Investigation of Properties of Guinea Fowl Feather for Engineering Application

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***Abstract*--Engineering materials are grouped in to metals and non metals; they are used in the design and fabrication of components, mechanisms and systems. Physical, thermal and electrical properties which includes bulk density, solid density, moisture content, specific heat capacity, thermal conductivity as well as electrical conductivity of guinea fowl feather material (fiber and quill ash) for both male and female respectively were determined using standard laboratory procedures. A total of 20 guinea fowls in order of 10 male and female respectively were sampled from Chiromawa Poultry processing Plant of Kano, Nigeria and used in this investigation. The feathers were recoverd after defeathering in pouches and sundried separatel. Fibre and quill of the feathers were separated manually,fibre was curded using a coffee grinder and quills were perturbed to ash.The standard samples wer subjected to scientific investigation and the mean values of the results obtained in order of female fiber, male fiber, female quill ash and male quill ash were:- bulk density (46.56, 37.89, 451.88, 418)kg/m^3 ; solid density (276.21, 258.33, 322.93, 286.31)kg/m^3; moisture content(db:2.60, 2.60, 9.8, 13.3) %; specific heat capacity(0.13, 0.17, 0.23, 0.64)J/g^{o}K; thermal conductivity(0.69, 0.73, 0.25,0.78) W/m^{o}K and electrical conductivity(1.67, 1.65, 1.68, 1.20)mS/cm.**

T-test was used in analysing the data and the results indicated that there was no significant difference between the means of values of the parameters investigated for the guinea fowl feather material (fibers and quills ash), at 5% level of significance In other words, the mean values of these parameters are said to be statistically the same.

Keywords: Feather, Quill, Fibre, Guinea fowl, Feather material

INTRODUCTION

Processing of agricultural products in Nigeria is as old as the agriculture itself. Crop farmers have experience of converting by-product of their primary processing in to animal feed, where as the by-product of their secondary processing are as well put to value addition. On the other hand, livestock farmers especially animal sector add value to their production by further processing their by-products. In Nigeria poultry was fond to be the most commercially produced livestock (NBS, 2006). Poultry production has become a fulltime job for many Nigerians and is considered to be a commercially feasible enterprise that contributes significantly to the Gross Domestic Product (GDP).

The common poultry produced in Nigeria are: local chicken, guinea fowl and imported brawlers, they are marketed and processed in the villages, urban and sub-urban. The major by-product of processing of these poultry is the feather. The process of removing these feathers from the bird is the highest energy consumer (Jekadunfa, 2008).Heavy dumps of these feathers are found disposed in all processing/marketing centers. As the crop farmers knew what to do with their by-products the poultry farmers has no idea on how to add value to their by-product.

Feathers distinguish birds from other vertebrates and play an important role in numerous psychological and functional purposes. Birds are covered entirely with feathers except on the beak, eyes and feet. Feathers not only confer the ability of flight but are essential for bird body temperature regulation. The guinea fowl (Numida Meleagris) is a common name for six (6) species of birds native to Africa, one specie also occurs on Madagascar and other Indian ocean islands.(Encarta premium,2009). Both male and female feathers as shown in plate1.1 are alike in color; mostly black, white dotted in all except of two species of one genus with small light colored spots.

Materials derived from guinea fowl feathers could be used advantageously in different applications. Such applications could potentially consume the billions of pounds of feathers produced annually as a by-product of the Nigerian poultry industry. (Nashe, 2009)

In Nigeria, the guinea fowls are developed commercially mostly by rural and sub-urban farmers and also found naturally in the bush. The guinea fowl possess twice as much feather as the local chicken (Nashe, 2009). Feather materials are developed from the separation of the raw feather into fiber and quill fractions and then size reduced into standard particle sizes. This provides more access to downstream value line processing as compared to the raw feathers. This work is geared towards investigating the guinea fowl feather physical, thermal and electrical properties that will expose it to use in the areas of thermal and electrical application.

2.0MATERIALS AND METHOD

2.1 Materials

Sample feathers of 10 female and 10male guinea fowls were collected directly from the processing line of Chiromawa poultry processing plant, along Zaria road Kano, Nigeria. Feathers collected were removed from guinea fowls (both male and female) by hot water scaldering and defeathering then diverted in to plastic pouches separately. The feathers were then cleaned, sterilized and sun dried. Afterward the two distinct materials observed on the feather (fiber& quill) were then separated as shown in plate (2.1&2.2).

Plate1.1: Raw Guinea fowl feathers

Plate2.1 Seperated quill fraction

Plate3.1: perturbed quill ash

Plate2.2 Seperated carded fibre Fraction

The fiber was carded using a coffee grinder and the quill undegoes direct fire perturbation.The resulting samples were then pakaged for experimentation.

Other instrumentation materials used includes: - weighing scale (0.01g resolution), oven (0-300^{0}C), copper calorimeter, thermal conductivity probe, electrical conductivity meter, thermometer (0-110), coffee grinder, measuring cylinder, balloons, reagent bottles and spatula.

2.2 Methods

Key properties including bulk density, solid density, moisture content, specific heat capacity, thermal conductivity as well as electrical conductivity was determined for all the samples (fiber and quill) of both male and female separately

2.2.1 Material separation

The dried sterilized feathers of male and female guinea involved solid-solid separation. Blade and scissors were used manually in separating the fiber and the quill materials Coffee grinder was used in carding the respective fibers, and the quills were perturbed directly by using fire, the mass ratio of fiber/quill was measured..

2.2.2 Bulk density

Using a cylinder and scale, the bulk density was measured by putting a sample of the guinea fowl feather material in a graduated cylinder of known volume and the content of the cylinder was tapped 20 times in case of the fiber and weighed on a digital scale having a resolution of 0.01g., the experiment was replicated three times for all samples of the guinea fowl feather materials.. The ratio of mass to volume gave the bulk density.

2.2.3 Solid density

The solid volume of the fiber was determined by immersing a rolled weighed mass of the fiber in to a known volume of water and the difference in volumes were computed. For the powder of the quill, a plastic balloon was used in which the volume of the balloon was first determined and known mass of the powder was placed inside the balloon and the loaded balloon was placed in a cylinder of water. The combined volume was measured; the difference between the combined volume and the balloon volume gave the quill powder volume. The ratio of mass to solid volume gave the solid density.

2.2.4 Moisture content

This was done by oven dry method (Mohsenin, 1980). Samples of known weights were stored in the oven of model number SM9023 at a temperature of 110^o for an average of 4hrs. The experiment was replicated 3 times and the moisture content was calculated (dry basis).

2.2.5 Specific heat capacity

A copper calorimeter was used to determine the specific heat capacity of the guinea fowl feather material as recommended by Aviara et al (2004) and Aisha (2009).

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Method of mixtures was employed using a copper calorimeter for measuring the specific heat capacity. The copper calorimeter was calibrated and placed inside a flask, samples of the guinea fowl feather material of known weight and temperature was placed into the calorimeter containing water of known weight and temperature. The mixture was stirred continuously using a copper stirrer and the temperature was noted every two seconds until equilibrium was reached and the rate of cooling after equilibrium was recorded.

Thus the equation governing the computation of the specific heat capacity as given by Aviara et.al.(2004) is:

$$CS = \frac{(Mc\,Cc + Mw\,Cw)\,[Tw - (Te + t'R')]}{Ms\,[(Te + t'R') - Ts]}$$

Where

Cs= specific heat capacity of the GFM (J/gK)
Cc= specific heat capacity of calorimeter (J/gK)
Cw= specific heat capacity of water (J/gk)
Mc=mass of calorimeter (g)
Mw=mass of water (g)
Ms=mass of GFM (g)
Te=equilibrium temperature of GFM and water mixture (K)
Ts=initial temperature of GFM (K)
Tw=initial temperature of water (K)
t'=time taken for GFM and water to come to equilibrium (s)
R'=rate of temperature fall after equilibrium (K/s)

The specific heat capacities of the samples were computed.

2.2.6 Thermal conductivity

The thermal conductivity was measured using a thermal conductivity probe.

3.2.7 Electrical Conductivity

The electrical conductivity for each sample was recorded using the Denver instrument Model 20 PH conductivity meter (Plate2.3). 10ml of concentrated acid (HCL of 0.1M) was mixed with 190ml of distilled water. A given mass of each sample was immersed in 50ml each of the acid solution and allowed to soak for 30minutes each at a room temperature of 25^{o}c. each of the samples were then filtered with a filter paper and each filtered solution was used to determine the electrical conductivity with the equipment

Plate2.3: electrical conductivity meter

2.3 Data Analysis

The data analysis was carried out using paired t-test (SAS, 91) for both male and female guinea fowl feather material at 5% level of significance.

3.0 RESULT AND DISCUSSION

3.1 Result
The results of the investigated parameters are presented in table3.0 below;

Table3.0: Mean values of the investigated parameters

Parameter	Designation	Mean Value	Standard Deviation
Moisture Content %(db)	**Female Fibre**	**2.6**	**0.216**
	Female Quill Ash	**9.8**	**1.70**
	Male Fibre	**2.6**	**0.08**
	Male Quill Ash	**13.3**	**0.50**
Fibre/Quill Ratio	**Female**	**2.7**	**0.07**
	Male	**1.4**	**0.016**
Bulk Density (kg/m^3)	**Female Fibre**	**46.56**	**2.02**
	Female Quill Ash	**451.88**	**17.06**
	Male Fibre	**37.89**	**5.02**
	Male Quill Ash	**418**	**38.20**
Solid Density (kg/m^3)	**Female Fibre**	**276.21**	**143.1**
	Female Quill Ash	**322.93**	**47.80**
	Male Fibre	**258.33**	**19.60**
	Male Quill Ash	**286.31**	**12.86**
Specific Heat Capacity ($J/g\,^oK$)	**Female Fibre**	**0.13**	**0.04**
	Female Quill Ash	**0.23**	**0.14**
	Male Fibre	**0.17**	**0.05**
	Male Quill Ash	**0.64**	**0.19**
Thermal Conductivity ($W/m\,^oK$)	**Female Fibre**	**0.69**	**0.32**
	Female Quill Ash	**0.25**	**0.06**
	Male Fibre	**0.73**	**0.048**
	Male Quill Ash	**0.78**	**0.38**
Electrical Conductivity (mS/cm)	**Female Fibre**	**1.67**	**-**
	Female Quill Ash	**1.68**	**-**
	Male Fibre	**1.65**	**-**
	Male Quill Ash	**1.20**	**-**

3.2 Discussion

Separation of fiber and quill using blades and scissors was found to be tedious and slow for mass production, Jeffrey (2006) used machine to separate fiber and quill of chicken feather. Therefore for real production, manual method may not be economical. The mass ratio of fiber and quill for female is all most 1:3 and that of male is 1:1.5, this conforms with Aisha(2009)finding were the female guinea fowl possess more feathers than the male.

The bulk density of fibers for both male and female was found to be within close range with what Aisha (2009) found as the bulk density for the overall guinea fowl feather un -separated. Bulk densities of the quill ash for both the species were also at par.

The value of the moisture content for the fibber was found to tally like in the case of the densities, and same applies to the quill ash. Jeffrey(2006) measured the moisture content of chicken feather using oven dry method and found it to be 8%(wb).While the samples of GFM used in these experiments were carded and perturbed.

The specific heat capacities measured using copper calorimeter as shown bellow indicated that the fibers of both male and female guinea fowl are in close value agreement, whereas the value for the quills ash showed some divergences. Going by this result the quill material can be said to absorb more heat than the fiber. The quill ash conduct less heat compared with the fiber. During the experiment, it was noted that the fiber turn to sublime at temperatures above 110^{o}C whereas the quill materials remains stable. Guinea fowl feathers have less heat conduction compared to chicken (Jeffrey, 2006).

The flow of electricity in the sample (GFM) of the female measured in mili Simens per centimeter was found to be equal; in case of male the fiber conducts more electricity than the quill ash (Table3.0). Generally both the specie has low electrical conductivity making them suitable for use where low conducting materials are needed.

4.0 CONCLUSIONS

The physical, thermal and electrical properties of the guinea fowl feather materials were investigated. Results of the statistical analysis indicated that there is no significant difference between the mean values of the bulk density, solid density, moisture content, SHC, thermal conductivity and electrical conductivity of both samples of quill ash and fiber for both male and female guinea fowl respectively. In other words, the mean values of these parameters are said to be statistically the same for both fibers male and female and quill of male and female. There was no segregation in electrical conductivity of the species materials. The determined parameters can be used as a guide in selecting an area of engineering application.

REFERENCES

1. Aviara, N.A., O.O. Ajibola, S.A. Oni (2004). Effect of Moisture Content and Temperature on the Specific Heat of Soybean TGX 1440-1E. Proceedings of the 4th International Conference of the Nigeria Institute of Agric. Engineers, Vol. 25, 183-191
2. Baryeh, A.E.; Mangope, B.K., (2003). Some Physical Properties of QP-38 variety of Pigeon Pea. Journal of Food Engineering, 56(1):59-65
3. Mohsenin N. N., (1986). Physical Properties of Plant and Animal Materials. (Second Edition.). Gordon and Breach Science Technology. 30(5), 335-338
4. National Berau of Statistisc.(2006). Nigerian Agricultural Survey Bulletin.
5. Nashe A.J.(2009).Determination of Physical and Thermal Properties of Feathers of some Poultry Breeds.Unpublished Thesis;Agriculrural Engineering Department,BUK,Nigeria.
6. Jeffrey W,Kock.(2006).Physical and Thermal Properties of Chicken Feather Material.Unpublished MSc. Thesis.Civil and Environmental Engineering Department,Geogia Institute of Technology-USA.
7. Jekadunfa, S. O (2008). Energetic Analysis of Poultry Processing Operation. Leonardo Journal of Science. Issue 10 P77-92.