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MEASUREMENT OF FIBRE AND FLEECE CHARACTERISTICS IN ANGORA WOOL : COMPARISON OF OFDA AND CROSS SECTION METHODS

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ABSTRACT

We conducted two experiments to evaluate the Optical Fibre Diameter Analyser (OFDA) and the Cross Section (CS) methods for estimating some quality criteria (fibre diameter and bristle content) in angora wool produced by angora rabbits. CS method had been earlier proposed as an adequate solution to determine angora fibre quality. But CS method require good operator skill and remain time consuming. Moreover very fine fibres were recently suspected to be undetected by CS method. An initial experiment (30 angora samples from 10 animals) indicated that OFDA measurements were as highly repeatable within a laboratory as CS one. In a second experiment (40 samples) both methods were compared. About fibre size characteristics, low correlations (ranged from 0.59 to 0.65) between methods were firstly observed. But it appears that CS method does not see accurately very fine fibres while OFDA detect fibres to 6 µm. High correlations (about 0.85) were found betwenn methods when fine fibres below 10 µm were removed from OFDA fibre distribution. About bristle content, a good indirect estimation can be obtained by using the coarse fibre content routinely determined by OFDA. In conclusion OFDA method is capable of determining rapid estimates of angora fibre quality.

INTRODUCTION

Angora wool is a speciality animal fibre produced by angora rabbit. Today, general quality of angora fibre is poor mainly because of felting and heterogeneity in fibre length. This felting default is probably due to a low bristle content associated to an excessive fineness of bristles. Breeding programme are currently in progress on German and Chinese strain in order to improve these traits. But, measurements of bristle content which usually is low and vary from 0.2 to 1.8 %, and bristle diameter are not very easy to undertake as the different fibre types of the fleece have to be sorted.

In the wool industry, different methods of measuring fibre quality criteria (fibre diameter) are widely adopted by producers, manufacturers and traders. Most of these methods which have been developed basically for wool and mohair fibres are based on image analysis by observing fibre snippets in profile. But some differences may arise due to the influence of fibre properties. The animal fibre type is an other important source of variation, mainly when fibres are medullated or when the cross section shape is not circular as it is in angora. As a solution, Allain and Thebault (1995) proposed a rapid method for measuring cross section characteristics of the different fibre types of the Angora rabbit fleece. However this method is not widely used as it required good operator skills and remained time consuming. In the wool and mohair industry, fibre diameter and medullation are now widely determined by using the Optical Fibre Diameter Analyser (OFDA) methodology. A preliminary study indicated no relationships between OFDA and cross section (CS) methods (Allain and Thebault, 1995).

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However, new development have now been made on OFDA and it appears that the CS method is not able to see accurately very fine fibres, below 10 μm while OFDA detects fibres to 6 μm as recently reported (Baxter, 1998) by analysing data from a round trial on cashmere and mohair different methods between laboratories (Phan and Souchet, 1998).

The purpose of this study is to evaluate the OFDA for accurate and rapid estimation of fibre quality in angora wool in comparison to the cross section method by taking account limits of CS method to see fibres below 10μ.

MATERIAL AND METHODS

Angora wool samples and experimental design.
Angora wool samples were taken by shaving with a razor blade from the back adult French angora rabbit issued from the Angora rabbit farm of Institut National de la Recherche Agronomique at Le Magneraud, BP 52, 17700 Surgères, France. In a first experiment, 30 samples from 10 animals were analysed in duplicate by OFDA method in order to evaluate measurement variability. In a second experiment, 40 samples were determined for fibre and fleece characteristics according both CS and OFDA methods. Additionally by using the CS method, all samples were analysed in duplicate or in triple in order to estimate repeatability of CS measurements.

OFDA measurements
All samples were determined for fibre diameter and fibre diameter distribution according to the procedure outlined in the International Wool Textile Organisation (IWTO) test method (IWTO, 1995). The OFDA was calibrated according to the IWTO calibration procedure (IWTO, 1995) for measuring the fibre diameter distribution of wool. OFDA measurements have been made at « Institut Textile de France Sud » (Aussillon, Boulevard du Thoré, 81204 Mazamet, France). For measurements of each angora wool sample, between 50 and 100 mg fibre snippets (2 mm long) were obtained at random by cutting fleece samples of angora wool with a guillotine at about 2-3 cm from the base of the whole staple. Thereafter the snippets were spread uniformly over the surface of a microscope slide. The slide is then placed on a microscope stage and moved step by step under computer control in order to screen the whole slide. At each step, a video system is instructed to capture and analyse a fibre image frame. Two different slides from each angora wool sample were submitted to fibre diameter determination. Average fibre diameter with standard deviation and full fibre diameter distribution were determined by measuring rapidly 4,000 different fibres per slide. Additionally, the rate of fibre having a diameter higher than 30μm is routinely obtained.

Cross section measurements
CS method developed by Allain and Thébault (1995) is based on an automated image analysis system designed to measure various characteristics of the cross sections of fibres prepared by a rapid histological technique of a fibre bundle. From each fibre sample 3 different bundles taken at different locations inside the sample were extracted and mixed in a small bundle which was embedded with an adequate medium allowing rapid inclusion (nail varnish or a paper glue made with polyvinyl resin) and then introduced into a capillary sheath of plastic material. Thereafter with the aid of a fibre microtome (ITF-Fibrotome, Instrument S.A, Division Adanel - Lhomargy, 15, Avenue Jean Jaures, BP 238, 94203 Ivry/Seine, France) into which the sheath is introduced, cross sections of about 50 to 80 microns thickness are done using a razor blade and mounted on a glass microscope slide. Up to 5,000 different fibres can

be observed on each sheath (with a fibre bundle inside) section. An appropriate image analysis software has been developed to obtain simultaneously measurements of different characteristics of the cross sections of individual fibres (up to 300 per image) such as area, perimeter, and smallest, largest and mean fibre diameter as well as identification and counting the different fibre types inside the angora rabbit fleece.

Statistical analysis

Accuracy and repeatability of OFDA and CS measurements were determined from estimates of variance components according to the following random model of variance analysis with the SAS VARCOMP procedure (1993) :

$$Y_{ijklmn} = \mu + S_i + A_{ij} + e_{ijk}$$

where: Y_{ijk} is the *k*th observation on the *i*th sample, the *j*th animal; μ the overall mean; S_i the random effect due to the sample analysed; A_{ij} the random effect due to the sample within animal. Precision is the residual standard deviation. Repeatability the ratio between within sample (or animal) variance components and total variance.

Comparisons between OFDA and CS measurements were made by using SAS CORR and REG procedures (SAS, 1993) from two datasets. The first data set included all raw measurements from each sample given by OFDA and CS apparatus while in the second one, all fibres having a diameter lower than 10 µm whatever the measurement method were removed in order to take account the difficulties of CS to see accurately fibres below that limit.

RESULTS AND DISCUSSION

Variability of OFDA measurements

The different criteria defining quality of angora wool which are easily determined by OFDA are average fibre diameter, standard deviation or coefficient of variation fibre diameter and the rate of coarse fibres defined as fibres having a diameter higher or equal to 30 microns. All these characteristics are determined on a few minutes (3 to 5 minutes / sample including preparation and measurement) by measuring 4000 fibre snippets per sample. Basics statistics of these different quality criteria are summarised on table 1.

Table 1: Basics statistics on OFDA quality criteria of angora wool samples.

N = 30	mean	standard deviation
mean fibre diameter (µ)	15.4	1.3
standard deviation of fibre diameter (µ)	6.6	1.5
coefficient of variation of fibre diameter (%)	42.7	7.3
Coarse fibre rate * (per 1000)	30.3	17.5

* % of fibres with diameter = or > 30µ

Variability of OFDA measurements expressed as components for between-sample (or within animal) and between-duplicate (or within sample) variance are given in table 2. Repeatability of OFDA measurements, expressed as the ratio of the between-duplicate variance to the total variance was 99.6 %, 98.3 %, 97.6 % and 98.0 % for mean fibre diameter, standard deviation

and coefficient of variation of fibre diameter, and coarse fibre rate respectively. Thus within a laboratory there were very few variability between measurements. However round trials between laboratory are required to evaluate efficiency and accuracy of this method for angora wool measurements. Precision of measurements were high : 0.1 µm and 2.5 per 1000 for mean fibre diameter and coarse fibre rate respectively.

Table 2 : Variability of OFDA measurements in angora fleece samples (n=30).

OFDA measurements	Between sample variance	Within sample variance	Error variance
mean fibre diameter (µ)	1.62	0.21	0.01
standard deviation of fibre diameter (µ)	2.07	0.29	0.04
coefficient of variation of fibre diameter (%)	48.03	7.61	1.37
Coarse fibre rate * (per 1000)	273.3	49.1	6.4

* % of fibres with diameter = or > 30µ

Variability of CS measurements expressed as components of between-duplicate variance are given on table 3. As expected and shown previously (Allain and Thebault, 1995), high repeatability of CS characteristics measurements were observed : 94.8%, 93.8%, 97.0%, 95.8% and 86.9 % for CS area, smallest, largest and mean diameter, and bristle rate respectively.

Table 3 : Basic statistics and variability of CS measurements in angora wool samples (n=40).

Cross section characteristics *	Mean	Standard deviation	Within sample variance	Error variance
Mean area (µm²)	167.0	28.0	582.8	36.4
Mean diameter (µm)	15.8	1.3	1.63	0.07
Mean smallest diameter (µm)	13.7	1.1	1.32	0.09
Mean largest diameter (µm)	17.8	1.4	1.96	0.06
Bristle rate (per 1000)	12.6	7.8	64.1	9.6

* fibres below 10 µm were removed.

Comparison between OFDA and CS measurements

Basic statistics of both CS and OFDA measurements made on 40 angora wool samples are given on table 3 and 4 and correlations between methods on table 5.

Low correlations (ranged from 0.59 and 0.65) were observed between OFDA and CS fibre size measurements when all data from OFDA were taken into account. Such result confirms earlier investigations (Allain and Thebault, 1995). But when fibres below 10µm were removed from the full fibre diameter distribution given by the OFDA method, a high correlation (about 0.85) was observed between methods for fibre size characteritics. This observation confirms earlier findings about CS method which does not see accurately fibres below 10 µm while OFDA detect fibres to 6 µm (Baxter, 1998). In fact CS method can detect some very fine fibres but with a low accuracy and depending upon the quality of the histological preparation. Consequently, the OFDA method seems to be more accurate than CS method for determining fibre quality in angora.

Table 4: Basic statistics on OFDA fibre measurements of angora wool samples (n=40).

	Raw data set		Adjusted data set *	
	mean	standard deviation	mean	standard deviation
Mean fibre diameter (µm)	14.7	1.1	16.0	0.9
SD of fibre diameter (µm)	5.2	0.8	5.0	0.9
CV of fibre diameter (%)	35.7	5.6	31.5	5.2
Coarse fibre rate (%)	1.35	0.59	1.35	0.59

* fibres below 10 µm were removed

Table 5 : Correlation between OFDA and CS characteristics in angora wool samples (n=40)

OFDA measurements	CS measurements	Raw dataset	Adjusted dataset *
Mean fibre diameter (µm)	Mean CS area	0.59	0.84
	Mean CS diameter (µm)	0.62	0.86
	Mean CS largest diameter (µm)	0.59	0.84
	Mean CS smallest diameter (µm)	0.65	0.85
Coarse fibre rate (%)	Bristle rate (%)	0.85	0.85

* data are adjusted to CS measurements abilities (only fibres with diameter > 10 µm)

However OFDA does not take well into account the non circular shape of angora fibre as it determines only the width of a fibre snippet. OFDA mean fibre diameter is intermediate between smallest and largest CS width but close to the mean CS width. According to CS measurements the shape of angora fibre varies considerably from a rounded square or near circular for a down fibre to a rounded rectangle for an awn or intermediate fibre and a "bean like" shape for a bristle. The mean ratio between the largest and the smallest width is 1.29, 1.47 and 1.79 for down, awn and bristle fibre respectively as observed in the present study for each fibre type of the angora rabbit fleece. Thus validity of OFDA measurements could depend upon the composition of the angora sample. The highest down fibre content (which have a near circular shape) is, the more accurate mean OFDA fibre diameter measure is. The way how a non circular fibre lie on the slide and consequently how the snippet width is measured could be also another important source of variation of OFDA measurements. It seems however reasonable to expect that a fibre lie on the slide according to its minor or major axis at random as the fibre snippet is sufficiently long (2 mm) and not very curved. Moreover, all the 4000 fibre measurements are made at random from a slide containing several ten thousand fibres. Such hypothesis can also be confirmed by comparing diameter of OFDA coarse fibres and CS bristles measurement. The difference between mean CS width of bristle and mean OFDA diameter of coarse fibres or fibres equal or above to 30 µm is very low: 43.0 µm and 43.6 µm respectively.

An important other angora quality criteria is the bristle content. A bristle is a coarse medullated fibre with usually a "bean-like" cross section shape and at least 3 hair canal inside (Rougeot and Thébault, 1989). Mean CS width measurements indicates that all bristles observed in the present study ranged from 32.6 to 60.4 µm and intermediate fibres from 18.3 to 39 µm. OFDA coarse fibre rate is defined as the content of fibres equal or above to 30 µm and thus includes all bristles and the coarsest intermediate or awn fibres. Consequently this parameter could be widely used to determine angora quality as it is routinely measured and well correlated with CS bristle content.

CONCLUSIONS

Both CS and OFDA methods show very low variability measurement within a laboratory when determining fibre quality in angora. These methods give different but complementary fibre quality characteristics. CS method described well size, shape and content of each angora fibre type of the angora rabbit fleece. OFDA determined accurately and very rapidly mean fibre diameter and the full fibre diameter distribution with low operator skill. However it is clear that CS method does not see accurately very fine fibres while OFDA does. Furthermore, a good indirect estimation of bristle content can be obtained with OFDA coarse fibre content.

In conclusion OFDA, even if it does not take well into account the non circular shape of the angora fibre is a promising system for accurate and rapid estimation of angora fibre quality.

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