume of boiler.

$V_b = 0.00325 \times 100$

$V_b = 0.325m^3$

V_b is the volume of the boiler.

ii) Height of Boiler

$$H_b = \frac{v_b}{\pi R_b} \quad (6)$$

$$R_b = \frac{D_b}{2} = \frac{0.7}{2} = 0.35m$$

Where;

H_b is the height of boiler.

D_b is the diameter of the boiler.

R_b is the radius of the boiler.

$$H_b = \frac{0.325m^3}{3.142 \times (0.35)^2} = \frac{0.325}{0.3849} = 0.844m^2$$

In order to allow a little space above the level of water in the boiler an additional safety Height of 0.002m was chosen.

$H_b = 0.844 + 0.002 = 0.85m$

2.2.2 Heat Required For Parboiling of Paddy Rice

To determine the quantity of heat required to boiler water both for soaking and parboiling of the above given quantity of rice.

Using the formula;

$$Q_h = M_w\ C_w\ \Delta T \quad (7)$$

Where;

Q_h is the quantity of heat required for boiling water(J)

M_w is the mass of water required (kg)

C_w is the specific heat capacity of water (J/kg/K)

ΔT is the change in temperature (K)

To determine the mass of water required by using the relationship between the amount of Paddy and the amount of water required.

1000kg of paddy required 1300kg of water (Wimberly, 1983). From this statement it can be Interpolated to get the mass of water needed for both parboiling paddy rice required 1300kg of water, 100kg of paddy rice will required

$100 \times \frac{1300}{1000} = 130kg$

Therefore, if 100kg of paddy required rice 130kg of water for parboiling.

Addition of 50% excess Water, 40% of water for parboiling of the paddy rice to be used for Parboiling 10% of water is to be left in the boiler after soaking and parboiling of the paddy Rice.

Adding 50% excess water;

$\frac{50}{100} \times 130 = 65kg$

Adding up the required amount of excessive water,

Total mass of water need is 130 + 65 = 195kg

Where;

130kg is the actual mass of water required 65kg is the excess mass of water added to actual mass.

To determine the quantity of heat required to heat mass of water which is 195kg. Using equation 7

$Q_h = M_w\ C_w\ \Delta T$

Data;

Q = ?

Mass = 195kg

C = 4200 J/kg/k

$\Delta T = (T_2 - T_1)$

T_1 is the initial temperature of water at room temperature = 4^oC (277^oK).

T_2 is the final temperature of water after heating = 100^oC (273^oK)

Hence; $Q = 195 \times 4200 \times (373-277)$

$Q = 78624000J.$

Plus addition of 50% excess what, since heat loss during the process of generating the heat energy and to make the generated heat very effective.

50% expected heat loss, $\frac{50}{100} \times 78624000 = 39312000J$

An expected heat loss is 39312000J. Therefore, actual heat required equal expected heat loss plus heat generated.

Actual heat required = heat generated + expected heat loss.

Actual heat = 78624000 + 39312000

Actual heat required = 117936000J

$Q_{max} = 117936000J$

2.2.3 Weight of Steam Tank

$$W = Mg \quad (8)$$

Where;

W is the weight of steamer

M is the mass of steamer

G is the acceleration due to gravity and

$$M = \rho\ V \quad (9)$$

Where;

P is the density of steamer

V is the volume of the steamer also

$$V = \pi\ r^2 h \quad (10)$$

Where;

r is the radius of steamer = 0.3m

h is the height of steamer = 0.76m

Then, from eqn (10)

$V = \pi \times 0.3^2 \times 0.76$

$V = 0.2149128m^3$

Mass of steamer (M) = ρ V from equation (9) and ρ is the density of mild steel which is $7.85kg/m^3$. Therefore,

M = 7.85 x 0.2149128

M = 1.6871kg

Hence, weight of steamer (W) = Mg from equation (8)

Where mass of the steamer is 1.659kg and acceleration due to gravity is $9.81m//s^2$. Therefore,

W = 1.659x 9.81

W = 16.55N

Since the mass of paddy plus water is 230kg, then

International Journal of Engineering Innovation & Research
Volume 4, Issue 5, ISSN: 2277 – 5668

$W = 230 \times 9.81$

$W = 2256.3N$

Weight of screen plus pipe =3.2N

Total weight $W_T = W_{pw} + W_s + Wps$ (11)

Where;

W_{pw} is the weight of paddy plus water, W_s is the weight of steamer.

$W_T = 2256.3 + 16.55 + 3.2$

$W_T = 2276.05N$

$W_T = 2.276KN$

2.2.4 Bearing

It permits relative motion of two parts in one or two direction tends to assist motion in the

Direction of applied loads, it has the same bore diameter with the pipe. Pillow bearing is used here to carry both axial and radial loads.

i) Design Analysis of Bearing

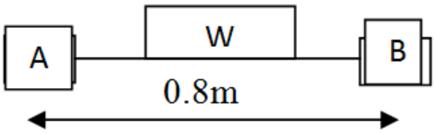


Fig.1. Free body diagram

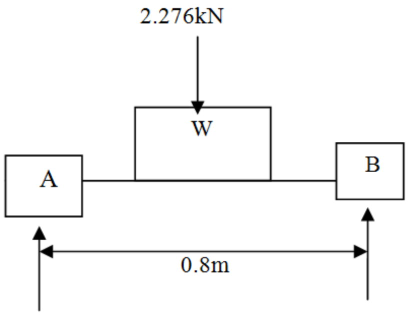


Fig.2. Free body diagram

$R_a + R_b - R_c = 0$

$R_a + R_b = R_c$

$R_a + R_b = 2.276kN$ (12)

Taking moment about point A

$R_b = 2.276 \times 0.5$

$R_b = 1.138kN$

Substituting R_b into equation 11

$R_a = 2.276 – 1.138$

$R_a = 2.273kN$

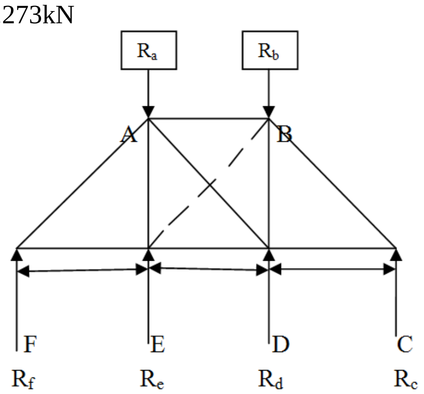


Fig3. Free body diagram

Since, upward forces is equal to downward forces

$R_f + R_e + R_d + R_c = R_a + R_b$

Where;

$R_f = R_e = R_d = R_c$ and also $R_a = R_b = 1.138kN$

Then; $4R_f = 2R_a$

$4R_f = 2R_a$

$4R_f = 2(1.138)$

$R_f = \frac{2.276}{4}$

$R_f = 0.569kN$

Therefore,

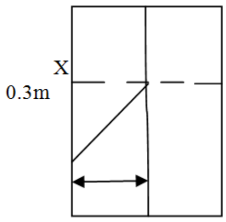
$R_f = 0.569kN$

$R_b = 1.138kN$

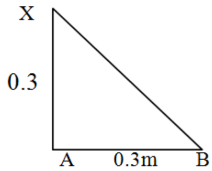
$R_c = 0.569kN$

$R_d = 0.569kN$

2.2.5 Determining Angle of Tilt of the Steamer



A 0.3 B



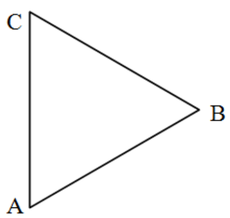
$\text{Tan } Ø = \frac{Ax}{Bx}$ (13)

$\text{Tan } Ø = \frac{0.3}{0.3}$

$\text{Tan } Ø = 1$

$Ø = \tan^{-1} 1$

$Ø = 45^0$



$Ø = Ø + 90^0$

$Ø = 45 + 90^0$

$Ø = 135^0$

Therefore, the angle of tilting is 135^0

2.2.6 Volume of Boiler

$V_b = \pi r^2_b h_b$ (14)

Where;

r_b is radius of boiler = 0.35m

h_b is the height of boiler = 0.85m

$V = 3.142 \times (0.35)^2 \times 0.85$

$V = 0.3272m^3$

2.2.7 Mass of Boiler

$M = \rho v$

Where;

ρ is the density of boiler (mild steel) = 7.85kg/m^3

$M = 7.85 \times 0.3272$

$M = 2.56852kg$

2.2.8 Weight of Boiler

$W_b = M_c g$

Where;

g is acceleration due to gravity = 9.81m/s^2

M_b is the mass of boiler = 2.56852kg

$W_b = 2.56852 \times 9.81$

$W_b = 25.1972N$

Since total mass of water needed is 195kg

Weight of water

$W_w = M_w g$

$W_w = 195 \times 9.81$

$W_w = 1.912KN$

Total weight

$W_T = W_b + W_w$

$W_T = 25.1972 + 1912.95$

$W_T = 1.983KN$

Where;

W_b is weight of boiler

W_w is weight of water

2.2.9 Design Analysis of Boiler Stand (heat generating chamber)

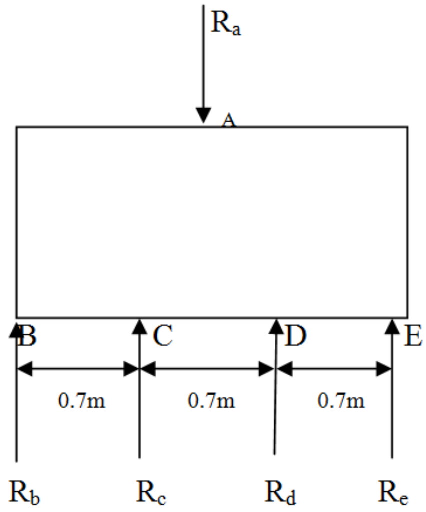


Fig.4. Free body diagram

Downward forces is equal to the upward forces

$R_d + R_c + R_b + R_f = R_A$

Where;

$R_b = R_c = R_d$ and $R_a = 1.938KN$

$4R_b = Ra$

$R_b = \frac{1.938}{4}$

$R_b = 0.4845KN$

Therefore;

$R_b = 0.4845KN$

$R_c = 0.4845KN$

$R_d = 0.4845KN$

$R_a = 0.4845KN$

Two different sizes of pipe, 35mm and 75mm was selected to serve as shaft for the bearing sizes, 35mm x 75mm (35BA02, 7207B) and 75mm x 140mm (75BA02, 7215B) internal and external diameter respectively. Pipe was designed to connect the boiler with the steamer for free flow of both water and steam in the system.

2.3 Component of Tiltable Discharge of Rice Parboiling Equipments

1. Boiler
2. Steamer Stand
3. Steamer

1) Boiler

The boiler is a cylindrical in shape (0.7m x0.85m) was fabricated with gauge 16 mild steel sheet. It was raise on top of stand at 0.8m above the ground level, where heat will be generated to the boiler, water pipe (38mm) was used to connected boiler at 0.2m from the bottom, steaming pipe (38mm) was fixed 0.5m above water pipe in the same direction, drain valve (25mm) was fixed to released water from boiler at 0.05m from the bottom directly opposite to the water pipe, and pressure relief valve (25mm) was fixed at top of the boiler to relieves the excess pressure and to regulate the pressure in the boiler.

Water Valve: is a device used to controlled the passage or free flow of water through a pipe and it was open when soaking is on process and it should be close after soaking of the paddy rice.

Steam Valve: is also a device used to controlling the movement of steam from the boiler to the steamer during the steaming processes of paddy rice.

Drain Valve: this is a device used to allow three-four of water used for soaking of rice should be drain out from the boiler after the soaking of the paddy.

Pressure Valve: is a device used to controlled, regulate and maintain the normal pressure.

Plate1: Boiler

2) Steamer

The steamer is also a cylindrical in shape (0.6m x 0.76m). was designed to contain 100kg of paddy rice par batch for steaming, it was fabricated on top of stand (0.8m x 0.6m x 0.4m) and connected with the aid of pipe (52mm) and bearing fixed together, the pipe passed through the centre of the steamer, false bottom made of metal screen placed 0.075m above the bottom of the steamer, pipe (52mm) was used to linked the steaming pipe to the false bottom of the steamer, the cover is used at the top of steamer to the prevent escape of unnecessary steam.

Steamer stand: The steamer stand is a rectangular in shape (0.8m x 0.6m x 0.4m), two bar was fixed to connect length 0.6m at 0.4m above the ground level and extend vertically to 0.3m above the bar, at that point bearing was fixed to each point to connecting the steamer to the stand through a pipe (52mm) to allow the rotation of steamer.

False Bottom: False bottom was made up of mild steel, two steel 0.08m x 0.075m and 0.080m x 0.075m, it was constructed and fixed, across each other at the bottom of steamer.

Net: a rod 5mm was constructed 0.05m by 0.05m and design to form 0.6m x 0.6m, covered round with mosquitoes net and place at the bottom on top of false bottom.

Tilt Handle: this is device used where operator would hold to tilt to discharge the steamed rice paddy from the steamer.

Stopper: was constructed at the stand of the steamer to control the steamer at angle of 135°C when discharge the steamed rice paddy from the steamer.

Steamer Cover: it was made from the mild steel and it was used as covered on top of steamer to protect, prevent lose, escape of the unnecessary steam during the process of soaking and steaming of the paddy rice.

Steaming Hook: it was constructed with rod 10mm; it was used to hold the steamer to maintain fixed position during the soaking and steaming of the paddy rice.

Plate 2: Steamer

Plate 3: Assemble of Tilted Rice Parboiler

Working principles

Clean paddy 100kg was pour inside the steamer, the boiler was filled with water and firewood were used as sources of heat generation, water valve was opened for water to passed into the steamer from the boiler through interconnected pipes (52mm and 38mm) in diameter, to soak the paddy at temperature of 70°C for 6 hours, the drain valve was opened for the soak water to drain to the lower level below the water pipe, then temperature was increase to 100°C, steaming valve was opened for steam to passed into the steamer from the boiler through interconnected pipes, therefore paddy was left inside the steamer for 40 minutes, the paddy had cracked, from bottom to top and the steaming was stopped, the steamer was tilted to discharge steamed paddy, the steamed paddy was sun dried thinly on woven mats, the dried paddy was allowed to cool in sacks for some time for temperature and stress distribution before milling.

III. Testing Procedures

Two set of 50kg of paddy rice each were soaked and steamed separately, the paddy used for the experiment were same variety. For experiment (A) 50kg clean paddy was introduced into the steamer which was soaked in hot water at 70°C for 6hours. After 6hours of soaking, the drain tap was opened for the soak water to drain to the one-fourth of water used for soaked paddy. The boiler was again heated to 100°C to produced steam to parboil the paddy for 40 minutes, the paddy had cracked from bottom to top and the steaming was stopped. The steamer was tilted to discharged steamed paddy, the paddy was weigh after steamed and then took to the sun dried thinly on mat, the dried paddy was allowed to cool for some time to reduce the temperature before milling.

Experiment (B) 50kg of clean paddy was also introduced to the steamer was soaked at the same temperature for 12 hours (overnight). The temperature was increase to 100°C in order to produce steam to steaming the paddy for 30 minutes, the paddy had cracked from bottom to the top, the steam was stopped and the steamer was tilted to discharge steamed paddy from steamer. The steamed Paddy was dried on woven mat, cooled and milled.

After cooling the parboiled paddy was milled with milling machine to de-hulling the paddy, it was milled separately. The mixture was then winnowed to remove chaff present. The milled rice was weighing and then sieved the milled rice to separate the broken grain from the whole rice and weighing them accordingly.

IV. Results and Discussion

4.1 Results

The performance evaluation of tiltable discharge rice parboiling equipment was carried out. The parameter showed below was obtained as a result from the experiments.

Table 1: Test carried out on rice parboiler

Experiments	wb (kg)	wa (kg)	times (hrs)	Temperature (℃)	MC(%)
A	25	30.62	6	70	18.35
B	25	32.14	12	70	22.22

Where

Wa is weight of paddy after soaking

wb is weight of paddy before soaking

MC is moisture content:

$$MC = \frac{M - M_0}{M} \times 100$$

For Experiment (A)

$$MC = \frac{30.62 - 25}{30.62} \times 100 = 18.35\%$$

Experiment (B)

$$MC = \frac{32.14 - 25}{32.14} \times 100 = 22.22\%$$

Table 2: Test carried out on rice miller

Experiments	A (Kg)	B (Kg)	Average
Weight of un-milled rice	25	25	25
Weight of milled rice	17.25	19.12	18.19
Weight of whole rice grain	15.61	18.07	16.84
Weight of broken grain	1.62	1.05	1.34

4.2 Percentage of the whole rice yield

$$Pw = \frac{Wa - Wb}{Wa} \times 100$$

$$= \frac{16.84 - 1.34}{16.8} \times 100 = 92.04\%$$

Where

Wa average weight of whole rice yield

Wb is average weight of broken grain

Pw percentage of whole rice yield

4.6 Milling efficiency

$$E = \frac{18.19}{25} \times 100 = 72.76\%$$

Where

E is the efficiency of the milling

4.3 Discussion of Results

The process of parboiling designed for this system was soaking in temperature ranging between 60 ℃ to 70℃ for 6hours or 12 hours (over night), after which the rice was steamed for 30 to 40 minutes at temperature of 100°C. From the experiment above the percentage head rice yield which was 92.04% and the efficiency of milling was 72.76%. Therefore, better parboiling and hence better gelatinization leads to high grain yield and high efficiency of milling. The result obtained showed that this system can help local farmer in timely processing of paddy and in making effective use of available good designed and fabricated of tilted steamed rice parboiling equipment and it was found to be easier, faster and better than manual packing of the steamed paddy.

V. Conclusion

This project work focused on the design and fabrication of a tiltable discharge of rice parboiling equipment that is cheap, easily affordable to the local processing farmers, easy to maintain and less laborious to use. From the experiment above, soaking of paddy rice at 70°C for 6hours and 12hours respectively and steaming for 40 minutes, since soaking in hot water as in the improved method takes short time, fermentation of the paddy may not take place. Hence bad odour may not occur in the milled rice. The percentage head rice yield which was 92.04% and the efficiency of milling was 72.76%. Better parboiling and hence better gelatinization leads to high grain yield and high efficiency of milling and hence good quality of milled rice will be obtained. Therefore, this system can help local farmer in timely processing of paddy and in making effective use of available good designed and fabricated of tilted steamed rice parboiling equipment and it was found to be easier, faster and better than manual packing of the steamed paddy.

Recommendation

It was recommended for this design and fabrication, after parboiling of the paddy rice wheel barrow should be employed to convey discharged steamed rice from the steamer to the constructed slab for sun drying. The fabrication of this project needs government support to encourage people in rural area who have been encouraged into mechanized large-scale rice production, can have a equipment/machine that can parboiling their rice and tiltable discharged the steamed rice than manual parking of the rice, this method of parboiling was found to be easier, cheap, and faster with less human effort.

REFERENCES

[1] Ali, N., and T. p. ojha. 11976. Parboiling In Rice Postharvest Technology, 163-204.
[2] E. V. Araullow, D. B. Depadua, and M. Graham, eds. Ottawa, Canada.: International development research center.
[3] Bayou Farm and Industries Limited. 2009. On Rice value chain development plan: Kadunarice industry supply and development program.
[4] Bhattacharya, K. R. 1985. Parboiling of Rice, In Rice; chemistr y and Technology, 289-348.
[5] B. O. Juliano, ed. st. paul, minn.: American Association of cereal chemists.
[6] Chattopadhyay. P. K. and O. R. Kunze, 1986. Fissuring characteristics of parboiled and milled rice Trans. ASAE 29(6); 1760-1766.
[7] Gariboldi, F. 1972. Parboiled rice, In rice: chemistry and Technology, 358-380.
[8] D. F. Houston, ed. St paul. Minn: American Association of Cereal Chemists.
[9] Gbabo. A. 2001. "The effect of variety and processing parameters on rice quality"
[10] Grist. D. H. 1983. "rice" New Edition (pp 217-232)
[11] Olarewaju, V.J. (2005) Design and construction of a conical screen centrifugal filter for groundnut oil slurry. Unpublished M. Eng Thesis, Department of Mechanical Engineering, Federal University of Technology, Minna.
[12] Pillaiyar, P. 1988. Parboiling in Rice Post production Manual 167-229 New Delhi India: wile Eastern.
[13] Velupillai, L. and L. R. Verma, 1982. Parboiled rice quality as affected by the level and distribution of moisture after the soaking process. Trans. ASAE 25(5): 1450-1456.
[14] Wimberly, J. E. (1983). Technical handbook for paddy postharvest industry in developing countries. International Rice Research Institute (IRRI). Los Banos, laguna phiolippines.

APPENDIX


Fig.5. Sample of Paddy rice (before parboiling)


Fig.6. Sample of paddy rice (during dry stage)


Fig.7. Sample of steamed rice


Fig.8. Tilting of steamer to discharge paddy rice

Fig 9: Equipment set-up for parboiling rice

Fig 10: Sample of milled rice