Biofibre Production from Chicken Feather

F.J. Tseng and CJR Verbeek

Composites Research Group, Department of Science and Engineering, University of Waikato, Gate 1 Knighton Road, Private Bag 3105, Hamilton 3240, New Zealand. (fjt2@students.waikato.ac.nz)

Abstract

The global poultry industry generates at least 2 million tonnes of chicken feather every year. Feather fibre has potential as reinforcement for polymer composites with light-weight, thermal insulation and acoustic dampening properties. This study aimed to develop a process to produce clean fibre recovered from chicken feather. Raw feather was decontaminated by 0.15% sodium hypochlorite in 25 L water at pH 10.0 for two 30 min stages and cleaned by 0.15% hydrogen peroxide in 25 L water for three 30 min stages. Cleaned feather was comminuted in 300 L water using a centrifugal pump at 30 Hz impeller speed on full recycle for 4 h. Rachis and partially cut feather were removed using a 5 mm filter and fibre was recovered using a 1 mm filter. Wet fibre was dried in an air-forced oven at 70°C. Morphological studies revealed fibre surface remained intact after the treatment process.

Keywords: feather, poultry, chicken, fibre, keratin

Introduction

Feathers are currently hydrolysed into meal used for animal feed and fertiliser, which sells for about $530 per tonne [1]. New Zealand produced about 150,000 tonnes of poultry products in 2010 [2]. The major by-product in poultry processing is chicken feather, which makes up about 8.5% of a chicken's mass [3]. Wallace Corporation in Waitoa, Morrinsville processes over 10,000 tonnes of wet chicken feather every year.

Chicken feather consists of 91% keratin, 1% lipid and 8% water [4]. Keratin is a protein rich in cysteine bonds and hydrophobic side chains, making it tough and chemically resistant [5]. As a feed additive it lacks methionine, histidine and lysine, which are essential nutrients for animals [6]. As a fertiliser, it contains excess nitrogen.

Feather morphology depicted in Figure 1 consists of barbs extending at an angle from a central hollow rachis. Barbules have hooks called barbicels, which connect barbules on adjacent barbs. There are also several types of feathers, such as contour feathers for flight, and down feathers for insulation, which does not contain barbicels. The lipid component is sebum secretion from the preen gland, which is constantly applied onto feathers to ensure the barbules stay interlocked.

Figure 1: Chicken feather morphology.

Barb material properties are summarised in Table 1. Feather fibre is an excellent candidate for light-weight composites due to its low density. Its single filament mechanical properties are substantially lower than synthetic fibres, so it is not suitable for high performance applications. The fibre dimensions are comparable to cotton and wool.

Table 1: Chicken feather barb material properties [7].

Dimensional Properties	Value	Mechanical Properties	Value
Density (g cm^{-1})	0.89	Strength (MPa)	113
Diameter (μm)	15 to 110	Modulus (GPa)	2.8
Length (mm)	3 to 13	Elongation (%)	7.7

Feather fibre is a multipurpose, cost effective reinforcement for polymer composites. Its incorporation in plastic, wood, concrete and cardboard makes the product lighter, insulate from heat loss and improve sound attenuation.

Raw feather shown in Figure 2 also contains preen oil, offal, faecal matter and poultry processing water. Impurities coat the entire feather, and particulates are trapped by layers of barbules and hooked barbicels holding adjacent barbs together. These substructures present an extensive and tortuous hydrophobic surface.

Figure 2: Raw feather.

The objective of this study was to develop a process to produce clean fibre recovered from chicken feather. In the treatment process, the heterogeneous characteristics of feather had to be considered.

Materials and Methods

Raw feather supplied by Wallace Corporation contained about 15% hexane extractables such as preen oil, as well as other contaminants. Treating feather with sodium dodecyl sulphate solutions did not reduce the hexane extractable contents, whereas ethanol or hydrogen peroxide solutions were able to reduce hexane extractable to about 10% in one equilibrium stage.

Raw feather was suspended in 25 L water in a Lamort pulper to be decontaminated using 2 stages of 0.1485% sodium hypochlorite adjusted to pH 10.0 with 1 M sodium hydroxide and cleaned in 3 stages of 0.15% hydrogen peroxide. The pulper disc impeller agitated the suspension at 10 Hz for 30 minutes at each stage.

Cleaned feather was comminuted in a stainless steel tank containing 300 L water using a centrifugal pump at a flow rate of 30 Hz on full recycle for 4 hours. Rachis and partially cut feather were removed using a 5 mm aperture filter and fibre was recovered using a 1 mm filter. Wet fibre was dried to constant mass in an air-forced oven at 70°C.

Results and Discussion

Bacteriological tests confirmed pathogens such as *Campylobacter*, *Salmonella* and *Enterobacteriaceae* were removed during treatment. Colour analysis revealed that raw feather showed 76% whiteness, which was increased to 86% whiteness after three stages of hydrogen peroxide washing. Clean feathers were fluffy and off-white, compared to a brownish yellow colour of raw feather with a foul odour.

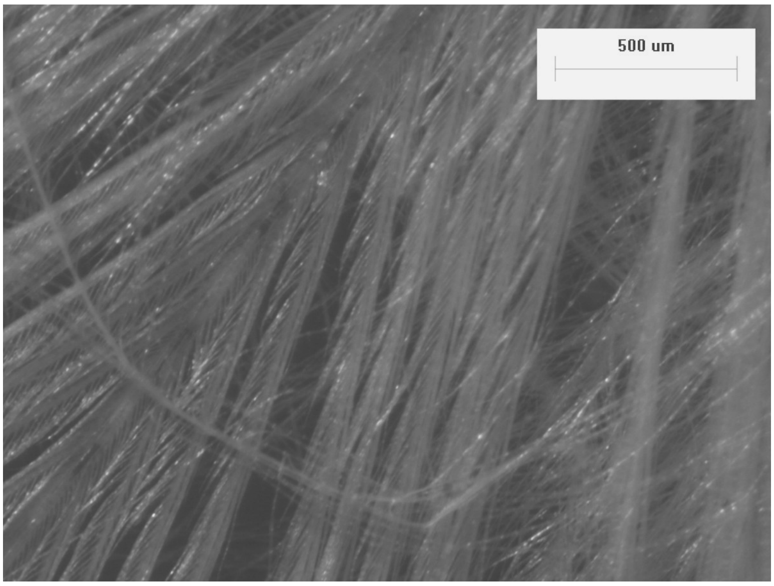

Figure 3: Feather after three stages of 0.15% hydrogen peroxide cleaning.

Half of the mass of feather is rachis, and fibre yield was 27% of feather input, or 54% of theoretical yield. Morphological studies revealed that the fibre surface was not damaged by this comminution method (Figure 4). The fibre product consists of barbs with intact barbules and thin rachis with barbs sheared off.

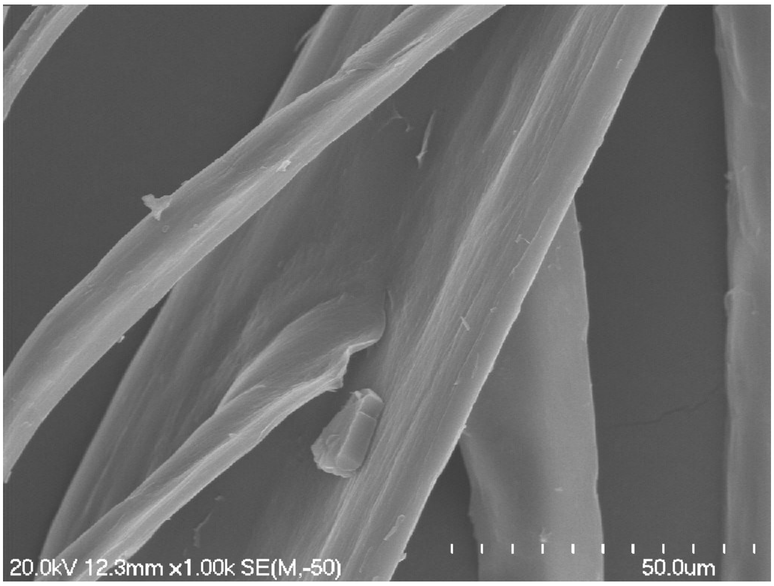

Figure 4: Feather surface after comminution.

Conclusions

The large scale process could be improved to produce fibre quality that is more consistent with that obtained in lab scale processing, in terms of fibre whiteness and hexane extractable content. Information on fibre diameter and length distribution at different operating conditions would be helpful for optimising pump impeller selection as well as pipes and valve arrangement that would reduce cavitation and fibre depositions.

Production scale development should consider equipment available within the rendering industry and can be supplemented with those available from the pulp and paper industry. The recovery process should use continuous filtration, such as the Beloit pressure screen. The proposed method is to cycle the suspension through the pressure screen controlled by valves that thickens the fibre fraction.

Further testing such as single fibre tensile tests would allow comparison with other types of fibre. The product should be tested in applications such as insulating materials and composites to determine its suitability.

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