INVESTIGATION INTO MECHANIZED DE-FEATHERING PROCESS AND OPTIMAL SCALDING TEMPERATURE OF EXOTIC AND LOCAL BIRDS IN SOUTHWESTERN NIGERIA

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Abstract

The ever increasing demand for poultry meat among the non-vegetarians world-wide has imposed greater responsibility on poultry processing industry. The traditional manual method of de-feathering of fowls is gradually going into extinction with the development of different capacities of de-feathering machines for both commercial and household use. This work is focused on development of a small scale de-feathering machine and to investigate into the optimal scalding temperature which can produce scalded chicken that has no scar. Randomly sampled birds from two categories of broilers birds (local and exotics breeds) from local markets of southwestern Nigeria were considered for determination of optimal scalding temperature, duration of immersion and feather plunking force. Effective and efficient de-feathering was achieved on local chicken at a scalding temperature between 80-85^{o}C for 5minutes immersion duration, while that of exotic chicken it took place between 65-70^{o}C for 3minutes immersion duration. Feather retention force (FRF) of each categories of bird also varies significantly. However the de-feathering quality was generally within the acceptable limit.

Keywords: De-feathering, Scalding; Feather retention force; immersion duration.

1.0 Introduction

Poultry meat is popularly consumed among non-vegetarians world-wide due to its low fat and calorific content. The relatively increased preference for chicken over some other type of meat has generated keen interests in poultry farming and processing industry. Likewise with the growing world population livestock consumption rate may have to increase correspondingly to meet the effective protein requirement of the world. Poultry processing has faced challenges that are of safety and health concern some of which include tasks that could result in cuts or lacerations, repetitive motion disorders, slips and falls, exposure to cold and wet climates, dust, dermatitis, chemicals, and noise(Barbut , 1998, Barbut, 2002; OSHA, 2004). To avoid accidents and infections form poultry carcasses which may occur during some of the processing operations there is need for user-friendly, reliably and efficient poultry processing devises (Ralph, 1980; Scolt, 2000).

A number of important activities are involved in the production of ready-to-cook (RTC) poultry a large percentage of which are labour intensive and these contribute to the high cost of processed poultry meat in the market. Identified production processes for eviscerated birds are (1) Pre-slaughter: catching and transport; (2) Immobilizing, killing, and bleeding, (3) Feather removal: scalding and picking, (4) Removal of head, oil glands, and feet, (5) Evisceration, (6) Chilling, (7) Cut-up, deboning, and further processing, (8) Aging, (9) Packaging, (10) Storage and (11) Distribution. Among the listed processes feather removal is the most time consuming and risky next to eviscerating process especially when carried out manually (Dicken and Shackelford, 1998).

De-feathering which form one of the important tasks in poultry processing particularly when manual method are used exposes workers to work musculoskeletal disorder, cuts, skin rashes, dermatitis and avian influenza virus. Solutions to some of these problems were suggestions from research findings(Scolt, 2000). The energy audit of some poultry processing plants with specific survey of five deferent relevant unit operations revealed that scalding and de-feathering is the most energy intensive unit operation accounting for 44% of the total energy consumption in the processing (Jekayinfa, 2007). Level of human exposure to occupational risk and other health hazard resulting from intense manual operation is significant in scalding and de-feathering operations. This calls for effective mechanization of the process which will support quality, safe, ergonomic and economic operation. Various machines have also been developed for de-feathering process which can handle either large or few number of birds (Glenn, 1998). However their demand and acceptance are different from one country to the other. Some years ago for instance, Nigerian government place

embargo on the importation of some poultry processed meat. This step placed a boost on the operation of local poultry Industry and allied. There are large number of large scale processing plants currently located around the world but small sized of household capacity are scarcely found.(Barbut, 2002). Homemade scalders: When first starting out, some small-scale producers use a large stockpot in the backyard heated with a fire. On-farm processors have also used propane burners (from outdoor turkey fryers), water bath pots made for canning, and hospital sterilizers (common before the advent of the autoclave).This study is focused on determining optimal scalding temperature (which is an important parameter in scalding and picking of feather), immersion duration and feather plucking force for both exotic and local birds in Southwestern Nigeria. The developed machine which performance test and evaluation is being presented has the potential of enhancing safety, comfort and economic production of RTC birds.

Development of small scalding and picking machines though exist in different forms in many advanced countries. It's presence in Nigeria is yet unpopular partly because of it's cost which is unaffordable by many. This contributes to the high cost of processed chicken in the market as well as the choice of manual poultry processing methods by various households in Nigeria. For instance a typical imported <16 bird scalding machines cost ₦1920,000 ($12,000). Other house hold type with varying feature and accessories designed to handle less than 5 birds sells between ₦83,200 ($532.5) and ₦480,000 ($3000) which are on the high side for an average Nigeria. However scalding machine and other poultry processing equipment are exclusively used by large scale poultry processing firms.

2.0 Materials and Methods

Mild steel was used in the fabrication of about 60% of the components of the machine. This material is found most suitable due to its availability, low cost, light weight and other favorable mechanical, chemical and thermal properties. The mild steel components that have to be in contact with scalded bird are coated with galvanized paint in other to enhance its corrosion resistivity.

The machine is made up of three identifiable assemblies with their functional components. These are base unit (cast-turn, table frame, top plate, cross member, coupling, electric motor, pulley and belt,), housing unit (frame cover, the drum, drum support, bolt and nut, fingers and bearing) and the over-hanged unit (the hanger, crank rod, handle and rope). Factors considered in the design of the machine in other for it to be suitable for eatery and household use (e.g. cutleries, machine and kitchen tools) are safety, portability, low cost of

production, production capacity, durability of fabrication materials, materials availability ease of alteration, finishing, reliability and ease of operation.

2.1 The Operating Mechanism

The de-feathering mechanism consists of a rotating cylinder (drum) made of galvanized steel material, 0.5mm thick, studded with a series of rubber fingers slotted horizontally to the side wall of the cylinder. The remaining space that exists between two adjacent rubber fingers forms the housing unit for the chicken where the operation will be performed. The galvanized steel was selected for the design of the cylindrical drum because of its high resistant to corrosion or rust, temperature effect and fatigue, which might necessarily occur in the housing unit as a result of a simple air-water reaction (corrosive environment), heat produced from the chicken and effect of cyclic stress, respectively. This effect is most pronounced when ferrous materials are utilized.

2.2 De-feathering Process

The de-feathering process starts with the manual feeding of bird whose feathers are to be plucked by the machine. The chicken which has just been soaked in hot water is lowered into the de-feathering mechanism by winding the feeding mechanism made of simple crank rod with wooden handle. The bird being lowered down into the de-feathering mechanism which is made of galvanized steel drum lined internally with rubber fingers is subjected into a rotary motion by the transmitted torque from the electric motor. The carcass is rubbed with the rubber fingers and the feathers are thereby plucked continuously until the bird is completely scalded.

2,3 Experimental Procedure

The effect of age, scalding temperature, duration and plucking force on both exotic and local birds were checked for ease of de-feathering and skin appearance. Materials used for this test include lagged container, stirrer, thermometer, stopwatch, boiling ring, feather stiffness meter, de-feathering machine and matured local and exotic chickens.

Sample of local and exotic birds with average mass of 1.50 and 3.50kg respectively were tested. The test procedure was as follows:

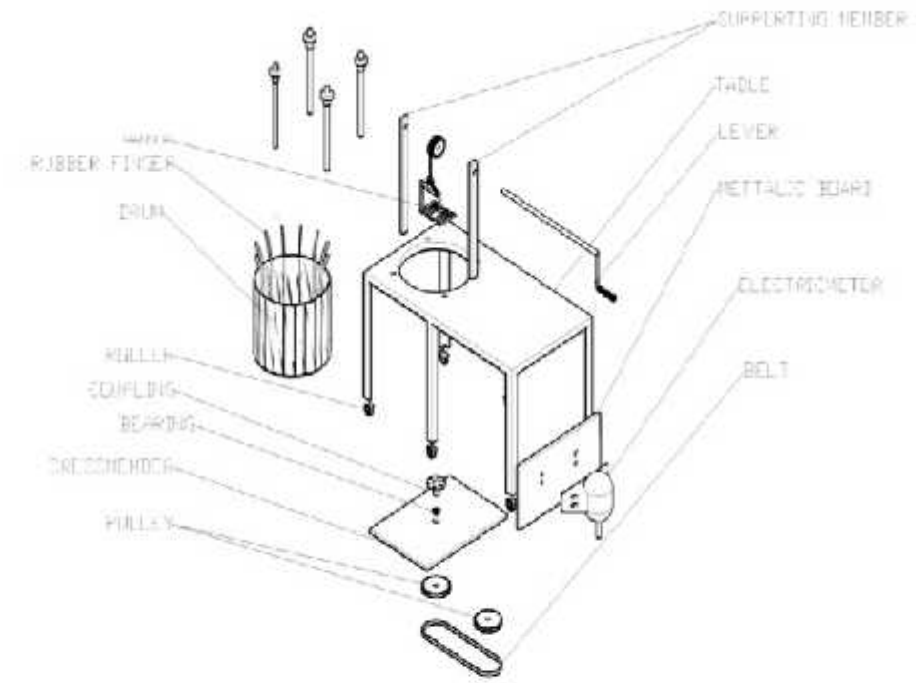
The lagged container was half filled with water which was heated using boiling ring. A thermometer was introduced to check the temperature intermittently. A stirrer was used to agitate the heated water to ensure uniformity in temperature. The hot water was poured inside

the drum and a test temperature for scalding is maintained inside the drum. At different temperatures of 55^{o}C, 60^{o}C, 65^{o}C, 70^{o}C, and 75^{o}C the exotic breed was dipped in the hot water and was held in the water for 1 minute, 2minutes and 3minutes. Similar test was carried out on local bird at temperatures of 65^{o}C, 70^{o}C, 75^{o}C, 80^{o}C, 85^{o}C, and 90^{o}C, for 5 minutes, 10minutes and 15minutes. A stopwatch was used to ensure accurate immersion duration. For each temperature and immersion durations mix the scalded chicken was transfer to the test machine and de-feathering was carried out in three replicates. Then the force for plucking the feather of the birds was recorded. The plucking force for the un-scalded birds was also measured with the used of feather stiffness meter (FSM) fixed on the fabricated de-feathering machine.

3.0 Results and Discussions

Figure 1 shows the assembly diagram of the machine. The entire component parts were obtained locally while almost all except the electric motor were fabricated local within the country hence the reduction in the cost of the machine. The overall weight of the machine is 32kg which made it relatively portable for use as make-shift farm equipment. To meet up with both federal and state requirement stainless steel was used for component that has direct contact with the bird being scalded. Likewise galvanized steel material was used for those parts having indirect contact.

Table 1 shows the feather retention force (FRF) for the contour and down feathers of both local chicken and exotic bird. It was found that about two-third of retention force required to pluck contour feather of an un-scalded local chicken is needed for similar operation on exotic bird and about half of retention force require for the down feather of local chicken is needed required for that of exotic bird. The higher feather stiffness of local chicken suggests higher plucking force and consequently higher scalding temperature compare to the case of exotic bird. Figure 2 shows the de-feathering machine in operation. A bird is scalded on at a time within an average of 3minutes. Both contour and the down feather are plucked with varying plucking force measured with feather stiffness meter. Student t test was carried out to compare the feather plucking force at varying immersion durations using XLSTAT 2010.08.



EXPLODED VIEW OF PARTS

Table 1: Feather retention force (FRF) for un-scalded birds

Type of bird	**Force to pluck out contour feather (N)**	
	Contour feather $\bar{x}$ **(SD)**	**Down feather** $\bar{x}$ **(SD)**
Local	41.53(3.32)	12.54(0.92)
Exotic	25.79(3.20)	7.11(1.33)

Figures 3 – 6 show that there is inverse relationship between plucking force and the immersion temperature. For the local chicken significant deference in plucking force occurs between the temperature 75 and 80^{O}C ($p < 0.0001$) at both $\alpha = 0.01$ and 0.05 while from 80 ^{O}C to 85^{O}C and 85^{O}C to 90^{O}C (p-value 0.232 and 0.538) at $\alpha = 0.05$ there is no significant deference in plucking forces recorded. This suggests that an optimal temperature exist between 75^{O}C and 80^{O}C at which de-feathering process can be carried out minimum operating cost.

It was also found that the force for plucking out both contour and down feather of Exotic bird also exhibit similar pattern with no significant deference in mean values noticed at temperature range 55 – 60 ^{O}C and 70 – 75 ^{O}C (p-vales 0.059 0.724 for contour feather and p-value 0.326 0.646 for down feather) while significant deference was recorded for temperature range 60 – 65 ^{O}C and 65- 70 ^{O}C (p-value 0.005, 0.003 for contour feather and p-value 0.036, 0.011 for down feather). In this case the optimal temperature for the de-feathering occurs around 70±5^{O}C temperature.

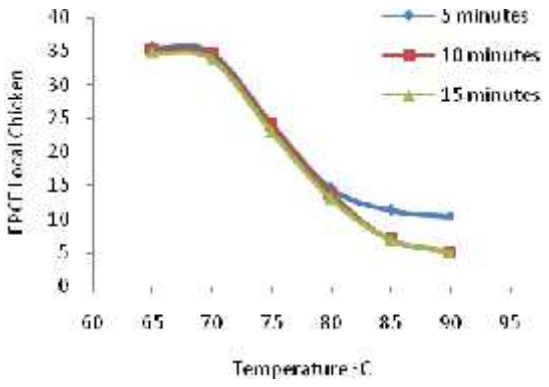


Figure 3 Plucking Force with Temperature for Contour Feather of Local Chicken

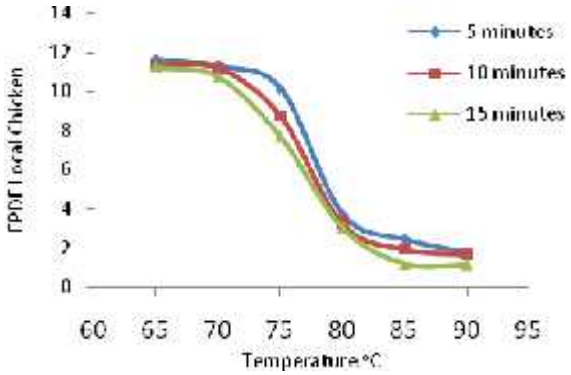


Figure 4: Plucking Force with Temperature for Down Feather of Local Chicken

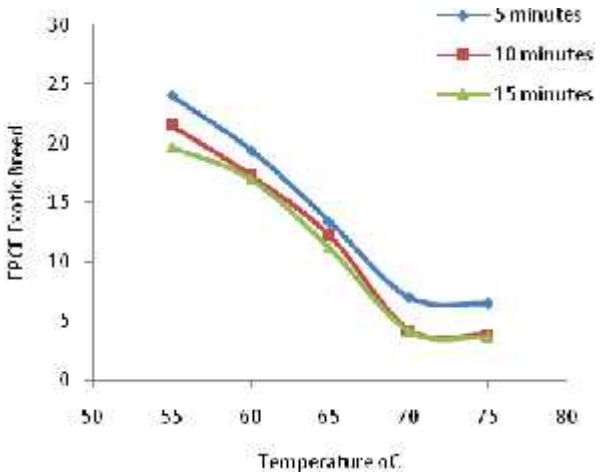


Figure 5: Plucking Force with Temperature for Contour Feather of Exotic Breed

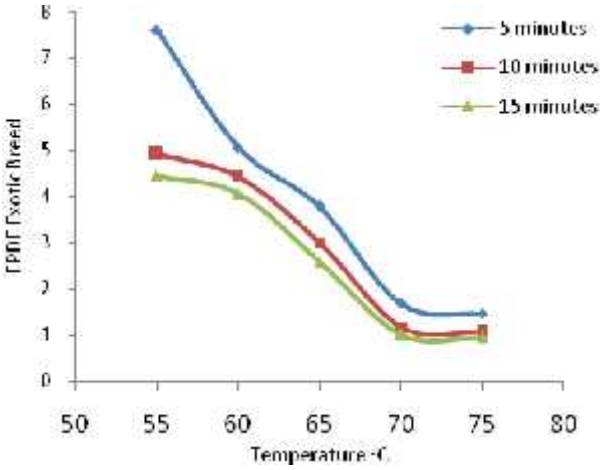


Figure 6: Plucking Force with Temperature for Down Feather of Exotic Breed

3.1 Cost Estimation of the Machine

The unit cost of the machine which includes costs of material, machining/processing, energy, transportation and overhead was estimated at ₦38,000:00 ($237.5). This compare favorably with typical scalding equipment which is obtainable at minimum of ₦85,200 ($532.5). The imported scalding machine are however very scarce in the market possibly for lack of patronage because its price is out of reach of peasant poultry farmers in the country The risk of availability of spares and skilled repairer also compound the problem use of the machine aside from the high level of illiteracy among the farmers.

4.0 Conclusion

Poultry meat processing though necessary could expose the individual involve to health hazard of higher magnitude. This study has explains the performance of a locally developed de-feathering machine at an affordable price. The machine was able achieve a clean de-feathering of single bird at a time and within average of three minutes per bird. Temperature monitoring and control is very importance in scalding operation as it posses some safety challenges and a determinant for quality of scalded bird. Temperature of water for the de-feathering obtained of the chickens shows that scalding free of damage on the skin is economically achieved at lower temperature for exotic breed compared to local chicken of the same weight hence a reduce processing time and risk.

Cost of production of the machine as well as cost of processing the bird is relatively reduced compared with existing de-feathering machines but with reduced production capacity. It is proved that the unit price of scalded bird can be reduced using the locally made scalding machine and thereby guarantee the safety of local processing farmer. This study therefore suggests that full support of agricultural business by government especially in areas where risk factors are high is very necessary to enhance sustenance of food and agricultural produce in the country. Such supports include the establishment of food processing and agricultural implement fabrication shops capable of manufacturing homemade equipment both at small and large scale, provision of farmer friendly loan scheme and continue education of poultry farmers.

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