TEKSTİL VE MÜHENDİS

(Journal of Textiles and Engineer)

http://www.tekstilvemuhendis.org.tr

Interlaboratory Test Performance of a Portable Fiber Tester

Taşınabilir Bir Lif Ölçüm Cihazının Laboratuvarlar Arası Ölçüm Performansının Karşılaştırılması

E.C. QUISPE[1,4], M.J.RUBIO[1], D. SACCHERO[2], M.D. QUISPE[3]
[1]NationalUniversity Agraria La Molina.Avenue La Molina s/n, Lima, Perú.
[2]TextileFibers Laboratory. National Institute of Agricultural Technology. Bariloche. Argentina.
[3]Maxcorp Technologies S.A.C. 855 Los Ruiseñores Street. Office 403. Santa Anita. Lima.Perú.
[4]Natural Fiber Tech S.A.C. 796 Felipe de Zela Street. Office 302. Santa Anital, Lima, Perú.

Online Erişime Açıldığı Tarih (Available online):31 Aralık 2019 (31 December 2019)

Bu makaleye atıf yapmak için (To cite this article):

E.C. QUISPE, M.J.RUBIO, D. SACCHERO, M.D. QUISPE (2019). Interlaboratory Test Performance of a Portable Fiber Tester**,** Tekstil ve Mühendis, 26: 116, 330-334.

For online version of the article: https://doi.org/10.7216/1300759920192611603

Sorumlu Yazara ait Orcid Numarası (Corresponding Author's Orcid Number) :

https://orcid.org/0000-0001-9651-2702

TMMOB Tekstil Mühendisleri Odası
UCTEA Chamber of Textile Engineers
Tekstil ve Mühendis
Journal of Textiles and Engineer

Yıl (Year) : 2019/4
Cilt (Vol) : 26
Sayı (No) : 116

Araştırma Makalesi / Research Article

INTERLABORATORY TEST PERFORMANCE OF A PORTABLE FIBER TESTER

E.C. QUISPE[1,4*]
https://orcid.org/0000-0001-9651-2702
M.J.RUBIO[1]
D. SACCHERO[2]
M.D. QUISPE[3]
https://orcid.org/0000-0003-0884-8789
[1]NationalUniversity Agraria La Molina.Avenue La Molina s/n, Lima, Perú.
[2]TextileFibers Laboratory. National Institute of Agricultural Technology. Bariloche. Argentina.
[3]Maxcorp Technologies S.A.C. 855 Los Ruiseñores Street. Office 403. Santa Anita. Lima.Perú.
[4]Natural Fiber Tech S.A.C. 796 Felipe de Zela Street. Office 302. Santa Anital, Lima, Perú.

GönderilmeTarihi / Received: 16.07.2019
Kabul Tarihi / Accepted: 15.12.2019

ABSTRACT: The objective of this research was to construct and to evaluate a portable fiber tester (PFT) for in field fleece and fiber test use. The standard wool top (SWT) samples were used for comparative measurement of fiber diameter using PFT in three laboratories without restricted ambient temperature or relative humidity control. Linear model with three factors was used to derive the least square means and variance components were determined. The PFT is constructed to be a compact and lightweight device of high-speed fiber testing. It works using digital image technology that measure and evaluate the fiber diameter variability of each wool sample within 45 seconds. The results show that the average fiber diameters measured by PFT at three labs are within IWTO defined tolerance values. There were no significant lab effect whereas, variance of labs remained as low. It can be concluded that PFT is a new instrument with high precision and accuracy to measure the fiber diameter of wool fleeces, which may be operated in differing field conditions.

Key Words: Instrument, evaluation, wool, accuracy, precision.

TAŞINABİLİR BİR LİF ÖLÇÜM CİHAZININ LABORATUVARLAR ARASI ÖLÇÜM PERFORMANSININ KARŞILAŞTIRILMASI

ÖZET: Bu araştırmanın amacı, saha testi kullanımı için taşınabilir bir lif test (PFT) cihazı oluşturmak ve özelliklerini değerlendirmektir. Standart yün tops (SWT) numuneleri, sınırlı sıcaklık veya nem kontrolleri olmayan üç laboratuvarda PFT kullanılarak lif çapının değerlendirilmesinde kullanılmıştır. Üç faktörlü doğrusal model en küçük kareler ortalamasını elde etmek için kullanılmıştır ve varyans bileşenleri de belirlenmiştir. Buna ek olarak, ölçümde doğruluk ve hassasiyet de belirlenmiştir. Dijital görüntü teknolojisini kullanan ve her numune için lif çapını 45 saniyede değerlendirebilen PFT, kompakt ve hafif olacak şekilde üretilmiştir Sonuçlar, tüm laboratuvarlarda PFT ile ölçülen ortalama lif çapının IWTO tarafından tanımlanan tolerans değerleri dahilinde yüksek bir hassasiyetle olduğunu göstermektedir. Önemli bir laboratuvar etkisi bulunmazken, laboratuvarların varyansları düşük kalmıştır. PFT'nin farklı koşullarda çalıştırılabilen, yün elyaf çapını ölçmek için yüksek hassasiyet ve ölçüm doğruluğunda bir alet olduğu sonucuna varılabilir.

Anahtar Kelimeler: Cihaz, değerlendirme, yün, kesinlik, hassasiyet.

SorumluYazar/Corresponding Author:*edgarquispe62@gmail.com*
DOI: *10.7216/1300759920192611603, www.tekstilvemuhendis.org.tr*

***This study was presented at "International Congress on Wool and Luxury Fibres (ICONWOOLF)", April 19, Çorlu, Turkey*

Fiber production is very important for textile industry in many countries. The world wool production recorded at total 1,166 million kilograms greasy (mkg) in the marketing year of 2014/15. The countries of Australia, New Zealand, China, and Russia are the main producers of wool. In luxury fiber, Peru is a main producer of alpaca and vicuña fiber, China and Russia of cashmere, Tukey, USA, and South Africa of mohair, whereas, China and France of Angora hair, and China and Mongolia of camel hair [1,2]. For these reasons, wool and luxury fiber production involves many people and it has a strong economic impact [2].

Fiber diameter is a principal factor of the wool quality determination for fleece production, wool trading, and textile processing [3]. In many genetic improvement programs for sheep, camelids and goats, the principal objective is to decrease average fiber diameter, because it is a factor that determine the price of fibers and breeding animals for commercialization. Fleeces and animals with fine fiber have a high price compared with fleeces and animals with coarser fibers. Likewise, fiber diameter value is an indicator of the fineness with which a yarn can be spun. Consequently, finer wools can be processed into yarns which are aptly suited for high value apparel textile end uses. Thus, finer wools can produce fabrics of characteristically light weight, soft, with superior handle and drape [4].

Therefore, it is important to measure fiber diameter of wool samples with a high accuracy, precision and quickness [5]. Currently, there are a few instruments in use to measure fiber diameter of either greasy or clean wool samples at wool center laboratory and warehouse [6]; however, those were lack of portability, price affordability, measurable limitation, and inflexibility for field use on farms. Although OFDA, FIBER EC and Laserscan are main instruments currently used in industry but they are not portable and are very expensive [7]. Fibre Lux is a portable instrument that is easy to use on farm but has a limited range in measurement and only works in wool [8].

So, the objective of this research was to design and construct a portable fiber tester (PFT), and evaluate its accuracy and test precision under conditions without restricted ambient temperature or relative humidity control.

2. EXPERIMENTAL

2.1. Location and Materials

The design and construction of the PFT was conducted at Autonomus National University of Chota, and Maxcorp Technologies SAC of Lima, Peru, during November 2015 to December 2016. The PFT design has four sub components (optical, mechanical, electronic, and software) that were directed at measuring average fiber diameter (AFD) objectively in various parts of the fibers, which also allowed for measurement of the standard deviation of AFD (SDAFD).

The PFT inter-laboratory test was performed simultaneously at three conventional laboratories, located in Lima, Chota and Cusco, Peru in a setting up facility without a restricted ambient temperature or relative humidity controls. Some environment indicators are shown at Table 1.

2.2. Construction of Portable Fiber Tester

The mechanical and electronic sub components consisted of an industrial USB digital camera, with sensor CMOS and speed programmable exposure. It was used to capture the images to be processed with a zoom lens (objective and ocular) engaged with spacers. An LED lamp as light source and an Atmel AT mega 328 microcontroller for displacement of the XY coordinate table were used. The microcontroller also receives signals from the environmental humidity and infrared temperature sensor (Model DHT22), which was connected to an electronic board. Those readings were then sent to a computer (laptop HP i3), where all signals was processed.

The images with fiber captured by a preconfigured digital camera with its SDK (Software development kit) were improved (pre-processing enhancement) by converting to grayscale (to distinguish poorly lighted fibers), followed by segmentation and smoothing, then images were binarized to distinguish background shows (1 = displayed, 0 = bottom). Morphological erosion and dilation operations were performed to remove unwanted contaminants and residues, thus providing homogenized images of the fibers. The skeletonization of the fiber images, a process that involved removing a pattern (fiber images) of the greatest possible number of pixels without affecting its general form, was carried out to obtain a line (skeleton) of a single pixel. It was then connected, evaluated, and located in the center and along each fiber image. To find outgoing branches of the skeleton, Hough transform was used to find straights along the curvature of the fiber samples from these images. Then, edge detection algorithms were developed to define the distance of the fiber diameter in pixels.

The case housing was prepared with acrylic sheet of 4mm thick. Mechanical, electronic, and optical subcomponents were mounted within it.

Table 1. Altitude, temperature, and humidity environment indoorat each laboratory were measured at each location where the Portable Tester Fiber was used.

Laboratory location	Altitude[1] m.a.s.l.	Environment temperature (°C)	Environment humidity (%)
Lima	161	20±0.8	54±2.1
Chota	2388	21±1.2	62±2.2
Cusco	4338	17±1.8	46±1.9

[1]Expresed in meters above sea level

2.2. Procedures

Eight International Standard Tops (ISTOPS) of known AFD and SDAFD, were obtained from the Testing Fiber Laboratory-INTA, Bariloche and used for calibration and evaluation of the PFT. Each of ISTOPS were prepared in snippets and divided in three subsamples. These were sent to each of laboratories for inter-laboratory PFT evaluation testing.

A calibration process was mandatory because the unit of measure of PFT is in pixels. The calibration was performed in according to the procedure of IWTO-47 [9], prior to PFT evaluation. Each subsample of ISTOPS at each laboratory was divided in three sub subsamples and then was measured with PFT.

For measurement, a fiber holder slide (FHS) was used. This accessory was made up of two sheets of glass. The sheet size was 7 x 7.3 cm with 1.5 mm thickness. The glass sheets were held together by adhesive tape on one end. The wool snippets were spread over a surface of one glass sheet using a spreader dispositive, at a controlled density, then covered with the second glass sheet, according to the operation procedure of PFT [5]. The prepared FHS with snippets was placed on the holder of the PFT and it was measured using the installed computer software.

The test precision was determined using standard deviation of the average of three standard deviations of individual laboratory data set, each one calculated using two measurement of the same subsample. Precision was calculated for one of 8 ISTOPS. Whereas, test accuracy was assessed using deviation of measurements, which were obtained with PFT from data reference of standard wool top measurement values. The test precision and accuracy was carried out at each laboratory location.

2.3. Statistical analysis

Data of AFD obtained by PFT were analyzed following the statistical procedure of R v 3.5.2. Linear model with three factors including effect of lab, sample, and subsample were used to derive the least square means. Variance components were determined also. In addition, it was evaluated in each laboratory according to the average of AFD using bars and plots diagrams. Software R version 3.3.0 and Excel were used for statistical analysis.

3. RESULTS AND DISCUSSION

The new design of PFT (called MINIFIBER), which features compact in size and lightweight at weight of 3.95 kg and within the dimension of 21.5 cm x 2.15cm x 27.5 cm. The PFT operates using digital image capture and its owner analytical program, which measures the fiber diameter values and captures digital data of per sample within 45 seconds. Information about measures (AFD, SDAFD, number of measures, temperature, environmental humidity and other information) are saved in an Excel file (Figure 1).

Figure 1. Portable Fiber Tester working at farm condition. The image of left side shows the small dimensions. The image of right side shows the portability

The compact size and lightweight of PFT makes it highly portable, as such features allow the PFT to fit inside a backpack (Figure 1) and handy to use on farms. The portability is very important, because in many countries with low-input animal fiber production systems, traveling and transportation between farms were difficult due to the lack of infrastructure [10]. Whereas, one person equipped with PFT can travel between farms on foot, work under the ambient temperature and humidity conditions at farms, and can provide test printed results on farm, because the PFT includes a thermal printer.

Table 2 shows the accuracy and precision of AFD measured with PFT for evaluation by three laboratories. The accuracy of PFT is between 0.00 a 0.30 µm for tops samples with measure about 17 µm, but for top samples with AFD of 37 µm varied between -1.28 a 0.05 µm (Figure 2). It has shown that increasing the fiber thickness of top samples decreases the measurement accuracy. In general, such accuracy values in all tops samples with variation from 17.34 to 37.02 µm were less than 1.00 µm. This result demonstrates that PFT has an acceptable accuracy in accordance to the tolerance values described by IWTO-47 (2015).

Table 2. Accuracy and Precision Portable Fiber Tester (PFT) of average fiber diameter (AFD) in three laboratories at interlaboratory test. Accuracy is the difference between AFD of each laboratory minus AFD of ISTOPS.

AFD of ISTOPS	Accuracy* of PFT in three laboratory			Precision* of PFT in three laboratories		
(µm)	Lab 1	Lab 2	Lab 3	Lab 1	Lab 2	Lab 3
17.34	0.00	0.30	-0.15	0.02	0.01	0.01
18.58	0.10	-0.22	-0.20	0.03	0.04	0.05
20.40	-0.77	-0.30	-0.58	0.04	0.02	0.01
23.61	-0.49	-0.58	-0.38	0.04	0.05	0.03
26.84	-0.32	-0.55	-0.55	0.02	0.05	0.07
30.57	-0.73	-0.25	-0.59	0.13	0.05	0.11
33.10	-0.81	-0.65	-0.99	0.11	0.08	0.03
37.02	-1.28	-0.73	-0.73	0.09	0.08	0.05

*Accuracy is expressed by the difference between AFD of each laboratory minus AFD of ISTOPS. Precision is determined by standard deviation of average of three standard deviations each one obtained two measurement of same sub subsample.

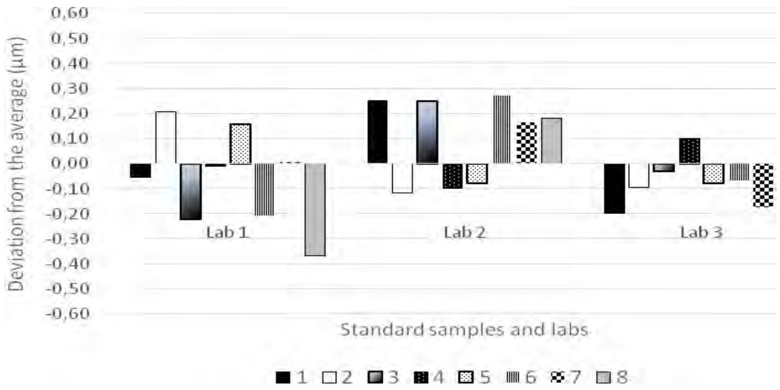

Figure 2. Deviations of average fiber diameter of each one ISTOPS using Portable Fiber Tester in three laboratories using eight ISTOPS.

The precision of the PFT- assessed through standard deviation -, varies between 0.01 a 0.11 µm. These are low values compared with the POFITEST evaluation [5], and they indicated a good precision for the PFT. That is, when measuring AFD in a same sample with the PFT the AFD is repeatable.

At statistical analysis through of model linear, there were no significant lab effect (p-value = 0.97). However, there were enough evidence indicate that the difference among samples and subsamples (p-value < 0.001) was significant. In addition, as shown in the Table 3, variance of laboratories was remained low (0.01%) although these tests were performed under a varied condition of humidity or temperature, but the variance of samples was much higher than variance of subsamples (99.61 and 0.38%, respectively).

The low absolute and relative values of among laboratories variance show that the operational manipulation, location and environment conditions have reduced effects on variation AFD performed by PFT instrument. Also, low among subsample variance showed that if one fiber sample is divided into subsamples, these will be slightly differed for AFD. For this reason, to compare among instruments accordingly to measure AFD it should use same subsamples conveniently; otherwise the difference could be increased for such effect.

Table 3. Variance components of three source of variation

Source of variation	Absolute value (μm^2)	Relative value (%)
Among laboratories	0.01	0.01
Among samples	43.67	99.61
Among subsamples	0.17	0.38
Total	43.85	100.00

The inter-laboratory evaluation performance of PFT test fort AFD is shown at Figure 3. The results show that the average fiber diameter measured by PFT at all three labs are within IWTO tolerance values with except one sample top of 20.40 µm in laboratory 1. Accordingly, the summary of this inter-laboratory test results indicated that the Portable Fiber Tester performed AFD testing accurately and consistently at different laboratory with varying ambient temperature and humidity conditions. Therefore, the PFT instrument could be adopted as a farm field test instrument for AFD measurement of wool and fleece samples, which may be comparable or even capable to measure a wider range of fibers than the FibreLux (8) but consisted with OFDA and Laserscan instruments (11).

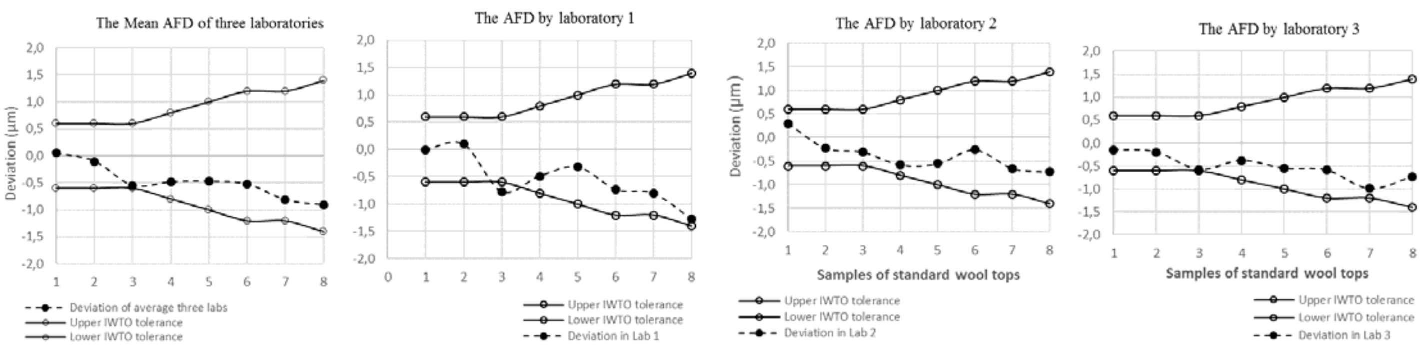

Figure 3. The mean AFD measures and variations of three laboratories according upper and lower IWTO tolerance.

4. CONCLUSIONS

This research has constructed and evaluated a new portable fiber tester for use in field fleece wool and fiber sample tests. The inter-laboratory evaluation results at three locations indicated that the portable fiber tester was performing consistently and accurately under various unrestricted ambient temperature and humidity. The instrument also has met the international wool and textile regulatory standards with a high precision and accuracy. The new portable fiber tester is recommended for measuring fiber diameter of wool and other animal fibers, specially, is suitable to be operated on farms in different ambient environmental conditions.

ACKNOWLEDGEMENTS

This research was supported by the PNIA by agreement N° 026-2016-INIA-PNIA/UPMSI/IE. The authors appreciated Mr. Saúl Fonseca and Dr. Tumen Wuliji for editing and revision of the English manuscripts.

REFERENCES

1. Hopkins, H.W. 1991. *Alternative animals for fibre production*. Proceeding of A seminar in the Community programme for the coordination of agricultural research, 5-10, October 24-25, 1991, A.J.F Russel Eds, Commission of the European Communities, United Kingdon,.
2. McGregor, B. 2012. *Properties, Processing and Performance of Rare Natural Animal Fibres: A review and interpretation of existing research results*. Rural Industries Research and Development Corporation Eds.; RIRDC Publication No. 11/150, Melbourne, Australia
3. McGregor, B. 2006. *Production attributes and relative value of alpaca Fleeces in southern Australia and implications for industry development*. Small Rumin Res. 2006, 61, 93-111.
4. Holman, B.W.B; Malau-Aduli, A.E.O. 2012. *A reviedw of shkeep wool quality traits* Annu Rev Res Biol, 2(1), 1-14.
5. Quispe, M.D.; Benavidez, G.; Sauri, R.A.; Bengoechea, J.J.; Quispe, E.C. 2017. *Development and preliminary validation of an automatic digital analysis system for animal fibre analysis*. S Afr J Anim Sci. [Online] 2017, 47(6), 822-833. https://www.ajol.info/index.php/sajas/article/view/162641 (accessed Mar 2, 2019).
6. Cottle D.J.; Baxter B.P. 2015. *Wool metrology research and development to date*. Text Prog, 47(3), 163-315.
7. Quispe, E.C.; Sacchero, D.; Quispe, M.D. 2018. *Potencial uso en la evaluación de lanas y fibras de animales de un novedoso caracterizador electrónico.* Rev Invest Vet Peru. [Online] **2018**, 99, 18 – 22. (in Spanish, English abstract). http://revistasinvestigacion.unmsm.edu.pe/index.php/ veterinaria/article/view/13677 (accessed Mar 2, 2019)
8. Walker, J.W.; Stewart, W.C.; Pope, R.; Spear S.L.; Ebert, M.; Murphy, T.W. 2018. *Evaluation of mean fiber diameter measurements by FibreLux micron meter and OFDA 2000 in Texas and Intermountain West wool*. Small Rumin Res., 159, 31-37.
9. IWTO-47-2013. 2015. Red Book Specifications, International Wool Textile Organization, Brussels, Belgium.
10. Kosgey, I.S.; Okeyo, A.M. 2007. *Genetic improvement of small ruminants in low-input, smallholder production systems: technical and infrastructural issues.* Small Rumin Res. 70, 76-88.
11. Van Zyl, A.M. 2000. *The relationships between mean fibre diameter measurement by Airflow, OFDA and Laserscan for South African wools from different breeds*, *Report No RWG 05*, Christchurch Meeting, IWTO, Technology & Standards Committee, Raw Wool Group.