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COMPARATIVE GROSS MORPHOLOGY AND PROPERTIES OF WING FEATHERS IN BROILER AND KUTTANAD DUCKS

Alphine Joseph[1*], K. M. Lucy[2], S. Maya[3], K. B. Sumena[4] and Tony Jose[1]

[1]Veterinary Surgeon, Animal Husbandry Department, Kerala,
[2]Professor, [4]Assistant Professor, Department of Veterinary Anatomy, College of Veterinary and Animal Sciences, Mannuthy,
[3]Professor and Head, Department of Veterinary Anatomy, College of Veterinary and Animal Sciences, Pookode,
Kerala Veterinary and Animal Sciences University, Pookode, Kerala
*Corresponding author: alphinejosephvsahd@gmail.com

ABSTRACT

Gross morphology and properties of duck wing feathers were studied in order to investigate the possibilities for the valorisation of waste duck feathers. Feather samples were collected from a total of 24 birds comprising of six males and females each of broiler Vigova Super-M ducks of six to eight weeks of age and spent Kuttanad (layer) ducks above 40 weeks of age from the Meat Technology Unit, College of Veterinary and Animal Sciences, Mannuthy, Kerala. The length and diameter of the feather barbs of these birds were recorded. Properties of barbs such as aspect ratio and fineness of barbs and density of whole feather fraction were also estimated and compared. The results pointed towards the sole features of the duck feather that are comparable with other natural or synthetic fibres for their substitution in various industries. Average length of barbs in broiler and Kuttanad ducks in the right side of right-wing feather was 2.32±0.10 cm and 1.83±0.07 cm, respectively. The diameter of the barbs was similar in both groups and the average diameter of barb was 0.06±0.004 mm which falls under spinnable diameterrange which is suitable for textile application. Aspect ratio of barbs of duck feathers was in the desired range to be used in textile manufacturing. The fineness and relative density of barbs showed almost similar values among the groups. The relative density of whole feather fractions in ducks was found to be 0.65±0.01g/cm^3. These results demonstrated the potential of duck feathers as a valuable raw material for spinning into thread, preparing slab or mat and they can be used directly or as composite for weaving clothing, eventually reducing the risk of environmental

pollution produced by the feather wastes and ultimately generating extra income to the duck farmers.

Key words: Wing feathers, Barbs, Properties, Kuttanad duck, Broiler duck, Aspect ratio

INTRODUCTION

Poultry processing industries produce large quantities of feather by-products that account for 40 * 10^9 kg annually throughout the world (Tesfaye *et al.,* 2017a). A slaughter house with a capacity of 50,000 birds slaughtered in a day can easily rack up approximately two to three tonnes of dry feathers. In Kerala, consumption of duck meat constitutes around 40 per cent of the total poultry meat consumption (Athira *et al.*, 2017). Consequently, duck meat industry contributes about half of the poultry slaughter waste in the State. Like other poultry industries, managing the waste products from duck meat industry is really a challenge. Among the waste products, feathers have caught special concern as they are not immediately being utilized by any other industries. Since duck feather contributes around 5 per cent of the body weight of the bird (Alphine *et al.*, 2019), it is apparent that the industry generates a large quantity of feathers as a waste product. Disposal of waste feathers has been dealt by different methods including landfilling and incineration (Veerabadran *et al.*, 2012). However, unsuitable dumping of these biological wastes by landfilling contributes to environmental damage and transmission of diseases (Tronina and Bube, 2008). Extreme depletion of the natural resources and environmental deterioration along with cumulative issues regarding waste disposal have propelled the researchers to focus on new bio-waste management devices to create renewable and sustainable energy or materials to replace conventional things. In order to determine the suitability for such applications, it is inevitable to understand the physical nature of duck feathers. In this research, the physical properties of the whole duck feather and of the component parts of the feather (barbules, barbs and rachis) were analyzed to assess the possibilities for beneficiation of waste duck feathers.

MATERIALS AND METHODS

Sample collection

Feather samples were collected from a total of 24 birds comprising of six males and females each of broiler Vigova Super-M ducks of six to eight weeks of age and spent Kuttanad (layer) ducks above 40 weeks of age from the Meat Technology unit, College of Veterinary and Animal Sciences, Mannuthy, Kerala. A minimum of 12 feathers from the wing region were collected from each bird. To clear out the foreign materials clung to the feathers, these were first washed with 5 per cent non-ionic liquid soap solution followed by rinsing with water. It was assumed that untreated feathers may contain different types of bacteria, which can attack feather keratin and make it weak. Hence, the feathers were sterilized with 95 per cent ethanol at 21°C for 30 min (Fan, 2008) and then rinsed with water and dried. The feathers were conditioned at a relative humidity (RH) of 65±2 per cent and a temperature of 20 ± 2º C. The barbs were separated from the rachis manually by cutting with scissors. For all samples prepared, their characterizations were conducted in a lab environment (temperature of 20 ± 2º C and a relative humidity of 65 ± 2%). The barbs obtained were then tested to characterize their different properties.

1. Fibre Length

Length is the longest dimension of the fiber in its natural state. The length of the barbs was determined using single fiber measurement method given by Booth (1974). Length of feather and feather fractions (rachis and barbs) were measured manually with the help of a scale and a pair of forceps by applying tension just to straighten the fibers. Average length of the feather and feather fractions was calculated.

2. Diameter

The diameter of the feather fractions (rachis and barbs) was measured at three different points along each fraction using stereo zoom microscope. The average diameter of each feather fraction was calculated.

3. Aspect Ratio

Aspect ratio was calculated by finding the ratio between average length of feather fractions (rachis and barbs) and average width of feather fractions (Jagadeeshgouda *et al.,* 2014). Aspect ratio = Length of the sample/Width of the sample

4. Fineness

Fineness of textile fiber is expressed in terms of denier which is the weight in grams of 9000 m of the material. Fineness of barbs was determined by weighing a known length of the barbs.

5. Density

Density of duck feather was obtained by measuring the volume of the feather pellet obtained by pressing of known mass of powdered feather under pressure using a KBr presser. Pelleting of feather prevent the air packed inside the powder. The diameter and height of the pellet was taken immediately after pressing. Density was calculated using the formula, Density = Mass / volume

RESULTS AND DISCUSSION

1. Length

Length of wing feather, calamus, rachis and barbs in different groups of birds are given in Tables and 2. The length of barb varied throughout the length of rachis in broiler ducks as well as in layer ducks. These observations are in accordance with those reported by Das *et al.* (2017) in the peacock feather barbs and this was a peculiar adaptation for aerodynamic performance in the species. The length showed significant difference between groups under study. Wing feathers were longer in broiler ducks. The maximum length was recorded in female broiler duck and minimum in male Kuttanad duck. Correspondingly, the length of calamus and rachis was more in broiler ducks. The length of rachis was almost similar in all groups without significant difference. The average length of barbs in broiler and Kuttanad ducks in the right side of right-wing feather was 2.32±0.10 cm and 1.83±0.07 cm, respectively. The values were obviously higher than that of chicken feather barbs (Reddy and Yang, 2007). May (2002) stated that the fibres having length greater than 1.27 cm could be spun and therefore duck feather rachis and barbs are suitable for this purpose. The Figure 1 depicts the varying length of barbs throughout the length of rachis of broiler and Kuttanad ducks. These short barbs can be used to spin into thread, used for weaving clothing and for preparing slab or mat after mixing with other synthetic materials. The Figure 2 depicts the average length of barbs on either side of rachis in broiler and Kuttanad ducks. Vane asymmetry was more in broiler ducks than in Kuttanad ducks (Fig. 3).

Tab. 1 Wing feather parameters in broiler and Kuttanad ducks' groups

Parameters (cm)		Broiler duck male	Broiler duck female	Kuttanad duck male	Kuttanad duck female	F-value
Length of wing feather		17.89±0.25[a]	18.30±0.37[a]	15.28±0.16[b]	17.80±0.24[a]	26.79**
Length of calamus		4.89±0.23[a]	4.63±0.07[a]	3.38±0.50[b]	4.45±0.07[a]	5.58**
Length of rachis		13.00±0.06	13.57±0.50	12.03±0.73	13.18±0.23	2.02[ns]
Length of barbs	Right side	2.47±0.14[a]	2.17±0.15[b]	1.88±0.10[c]	1.79±0.11[c]	12.002**
	Left side	1.53±0.06[b]	1.75±0.10[ab]	1.86±0.14[a]	1.54±0.11[b]	3.61*
Diameter of rachis		1.03±0.056	1.13±0.042	1.12±0.054	1.02±0.065	1.130[ns]
Diameter of barbs		0.06±0.005	0.06±0.004	0.06±0.004	0.06±0.004	1.523[ns]

(Means bearing different letters as superscripts differs significantly within a column)

(* significant at 5 % level, ** significant at 1% level, ns - non-significant)

Tab. 2 Comparison of wing feather parameters between broiler and Kuttanad ducks

Parameters (cm)		Broiler duck	Kuttanad duck	t-value
Length of wing feather		18.10±0.22	16.54±0.40	3.38**
Length of calamus		4.76±0.12	3.92±0.29	2.69*
Length of rachis		13.28±0.26	12.61±0.40	1.41^{ns}
Length of barbs	**Right side**	2.32±0.10	1.83±0.07	29.54**
	Left side	1.64±0.06	1.70±0.09	0.41 ^{ns}
Diameter of rachis		1.08±0.037	1.070±0.043	0.294^{ns}
Diameter of barbs		0.06±0.003	0.06±0.003	1.348 ^{ns}

2. Diameter

The average diameter of rachis and barbs in broiler and Kuttanad ducks is given in tables 1 and 2. All the groups under study showed almost similar diameter of rachis without much significant difference. The range of diameter of rachis was between 1.02±0.07mm to 1.13±0.04mm. The mean diameter of barbs at base, middle and tip of barb is depicted in figure 3. The average diameter of barbs was 0.06±0.004 mm. The diameter of rachis was lower and the diameter of barbs was greater than that of chicken (Tesfaye *et al*., 2017b). The diameter decreased from base to tip portion of the barb. According to Tesfaye *et al.* (2017b), the spinning of yarn and its flexibility are affected by the diameter of the fibre. The peculiarity of the duck barbs was that it had a spinnable diameter range which was suitable for textile application similar to that of chicken (Hearle and Morton, 2008). The structural parameters like diameter and spacing of barbs played major role in the water repellence property of feathers in water birds (Rijke, 1970).

3. Aspect Ratio

The average aspect ratio of rachis and barbs is given in table 3. The aspect ratio of rachis was highest in female Kuttanad duck and lowest in male Kuttanad duck. The aspect ratio of barbs in male broiler duck was 519.05±44.37 and female broiler duck was 541.47±53.98 whereas, in male and female Kuttanad ducks, the values were 523.27±43.47 and 561.43±37.26, respectively. These are in accordance with Tesfaye *et al.* (2017b) in chicken barbs. Desired aspect ratio of the fibre to be used in textile manufacturing is between 200 and 600 (Fathima and Balasubramanian, 2006) and hence the duck feather barbs can be used for this purpose. The values of aspect ratio were lesser for rachis than barbs in all the groups under study (Fig. 4). Similar observations were made by Schmidt (1998), where the barbs were found to be more durable. The aspect ratio of barbs was more in females than in male ducks. Similar reports in other birds are not available for comparison.

4. Fineness

Fineness of barbs in various groups under study is given in table 3. The fineness of barbs showed almost similar values and the difference was non-significant among the groups. The fineness was maximum for the barbs of broiler duck male and minimum for broiler duck females. Fineness was maximum for the barbs of male broiler duck (82.81±5.42) followed by male Kuttanad duck (77.93±6.41) and minimum for female broiler ducks (73.37±4.61). These findings confirm the earlier reports in chicken by Reddy and Yang (2007).

5. Density

The compression on feathers removed the vacant air apace between whole feather powder. Comparatively same relative density of all groups under study shows the similarity in the composition of broiler and Kuttanad duck feathers. The average relative density of whole feathers in broiler and Kuttanad ducks is shown in Table 3. The results showed no significant difference among groups. The relative density of whole feather fractions in ducks was lower (0.65±0.01g/cm^3) when compared to that of chicken (0.8 g/cm^3) as reported by Barone and Schmidt (2005) and Hong and Wool (2005). The density was considerably lower than that of other natural fibres like cellulose (1.5 g/cm^3) and wool (1.3 g/cm^3).

CONCLUSION

The gross morphological peculiarities and properties of duck feather fractions indicated that duck feathers can be used as a reinforcing material for composites and as textile fibers for the production of yarns and fabric. Because of the very low-density, duck feather rachis and barbs could be used for applications that necessitate outstanding compressibility, resiliency, light weightiness and sound

Tab. 3 Comparison of wing feather properties in broiler and Kuttanad ducks' groups

Parameters	Broiler duck male	Broiler duck female	Kuttanad duck male	Kuttanad duck female	F-value
Aspect ratio of rachis	127.64±6.83	120.20±4.70	108.28±5.64	132.54±9.50	2.34^{ns}
Aspect ratio of barbs	519.05±44.37	541.47±53.98	523.27±43.47	561.43±37.26	0.18^{ns}
Fineness of barbs	82.81±5.42	73.37±4.61	77.93±6.41	75.29±5.11	0.57^{ns}
Density of whole feather (g/cm^3)	0.65±0.02	0.65±0.02	0.64±0.02	0.65±0.02	0.05^{ns}

(Means bearing different letters as superscripts differs significantly within a column)

(* significant at 5 % level, ** significant at 1% level, ns - non-significant) prevention properties. Results of this study indicate that incorporation of duck feathers can be beneficial in various industries including construction, automotive, aerospace and plastics to make products that are lightweight and to improve sound attenuation. Using duck feather composites in the construction industry could be a major revolution to replace wood and plastic-based construction materials. Future studies will entail studies on other properties of duck feathers to determine their valorization pathways.

Figures

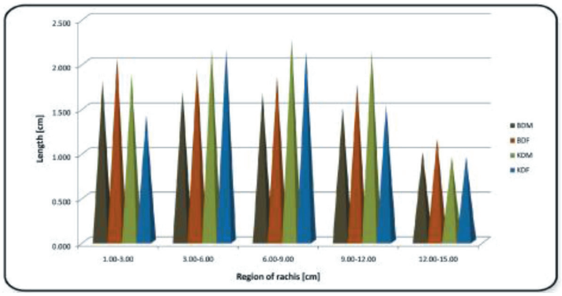

Fig. 1: Comparison of mean length of barbs at different regions of rachis in broiler duck male (BDM), broiler duck female (BDF), Kuttanad duck male (KDM) and Kuttanad duck female (KDF

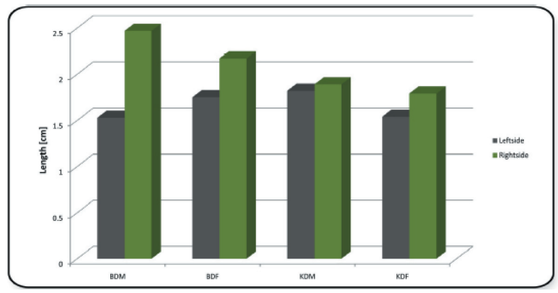

Fig. 2: Comparison of mean length of barbs on both sides of rachis i n broiler duck male (BDM), broiler duck female (BDF), Kuttanad duck male (KDM) and Kuttanad duck female (KDF)

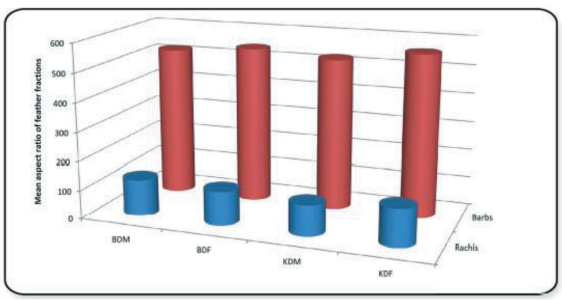

Fig. 3: Comparison of mean diameter of barbs at base, middle and tip of barbs in broiler duck male (BDM), broiler duck female (BDF), Kuttanad duck male (KDM) and Kuttanad duck female (KDF)

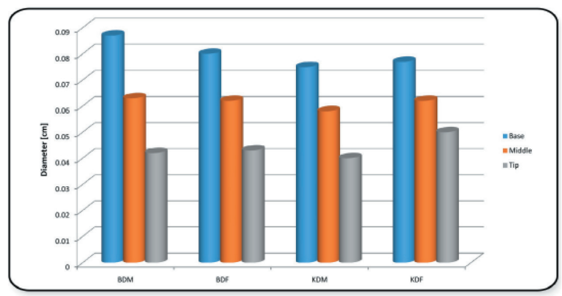

Fig. 4: Comparison of mean aspect ratio of rachis and barbs in broiler duck male BDM), broiler duck female (BDF), Kuttanad duck male (KDM) and Kuttanad duck female (KDF)

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