Fabrication of Manually Operated De-Feathering Machine for Rural Areas in Nigeria

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Abstract— In chicken processing, it has been found that the de-feathering operation is the most laborious and time consuming operation which has a limiting effect on the rate of production of ready-to-cook chicken meat This problem has been solved by various inventions of electrically operated de-feathering machine, however, the erratic power supply in many urban areas and unavailabilty of power supply in rural areas in Nigeria has limited the distribution of these machines especially in rural areas. This study focused on fabrication of a portable, low cost and efficient manually operated de-feathering machine using locally available engineering materials; The machine consist of three major parts, de-feathering chamber which includes the de-feathering drum and de-feathering (rotating plate) disk with rubber fingers, the power transmitting system which consist of bevel gear, input and output shafts and the de-feathering machine supporting frame and stand The fabricated machine was tested with both exotic and local chicken, after both exotic and local chicken were first soaked inside hot water (scalded) at a range of temperature 66^0C-70^0C and 76^0C-80^0C respectively for 90 seconds. The machine removed the feathers without any damage to the chicken in average of 14.8 seconds for exotic birds and 16seconds for local birds. it also discharged the feathers into the feather chamber. In conclusion, the machine of weight 17.5kg performed effectively with an average efficiency of 85.38 % and 79.88% for exotic and local chicken respectively.

Index Terms— Bevel gear, Chicken, De-feathering, Fabrication, Manually operated, Rubber fingers, Scalded

1 INTRODUCTION

In achieving certain degree of autonomy in nation's industrialization processes, the development of indigenous science and technology should be considered necessary. The need for de-feathering machine arose due to increasing in population, need for protein and high cost of other sources of protein compare to chicken. Physiological states such as injury, surgery or burns, increases the need for protein to provide repairing materials. Chicken is the most common or popular type of poultry and it is the second most consumed meat all over the world [1]. This "white meat" is regarded nutritional and affordable and offers a wide range of nutrients for very few calories. It has many health benefits not just the taste. Chicken has a very high protein content which plays a very important role in sustaining human muscles. it is basically a lean meat, which means it doesn't have much fat. therefore, eating chicken regularly can actually help losing weight in a healthy way with a high nutritional value. Chicken being an excellent source of protein, it also contains B vitamins, and selenium[1], [2]. According to USDA Food Composition Databases, that the nutritional values per 100 grams of raw chicken is averagely 153 Kcal. [1]. Chicken provides one of the best dietary sources of creatine which enhance physical performance, recovery, strength, and stamina. Chicken meat helps in the growth and repair of the body's tissues and boosts body metabolism. It is also considered to be rich in calcium and phosphorous. Both these minerals help in keeping our bones healthy. Eating chicken regularly also cuts the risk of arthritis just to mention a few. According to [3] consumption of chicken in the less developed countries has reflected in Kwashiorkor in growing children. **T**raditionally, chicken processing is not an easy task particularly in this part of the world and most especially in the rural areas of Nigeria. It is done manually by the use of hand after it has been soaked in hot water for few minutes. This process is tedious and time consuming which results in low output and could lead to injury. In order to avoid all of these challenges, there is need to fabricate a machine from locally sourced material. [**4**], also reported that the level of human exposure to occupational risk and other health hazard resulting from intense manual operation is significant in scalding and de-feathering operations which calls for effective mechanization of the process that will support quality, safe, ergonomic and economic operation.

A chicken de-feathering machine is an automated means of plucking feathers off poultry. It is usually used the purpose of de-feathering dead and scalded birds. Development of a poultry de-feathering machine is such an economical processing of a mechanized poultry processing plant to replace the removal of poultry feathers by hand for meat preparation, so as to increase the number of poultry being

processed in a day [5]. De-feathering is done after slaughtering the birds which is accompanied by bleeding period. The carcass is removed and lowered into a tank of heated water for a certain temperature level and plucked. The use of de-feathering machine in processing poultry has contributed tremendously to the successful processing of dressed and hygienic chicken for consumption. [6], [7] stated that various machines have also been developed for de-feathering process which can handle either large or few number of birds at a time although, some machines may have problem with heavier bird such as turkey depending on the model and method used.

1.1 Types or Categories of De-feathering

1.1.1Table top Plucker

It contains a rotating drum studded with rubber fingers while a flat table is position in the front of the drum. The operator holds the scalded birds up to spinning fingers and manually while the fingers remove the feather off. It is certainly an improvement over hands plucking but there are several drawbacks to this machine. Firstly you can only pluck one birds at time. Secondly you will have to get your hand into the work. Thirdly it takes practice to do a good and fast job. Lastly if you don't hold onto your bird tight the fingers will yank that critters right off your hand [8].

1.1.2 Tub-style Plucker

These machines hold dozens of rubber finger, some of these are in the rotating feather plate at all bottom of the machine, after turning the machine on, all the operator need to do is to drop in a scalding bird carcass or two and wait for about 15 second, and the birds will be clean. The machine will remove virtually every feather, including pin feather. The skin does not break when plucking (unless the scalding is too hot) and bruising never occurs. The only problem with tub plucker is that the ready-made tub pluckers are expensive [8].

However, most of the de-feathering machines that have been developed for poultry processing so far are mainly electrically operated de-feathering machines which is not perfectly suitable for some area around the country such as the rural areas and some urban areas in Nigeria due to erratic power supply or power outtake. In order to solve this problem, there is need to develop a manually operated de-feathering machine which will be suitable for both rural and some urban area where electricity is not readily available. This study is focused on fabrication of drum-style manually operated de-feathering machine for both exotic and local birds for rural areas in Nigeria from locally sourced engineering materials using bevel gear system In order to avoid complexity in fabrication, the machine is light, portable, low cost, kitchen size, de-feathering machine with less or no technical skill requirement for home use either in urban or rural areas. It has the capacity of de-feathering a chicken per time and a potential of enhancing safety, comfort and economic production of ready–to-cook chicken meat in both the urban and rural areas

2 Materials And Methods

The manually operated de-feathering machine was fabricated with the following tools and machines: Measuring tape, Scriber, Punches, Tap and die, Hack saw, Try-square, Grinding machine and Drilling machine, electrodes, welding machine and Lathe machine..

2.1 Material Selection

The materials used for fabricating the machine were selected based on availability of the materials, durability of materials and fabrication, properties of the material such as; physical properties, thermal properties, chemical properties, and mechanical properties, cost of production, safety, portability and ease of operation

Table 1: Engineering Materials Used and Criteria for Selection

S/N.	ENGINEERING MATERIALS USED	CRITERIA FOR SELECTION
1	Thermosetting plastic	High resistance to corrosion, light weight, low cost, good durability and resistant to water
2	Plywood	Low cost, high impact resistance, high strength to weight ratio, surface dimensional stability
3	Angle iron	It has the ability to bear excessive amounts of pressure and weight.
4	Iron Rod	**it** is malleable, ductile and very strong
5	Rubber rubbers	It is used to remove the feather
6	Nut and spring washer	It is used to couple the de-feathering disk with the output shaft
7	Galvanized steel sheet	It has excellent corrosion resistance, extremely durable and resistant to scratches from abrasion
8	Paint	It enhances resistance to corrosion
9	Bevel Gear	It was used to transmit the torque

2.2 Fabrication Procedures

The following operations were undertaken in the fabrication of the manually operated de-feathering machine.

Namely: measurement and marking out, cutting of material, welding, grinding, and drilling operation, The fabrication of the manually operated de-feathering machine was done in the following order. Fabrication of de-feathering drum (cutting, drilling, bending and welding of galvanized steel sheet),Welding of angle iron to the de-feathering drum to make the stand, cutting of iron rod to make the output shaft, cutting and bending of iron rod to make the input shaft, turning of one end of the output shaft with lathe machine and cutting of tread with tap and die on the turned part of the output shaft, erection of bearings and bevel gear on the input and output shaft, The crown of the bevel gear was fixed on the driving shaft (input shaft) while the pinion was fixed on the driven shaft (output shaft). Cutting and drilling of plywood and thermosetting platic to make de-feathering (rotating plate) disk, welding of supporting frame on the de-feathering stands, fixing of rubber fingers on the de-feathering disk and joining of de-feathering disk and output shaft with spring washer and nut, fixing of rubber fingers on the de-feathering drum grinding, finishing and painting.

The de-feathering machine consist of three major parts, De-feathering Chamber which includes the de-feathering drum and de-feathering (rotating) disk, The power transmitting system and the de-feathering machine stand.

2.2.1 DE-FEATHERING CHAMBER

2.2.1.1 De-feathering drum

The de-feathering drum was made using a 1540mm by 400mm galvanized plate which was marked out using scriber and punch. The punched sports were drilled using a 22mm drilling bit fixed on the hand drilling machine and then folded into a cylindrical shape of 49mm diameter and 400mm in height. A circular galvanized plate was cut and welded to the drum to covered the base of the de-feathering drum and the centre of the circular plate was drilled drum to accommodate the output shaft. A bearing housing was also made and fixed on centre of the circular plate to hold the bearing.

2.2.1.2 De-feathering (plate) disk

The de-feathering plate was made of both plywood of 0.6mm overlaid with thermosetting plastic of 2mm of thickness using adhesive gum. These materials were used instead of stainless steel to redu ce the weight and cost of production of the machine, The de-feathering plate was marked out using scriber and punch and the punched sports were drilled using a 22mm drilling bit fixed on a hand drilling machine. After the holes had been drilled the rubber fingers were fixed. The diameter of the de-feathering plate is 475mm and a clearance allowance of 0.75mm was between the rotating feather plate and the de-feathering drum.

2,2,2 Power transmitting system

This consist of a bevel gear of ratio 3 to 1, four sealed bearing, input and output shaft. The bevel gear is use where the axes of two shafts intersect. The bevel gear helps to transmit motion from input shaft in horizontally direction to output shaft in vertical direction. The sealed ball bearing was used to align the output shaft holding the rotating plate and the input shaft driving the bevel gear.

2.2.2.1 Input shaft

The input shaft was fabricated using an iron rod of 508mm length which was bent with the aid of acetylene flame into z shape whereby the longer arm of the shaft was 258mm and shorter arm is 125 making the vertical arm also 125mm. The input shaft was inserted into the two sealed ball bearing fixed on the supporting frame with the aid of bearing locker. The crown of the bevel gear was then fixed at the end of the longer arm of the shaft. A little piece of metal was welded to the input shaft before each bearings to prevent the input shaft from pulling out when winded.

2.2.2.2 Output shaft

The output shaft was made also with iron rod. The iron rod was cut with hack saw according to the specification 315mm long supported by two bearings, One end of output shaft was turned on the lathe machine and tap and die was used to make tread on it to accommodate spring washer and nut that coupled the de-feathering disk and the shaft together. The output shaft was inserted from inside the de-feathering drum through the two bearings with pinion of the bevel gear positioned in between the bearings and also meshes with the crown fixed on the driving shaft.. The shaft was also brazed at the inside of the drum and the other end of the output shaft to prevent it from falling out during operation.

2.2.3 De-feathering machine stand and Supporting frame

The de-feathering machine stand was made of three angle iron bars of 50 x 50mm of equal length 28mm to make the machine balance on the ground. They were cut manually using shearing machine and .joined to the de-feathering drum by welding using arc welding machine at equal angular distance of 120 degree to each other. The supporting frame were also welded to the de-feathering machine stand to reinforce the stand and also serves as a strong support table to bear the power transmitting system of the machine..

The contours of the welded joints on the machine were grinded using grinding machine in order to have good surface finishing and were painted.

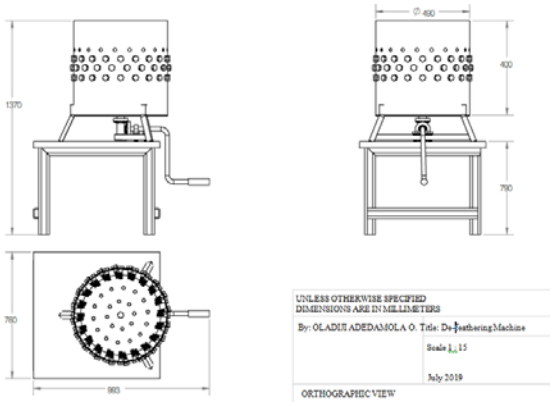

Fig1: Orthographic View of the Manually Operate De-feathering Machine

ITEM NO.	PART NUMBER	QTY.
1	Table	1
2	De-feathering drum	1
3	Input shaft	1
4	Rubber fingers	90
5	ISO 7412 - M16 x 50 - - 31 - WS	1
6	De-feathering disk	1
7	Bearing locker	2
8	Bearing	4
9	Output shaft	1

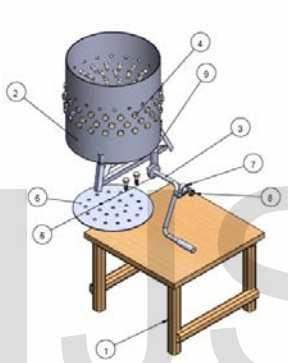

Fig 2: Model view **of** the Manually Operated De-feathering Machine and its components

2.3 Operating Technique of the De-Feathering Machine

The de-feathering operation begins with the manual loading of the machine with scalded bird (i.e. the chicken that was immersed in hot water for certain period of time) The machine is operated manually by winding the input shaft, which transmit torque to the output shaft with the help of the bevel gear, the bevel gear used was a straight bevel gear. The output shaft then subjects the de-feathering (rotating) plate into rotary motion. The rotation of the de-feather plate causes the scalded birds to rub its body against both the stationary rubber fingers lined internally along the de-feathering drum. The rubbing action gradually removes feathers off the birds continuously until the bird is completely de-feathered.

3 RESULTS AND DISCUSSION

The manually operated de-feathering machine was fabricated and tested. The performance test was conducted using both exotic and local birds. The weights of the birds were taken before (w) and after slaughtering (w_1) using digital weighing balance. The birds were scalded and placed inside the de-feathering chamber while the input shaft was winded. The number of revolution of input shaft was noted and recorded and the time taken to de-feather the chicken was also recorded. The weight of the chicken after de-feathering (w_2) and the weights of the birds after further and complete de-feathering with hand (w_3) were also measured and recorded. The weight of the feather removed by the machine was determined by subtracting the weights of birds after de-feathering with machine from the weight before de-feathering (w_1-w_2). Likewise total feathers plucked were determined by subtracting the weight of birds after complete de-feathering with hands from the weight of birds before de-feathering with the machine (w_1- w_3). The result of the de-feathering operation for both exotic and local chicken is as presented in Table 2 and Table 3 respectively

Table 2: Result Obtained from De-feathering Operation of Exotic Birds

Test	w	w_1 (kg)	w_2 (kg)	w_3 (kg)	Time (sec)	No. of Revolution N	Velocity (rev/min)	Efficiency $E_d = \frac{w1-w2}{w1-w3} \times 100$ (%)
1	1.450	1.382	1.302	1.295	17	15	159.0	91.95
2	1.368	1.316	1.256	1.253	10	13	233.5	95.24
3	1.695	1.657	1.565	1.557	16	16	179.8	92.00
4	2.370	2.272	2.189	2.155	15	13	156.0	70.94
5	1.748	1.709	1.622	1.596	16	14	157.3	76.99

Table 3: Result Obtained from De-feathering Operation of Local Birds

Test	w	w_1 (kg)	w_2 (kg)	w_3 (kg)	Time (sec)	No of Revolution	Velocity (rev/min)	Efficiency $E_d = \frac{w1-w2}{w1-w3} \times 100$ (%)
1	1.301	1.272	1.219	1.205	16	26	292.1	78.66
2	1.288	1.250	1.199	1.159	28	25	160.6	56.04
3	1.212	1.153	1.074	1.061	25	25	225.2	85.87
4	1.132	1.091	1.027	1.022	8	13	293.2	92.75
5	0.846	0.829	0.785	0.778	8	13	293.2	86.27

3.1 Determination of De-Feathering Percentage

Efficiency or Percentage of de-feathering,

$$E_d = \frac{w1-w2}{w1-w3} \times 100 \quad (1)$$

w_1 = weight of chicken after slaughtering but before de-feathering

w_2 = weight of chicken after de-feathering with the machine

w_3 = weight of chicken after manual de-feathering

$w_1 - w_2$ = weight of feathers plucked by machine

$w_1 - w_3$ = total weight of feathers of the chicken

3.2 Determination of De- feathering Velocity (Speed) of the Machine

$$\text{De –feathering velocity} = \frac{N}{t \times V.R} \times 60(\text{rpm}) \quad (2)$$

V.R = velocity ratio = Bevel gear ratio = 1/3

N = no. of revolution (turn)

t = de-feathering time (secs)

rpm = revolution per minute

[9], [10], [11]

Exotic Birds

$$\text{Average Efficiency} = \frac{\text{total sum of the efficiency}}{\text{total no of de-feathering operation}} \quad (3)$$

$$= \frac{91.95 + 95.24 + 92.00 + 70.94 + 76.99}{5}$$

= 85.38%

$$\text{Average weight} = \frac{\text{total weight of the birds}}{\text{total no of birds de-feathered}} \quad (4)$$

$$= \frac{1.450 + 1.368 + 1.695 + 2.370 + 1.748}{5}$$

= 1.726 kg

$$\text{Average de-feathering time} = \frac{\text{total de-feathering time}}{\text{no.of de-feathering operation}} \quad (5)$$

$$= \frac{17 + 10 + 16 + 15 + 16}{5}$$

= 14.8 secs

$$\text{Average de-feathering velocity} = \frac{\text{total number of revotion per minute}}{\text{no of de-feathering operation}} \quad (6)$$

$$= \frac{159.0 + 233.5 + 179.8 + 156.0 + 157.3}{5}$$

= 177.12 rpm

Local Birds

$$\textit{Average Efficiency} = \frac{78.66 + 56.04 + 85.87 + 92.75 + 86.27}{5}$$

$$= 79.88\%$$

$$\textit{Average weight} = \frac{1.748 + 1.368 + 1.695 + 2.370 + 1.450}{5}$$

$$= 1.233\ kg$$

$$\textit{Average de-feathering time} = \frac{16 + 28 + 25 + 8 + 8}{5}$$

$$= 16.0\ secs$$

$$\textit{Average de-feathering velocity} = \frac{292.1 + 160.6 + 225.2 + 293.2 + 293.2}{5}$$

$$= 194.2\ rpm$$

3.2 Discussion on Efficiency

It can be seen from Table 2 and Table 4 that there was inverse relationship between the weights of the exotic birds and the efficiency of the machine, as the weights of the exotic birds increases the efficiency of the machine reduces ($p < 0.022$) while there was no significant difference between the weights of the local birds and the efficiency of the machine. It was also found in Table 4 that there was a significant difference between the speed of the machine and the efficiency of the machine. This means that increase in the de-feathering speed (revolution per min) of the machine for de-feathering local bird would lead to higher average efficiency of the machine.

4 Conclusion

The fabrication of a portable, low cost and efficient manually operated de-feathering machine was achieved from locally available engineering materials and tested for the use of individuals for domestic purpose and local poultry farmers as well as small scale industries that involved in chicken processing in the rural areas where there is unavailabilty of power supply. It can be operated conveniently with little or no technical skill. It can de-feather a bird at a time. This machine will reduce the drudgery, time wasted, stress, and risk involved in traditional means of de-feathering chicken in the rural areas in Nigeria and the cost of production and operation is relatively low and user-friendly.

Acknowledgment

I wish to thank the Holy Spirit the custodian of witty inventions who has given me inspiration to fabricate this machine. Also I want to appreciate all the staff of Mechanical Engineering Department of Oyo State College of Agriculture and Technology, Igboora tor their immense contribution towards the success of this work.

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APPENDIX

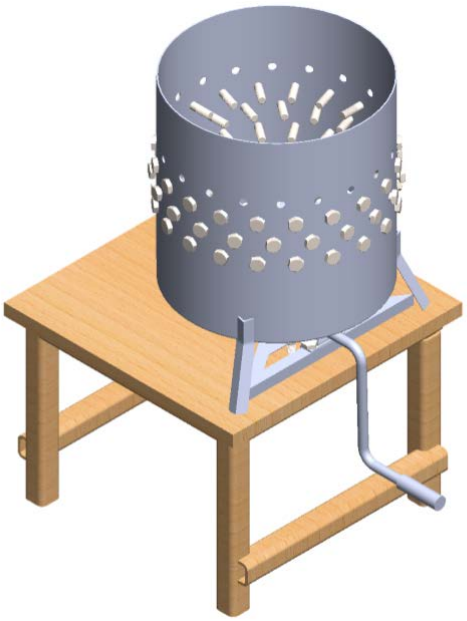
A: Bill of Engineering Measurement and Evaluation

S/N	Description	Amount (N)
1	Galvanized Steel Sheet (Half of a sheet)	8,200.00
2	Metal angle bar	1,000.00
3	Rubber Fingers	11,960.00
4	Electrodes	750.00
5	plywood	1,000.00
6	Thermosetting Plastics	2,000.00
7	Bevel gear	3,500.00
8	Shaft	1,000.00
9	Ball bearings	1,000.00
10	Adhesive gum	1,000.00
11	Transportations	1,550.00
12	Miscellaneous	1,000.00
	Total	32,960.00

Plate 1: De-feathering Disk (Plate)

Plate 2: Manually Operated De-feathering machine

Plate 3: The power transmitting system



3D Solidworks Model Showing the Isometric View of Manually Operated De-feathering Machine

Table 4: Peaerson Product Moment Correlation (PPMC) Test Showing the relationship between the weights of both Exotic and the Efficiency of the manually operated de-feathering machine

Exotic Birds

Variable	r-value	p-value	Remark
Weight kg	-0.89	0.022	S
Time t(sec)	-312	0.301	NS
Speed rev/min	0.652	0.117	NS

Local Birds

Variable	r-value	p-value	Remark
Weight kg	-0.525	0.182	NS
Time t(sec)	-0.727	0.082	NS
Speed rev/min	0.817*	0.046	S
P< 0.05 significant	S = Significant		NS = Not