INVESTIGATING THE COMFORT OF LESOTHO APPAREL WOOL AND ITS SUITABILITY FOR GARMENTS WORN NEXT TO SKIN

Papali E Maqalika*, Lawarance Hunter & Anton F Botha

ABSTRACT

Wool has been used extensively for outer garments, because of the scratchy characteristic affecting comfort. Previous research opened possibilities to explore the suitability of wool for garments worn next to the skin, this study assessed the comfort of Lesotho apparel wool and suitability for garments worn next to skin as determined by its fineness/the mean fibre diameter (MFD). Samples of Lesotho apparel wool taken from different classes of fineness were hand-scoured, spun and knitted into sleeves, which were evaluated for prickle by a consumer panel. The sensory evaluation was used to evaluate the prickle sensation evoked by Lesotho wool samples of different fineness/ MFD. Sleeve samples made from finer wool with low MFD were deemed comfortable and less prickly by the panellists. There were some exceptions of fine wool samples that were reported as prickly, this was discovered to have been due to the interference of the manual processing. It was concluded, therefore, that the Comfort Factor (CF) in some of the wool samples tested, indicated by the prickle level, rendered Lesotho wool suitable for wearing against the skin; however, it requires proper processing to ensure complete removal of impurities and standardised consistency in spinning and knitting. Some breeding improvements were also recommended.

KEYWORDS

Lesotho, wool, prickle, mean fibre diameter, comfort factor, sensory evaluation

— Dr PE Maqalika
ORCID ID: 0000-0003-4335-1153
Textile Science and Apparel Technology Unit
Consumer Science Department
National University of Lesotho
Maseru 100
Lesotho
Email: papali2020@gmail.com
*Corresponding author

— Prof L Hunter
ORCID ID: 0000-0002-6144-8453
Department of Textile Science
Nelson Mandela University
Gqeberha 6031
South Africa
Email: Lawrance.Hunter@mandela.ac.za

— Dr AF Botha
ORCID ID: 0000-0002-6490-2148
CSIR
Gqeberha 6031
South Africa
Email: afbothape@gmail.com

ARTICLE INFO
Submitted June 2024
Revision September 2024
Accepted September 2024
DOI: https://dx.doi.org/10.4314/jfecs.v1i1.271572

INTRODUCTION

Wool was traditionally perceived as the most suitable fibre for the formal wear market. The reputation wool has of being scratchy or prickly, sometimes even allergenic, resulted in many consumers steering clear from purchasing clothing containing wool, particularly when it will be worn next to the skin (Li 1998). Comfort is a key feature for customer satisfaction regarding garments which come in contact with the skin of the wearer. In recent decades, sensorial and functional comfort demands have increased from today's highly informed consumers, particularly with regard to garments made from animal fibres (Naebe *et al.* 2013). Wool competes with a number of other fibres, both natural and synthetic, some of which inherently possess the desired prickle-free characteristics. The stand of Lesotho's apparel wool is currently unknown; this ignorance threatens the fair trade of the aforementioned fibre. Prior to 2018, the largest broker for Lesotho wool and mohair Boeremaklaars Koőperatief Beperk (BKB) auctioned and exported about 90% of the wool produced in Lesotho. BKB is a South African broker that has been auctioning Lesotho wool for over 30 years, in its association with the Lesotho Wool and Mohair Growers' (LWMGA) association, BKB has taken interest in the improvement of the wool quality in Lesotho. This has been evident in the training sessions they held for the LWMGA members coupled with assistance to improve on the flock as per Lesotho government's recommendation for Merino Sheep breed (Mokhethi 2016). Very little of the wool is consumed locally by the private traders and crafts cottages.

According to Mokhethi (2016), Lesotho wool has a potential to contribute positively in the national economic growth significantly. It is worth noting that, until 2018, Lesotho wool was sold as a part of the South African wool clip, making it difficult to trace Lesotho wool to its ultimate destination and final product. The ultimate destination and use of Lesotho apparel wool is not known, unpacking the suitability of this fibre can inform the choice of garments that it can be used to manufacture. that would then inform the desired wool quality or improvement thereof. In light of the aforementioned, this study assessed wool samples of different mean fibre diameter (MFD) for prickle through a sensory evaluation.

FIGURE 1: LESOTHO GEOGRAPHICAL MAP SHOWING THE VARIOUS REGIONS (MEKBIB *ET AL*. 2011)

Among the properties of wool, MFD is one of those that influences the wool price notably, Baxter and Wear (2022) reported that MFD is the quality factor that usually has the greatest effect on price for all wool types, hence the decision to focus on MFD since it determines fineness of wool.

Lesotho is divided into four agro-ecological regions and 10 districts (Figure 1) based on climate and elevation. The four regions are the Lowlands (17%), Senqu River Valley (9%), Foot-hills (15%) and Highlands (59%), the latter being found in the mountains (Mekbib *et al*. 2011). Each of the districts stretches over a maximum of four regions, Mohale's Hoek being an example of one which stretches across all four regions. Depending upon their geographical position; the regions experience different climatic conditions, which, in turn, impacts on agriculture within the regions significantly, this effect includes stock farming. As it can be seen in Figure 1, the Senqu Valley region stretches over all other three regions and its climatic conditions are unique because of the proximity with the Senqu river. The conditions are usually not suitable for stock farming except for a few domestic animals intended for subsistence. Hence the absence of any wool production data in the study because wool reared for commercial purposes has been used for this study.

In the context of this study, Lesotho wool refers to the wool produced within the boundaries of Lesotho as a country. Most sheep reared for wool production in Lesotho are Merino. While the wool sheep breed is similar to the ones in South Africa, the farming practices from breeding all the way through to shearing differ in the two countries, Gonzales *et al*. (2020) describe wool production as subject to environmental variability. They continued to explain that fluctuations of the environmental conditions drive variations in the nutritional status of the sheep, wool growth and its quality, this is indicative of the differences likely to be found in Lesotho wool relative to South African wool. The observation that the research team made is that Lesotho sheep reared for wool are shorn once a year in Lesotho while in South Africa shearing is often done twice a year. The Merino has been recommended to the wool farmers in Lesotho because according to researcher like Allafi *et al*. (2020), Merino wool is a high-grade wool used to produce high quality garments and textiles preferred by markets and consumers.

Objectives

The study was developed with the following objectives:

1) To assess the extent of prickly sensation in the wool samples of different fineness
2) To determine the suitability of Lesotho wool for garments worn next to skin
3) To identify factors contributing to fabric evoked prickle

LITERATURE REVIEW

Understanding prickle

Prickle can be described as the unpleasant prickly or scratchy sensation associated with certain fabrics. Kennins (1992) explained that the prickle evokes the desire to scratch in a similar manner that itch does and may be described as "pricking with many needles", the associated degree of discomfort varying from one person to another and the wear conditions. Botha (2005) defined prickle as a sensation often complained about by consumers with respect to garments worn next to the skin, notably underwear, especially in the case of wool fabrics. According to Naylor (2010), fabric -evoked prickle sensations are sometimes linked to wool and wool blend fabrics worn next to the skin. The prickle sensation is realised through the skin as a sensory organ; therefore, it is important to understand the relevant mechanism involved in perceiving itch and pain by the skin. The skin, as the intermediary between the nervous system and the environment, becomes itself the sense organ, and as far as pain nerve endings are concerned, no other specialised organ than the skin tissue surrounds the endings (Jiyong *et al*. 2011; Bishop 1948). The skin is sensitive to the existence of prickle, which justifies the subjective manner in which prickle is usually measured.

According to Frank *et al.* (2021) fabric-evoked prickle originate from the coarser fibres in the fibre diameter distribution also known as coarse edge. Experiments have shown that the percentages of fibres greater than 30–32 µm correlate positively with prickle or itching and this threshold is similar for wool. Wool fineness contributes a greater percentage of its ability to exert prickle as described in the previous paragraph. However, the breed of the sheep and the structure of wool itself also plays a part in the itchiness perceived by wearers of woollen garments. Regarding the sheep breed, Yue *et al.* (2023) recounted that there are many molecular regulators are involved in hair follicle development which in turn impact the fibre MFD, this means that the sheep breed intended for wool production must be selected carefully. The structure of a wool fibre on the other hand, has a rough surface on the cuticle which may contribute to the prickly sensation.

As can be seen in Figure 2, the scales on the surface of the cuticle render the fibre rough. Depending on the leaning angle of the scales to the fibre, the surface may be rougher in which case prickle will be more likely to be perceived in such fibres and textile products made from the same. This is a confirmation of how complex the prickle sensation is as a concept and how important it is to understand all the contributing factors to be in a better position to reduce the prickle sensation perceived particularly as evoked by woollen garments that touch the skin when they are worn.

Skin as a sensory organ

The skin is a sensory organ and it plays a major role in the perception of prickle. It is also essential in the physiological and mental response processes associated with the perception of prickle. All these processes are important in understanding prickle, and so are the skin/garment interaction and sensitivity of different individuals, which ultimately determine prickle sensation and perception directly.

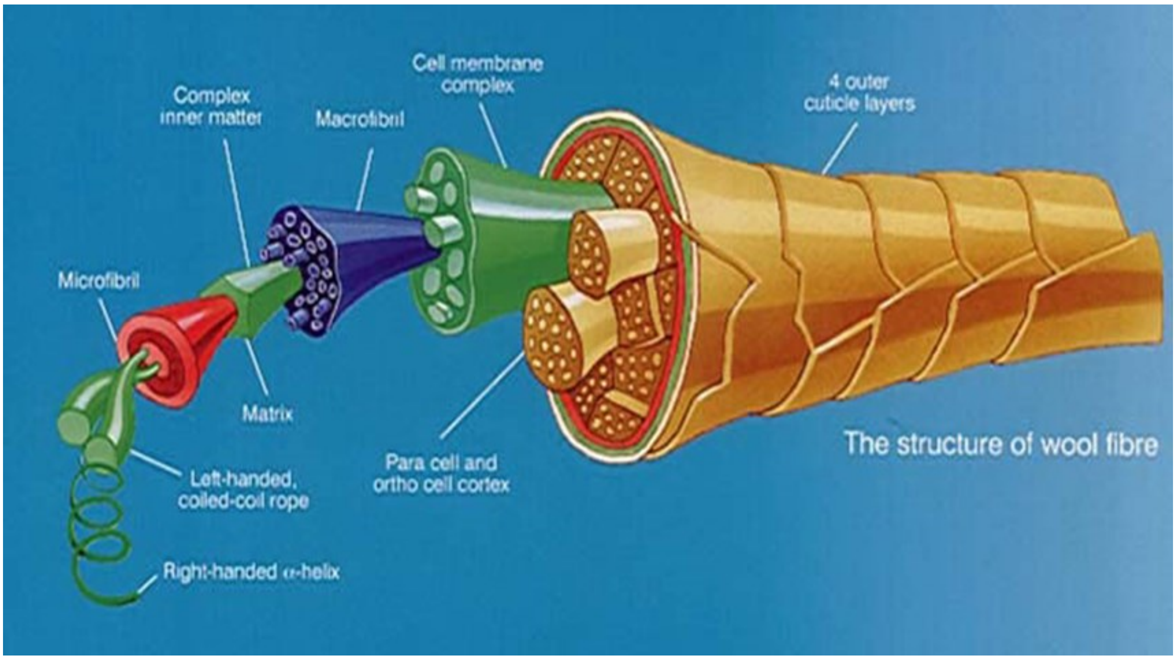

FIGURE 2: THE WOOL STRUCTURE

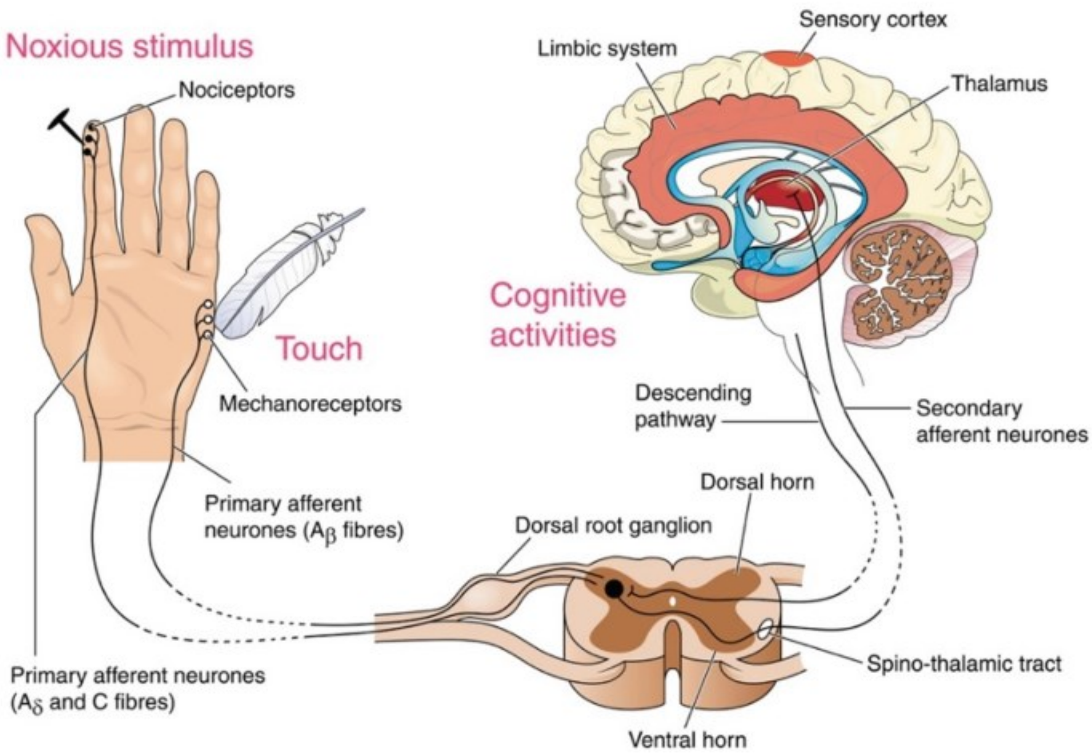

FIGURE 3: PATHWAYS FROM SKIN TO BRAIN (CRUCIANELLI & EHRSSON 2023)

The function of the sensory neurons of the peripheral nervous system and many primary afferent nerve fibres to the skin enable this perception (Ikoma *et al*. 2006). Figure 3 indicates the sensory receptors in the skin as well as the afferent and efferent neurons in the process of prickle sensation and reaction of the muscles as a result of the sensation. The afferent fibres are the ascending pathways transporting sensory information from the peripheral (sensory organs) to the central nervous system (CNS) in humans (Crucianelli & Ehrsson 2023). The properties of the skin contribute significantly to the sensitivity and intensity of fabric-evoked prickle. Some of the properties that may influence the perception of prickle include skin hardness and age, skin temperature and humidity, and the depth, density, and sensitivity of nerve endings. It is also believed that individual differences in the brain can influence the sensitivity to prickle and, therefore, prickle sensation (Downar *et al*. 2002).

MATERIALS AND METHODS

Sampling procedure

Samples drawn from the 2013/2014 season Lesotho wool clip were tested by the Wool Testing Bureau and stratified into identified fibre diameter ranges. The number of samples was not pre-determined; rather, it was determined by the number of fibre diameter ranges constituting the bulk of the 2013/2014 Lesotho wool clip on sale. A total of eighteen greasy wool samples (n=18), with mean fibre diameter ranging between 16.9 µm and 22.2 µm, were selected for the prickle evaluation (Table 1). Table 1 shows the selected details of the samples, particularly the MFD, CF) and the yarn linear density (tex). The linear density (tex) was calculated from the weight of 10 m yarn for each wool sample. The samples are shown in an ascending order of MFD, the subsequent tables report following the same order. CV that is seen as one parameter in the tables stands for coefficient of variation, it is a measure of variation in diameter measurement

TABLE 1: PRICKLE EVALUATION SAMPLE DETAILS (N=18)

Sample	Region	Yarn Linear Density (Tex)	Mean Fibre Diameter (µm)	CV of MFD (%)	Comfort Factor *CF (%)
1	Highlands	544	16.9	22.3	99.4
2	Foothills	537	17.3	23.4	98.9
3	Highlands	484	18.1	28.4	98.1
4	Foothills	584	18.2	21.9	99.6
5	Foothills	674	18.2	23.6	98.9
6	Highlands	573	19.1	22.9	98.6
7	Foothills	554	19.3	23.3	98.1
8	Lowlands	457	19.9	23.4	98.1
9	Lowlands	724	20.1	22.0	97.9
10	Foothills	689	20.3	23.1	97.3
11	Foothills	477	20.5	25.3	97.1
12	Foothills	734	20.5	24.3	97.1
13	Lowlands	612	20.7	24.3	96.9
14	Highlands	496	21.1	26.9	95.2
15	Highlands	452	21.5	27.5	93.2
16	Highlands	491	21.6	27.0	94.5
17	Highlands	605	21.7	22.0	95.5
18	Highlands	475	22.2	22.1	94.4

along and between individual fibres, relative to the average (or mean) fibre diameter. CVD is calculated by dividing SD of the diameter by MFD then multiplying by 100 to express as a percentage. CVD allows comparison of the variability of samples that differ in fibre diameter.

*CF - Comfort Factor: *The percentage of wool fibres with a diameter less than 30 µm (Malau-Aduli & Akuoch 2010).*

Sample preparation

Manual scouring, combing and spinning were done on the wool samples at a local handicraft centre in Teyateyaneng (TY) Lesotho, special care was taken to ensure that batches were not mixed since they were classed according to different fibre diameter measurements. The small samples could only be hand spun because of the lack of access to suitable machinery to process small batches of wool fibre into yarn. Each of the 18 sample yarns was knitted into a plain single jersey sleeve (±20 cm each inclusive of the rib part and 40 wales wide) with a rib and sewn together to form a forearm seam. A manually operated flatbed knitting machine, located at the Incubation Centre at the Second Avenue Campus of the Nelson Mandela University (NMU), was used. Four sleeves were produced from each of the 18 yarn samples.

Prickle Evaluation

The sensory evaluation procedure was followed to assess prickle. Prickle is a perception and as thus it is a subjective concept. There are a number of objective methods of assessing prickle such as the Kawabata Evaluation System for fabrics (KES-F) by Kawabata and Niwa (1991), Fabric Assurance by Simple Testing (FAST) by Ly *et al.* (1991) and Fabric Touch Tester that Malengier *et al.* (2021) used in the study they did. Indicative to the research developments in fabric comfort measurements, Hu *et al.* (2023) did research work on digitisation of fabric comfort, the is a multidimensional evaluation strategy of human perceptions of clothing comfort. A declaration is hereby being made that these advanced methods were not applied due to inaccessibility and financial constraints. The human body exhibits high tactile prickle sensitivity or physiological stimuli when in contact with fabric materials (Asad *et al*. 2016). The use of humans becomes important in the

TABLE 2: CRITERIA USED TO SELECT THE PRICKLE ASSESSMENT PANELLISTS

Attributes that qualified persons to form part of the wool prickle evaluation panel	
1	No callouses on the hands and fingers
2	No dry or chapped skin
3	Not on any drug therapy
4	Ability to detect and describe sensorial attributes of fabrics and mostly differentiate between intensities (levels)
5	Interest in the activity
6	Availability
7	Willingness to participate

measurement of product attributes that can only be perceived by human senses (Gengler 2006). The forearm position was selected for its effectiveness and convenience (Wang *et al*. 2007; Kennins 1992).

Selection of prickle assessment panellists

Twenty-four (n=24) members (16 students and 8 staff members) of the National University of Lesotho (NUL), in the Faculty of Agriculture, were selected to form the "prickle evaluation panel", of which eight (8) were male and fourteen (16) female. The ages ranged from 25 to 62 years. The panellists were selected after a screening test that assessed tactile acuity; this was considered essential since sensitivity varies significantly with age, degree of skin hydration, and other skin-related factors (Civille & Dus 1990). Their interests, availability and willingness to participate in the study were also considered; each panellist signed the consent form. Table 2 indicates the specific personal attributes that were assessed by the screening test. While all other attributes listed in Table 2 were easily observable, attribute 4 which indicates the ability of the panellists to detect and describe the sensorial properties of fabrics was declared by the panellists themselves. They were also requested to evaluate fabrics of known textures and comfort appreciation levels which did not form part of the assessment intended for this study. It is worth noting however, that there are testing instruments recently developed on the sensory research market for testing the same ability which would have been more objective however, the research team did not have access to such instruments at the time the study was conducted.

The sensory evaluation procedure

The panel members participated in a one-morning training session on the evaluation technique where they also signed the consent forms. Each of the 18 samples was evaluated 24 times, although a sample would be evaluated by different panellists each time. Each panel member was asked to wear each sleeve *(a sample of a given fibre diameter)* only once on their right forearm for a single sample test at one time, to obtain an estimate of prickle (Kennins 1992). Stroking the sleeve lightly on the forearm, they recorded their prickle rating as perceived on each sleeve before changing to the next one. The sensory attributes employed in the testing are defined in Table 3.

Each member evaluated five samples in the first session and four in the second session of each of the two days of the trials (i.e. 18 samples in all). Each sleeve presented in a cubicle within the room with wooden divisions to prevent visibility by the next panellist and communication between each other. The ranked was done on the seven-point hedonic scale by each panellist, where "1" represented the positive extreme, "7" the negative extreme and "4" a neutral response (Table 3). These were displayed on similar plates and labelled with a unique numbering system, which did not reveal the properties of the sample or any differences between samples. For the entire test, the same room was used to avoid differences in lighting and temperature. The hedonic scale shown in Table 3 shows the

TABLE 3: HEDONIC RATING SCALE USED FOR THE TACTILE ATTRIBUTES TESTED IN SENSORY EVALUATION

Attribute Rating	Tactile Attribute 1	Tactile Attribute 2	Tactile Attribute 3	Tactile Attribute 4
	Hand	*Prickle*	*Preference*	*Appeal*
1	Extremely soft	No prickle at all	Very highly preferred	Extremely appealing
2	Soft	Very slight prickle	Highly preferred	Highly appealing
3	Slightly soft	Slight prickle	Preferred	Appealing
4	Moderately soft/harsh	Moderate prickle	Moderately preferred	Moderately appealing
5	Slightly harsh	Strong prickle	Slightly preferred	Slightly appealing
6	Harsh	Very strong prickle	Very slightly preferred	Very slightly appealing
7	Extremely harsh	Extremely strong prickle	Least preferred	Least appealing

TABLE 4: CHARACTERISTICS OF SENSORY EVALUATION SAMPLES AND PRICKLE RESULTS

Samples	Mean Fibre Diameter (µm)	Comfort Factor (%)	Number of panellists and extent of prickle reported			Prickle score (n=24)*	Average weighted prickle score (%)
			Moderate Prickle	*Strong & Very Strong Prickle*	*Extremely Strong Prickle*	*Total*	
1	16.9	99.4	0	1	0	1	4.1
2	17.3	98.9	3	2	1	6	25
3	18.1	98.1	2	1	1	4	16.6
4	18.2	98.9	1	2	0	3	12.5
5	18.2	99.6	1	0	0	1	4.1
6	19.1	98.6	1	1	0	2	8.3
7	19.3	98.1	1	2	0	3	12.5
8	19.9	98.1	1	3	1	5	20.8
9	20.1	97.9	2	3	1	6	25
10	20.3	97.3	3	1	0	4	16.6
11	20.5	97.1	3	1	1	5	20.8
12	20.5	97.1	2	2	1	5	20.8
13	20.7	96.9	5	4	2	11	45.8
14	21.1	95.2	8	7	2	17	70.8
15	21.5	93.2	4	9	7	20	83.3
16	21.6	94.5	9	6	3	18	75
17	21.7	95.5	4	5	4	13	54.2
18	22.2	94.4	3	12	4	19	79.1

seven ratings for each attribute that was assessed by the consumer panellists in the sensory evaluation process. Each panellist evaluated each sample for the tactile attributes indicated in Table 3 namely hand, prickle, preference and appeal. For purposes of this study and because of the proven relationship with MFD and CF, prickle was the main attribute of assessment while the other three were more subjective even though they contributed to decision making for purchasing.

PRICKLE RESULTS AND DISCUSSIONS

The mean fibre diameter (MFD) correlated with the calculated CF as expected, and the prickle scores were also in agreement with the two quality properties on the general front. There were exceptions that are believed to have been a result of manual processing of the greasy wool samples during scouring and spinning. Table 4 shows the samples with their MFD and CF values as well as the prickle score acquired from the sensory evaluation.

The results of the subjective prickle

assessment are in line with previous research findings that prickle is primarily caused by the presence of a critical number of coarse fibres i.e. coarser than 30 µm (Naylor and Phillips, 1997 and Naylor, 2000). In addition, the length of the protruding fibre also plays a major role in evoking the prickle sensation (Asad *et al*. 2015; Vetharaniam *et al*. 2018).

*The Prickle score: *this represents the number of panellists who reported a sense of prickle for a particular sleeve sample (out of total number of 24 panellists).*

In Figure 4, the prickle score is plotted against the MFD, and as it could be expected, there is a fair correlation between the two, since the percentage of coarse fibres (>30 µm) and CF are related to the MFD (Naylor 1992; Botha 2004; Naebe *et al*. 2013). Nevertheless, the correlation is significantly lower ($R^2 \approx 0.6744$) than that for the CF, which is as expected since, in addition to MFD, the diameter distribution (SD and CV) plays a role in determining the level of coarse fibre (CE).

In Figure 3, the number of panellists reporting a prickle sensation (response) for a particular sleeve sample has been plotted against the CF of the wool used to produce the sleeve. From this figure, it is apparent that there is a fairly good correlation between the two parameters, a higher CF being associated with the lowest prickle, as assessed by the respondents, which is in line with the findings of other researchers (Naylor 1992; Ramsay *et al*. 2012; Asad *et al*. 2016; Mahar *et al*. 2013; McGregor *et al*. 2015; SGS 2011). It confirms that the calculated CF can be used as a fairly accurate measure of prickle as experimented in practice (CSIRO 1994).

The manual scouring and spinning used in sample preparation, seem to have influenced the prickle results reported by the panellists. For instance, the removal of all impurities including VM from greasy wool manually could not be satisfactorily thorough and were not standardised. The tension of the twist for each sample may not have been the same, nor may the density of the fibres spun together. This

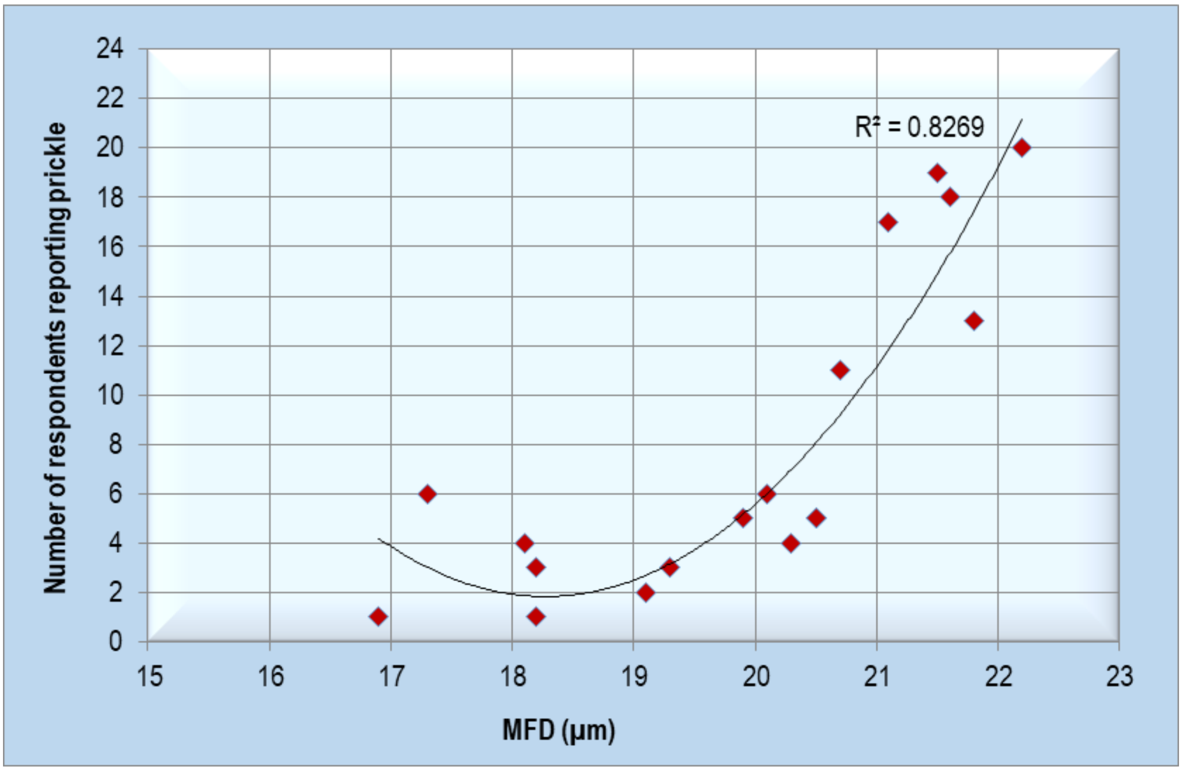

FIGURE 4: PRICKLE SCORE VS MFD

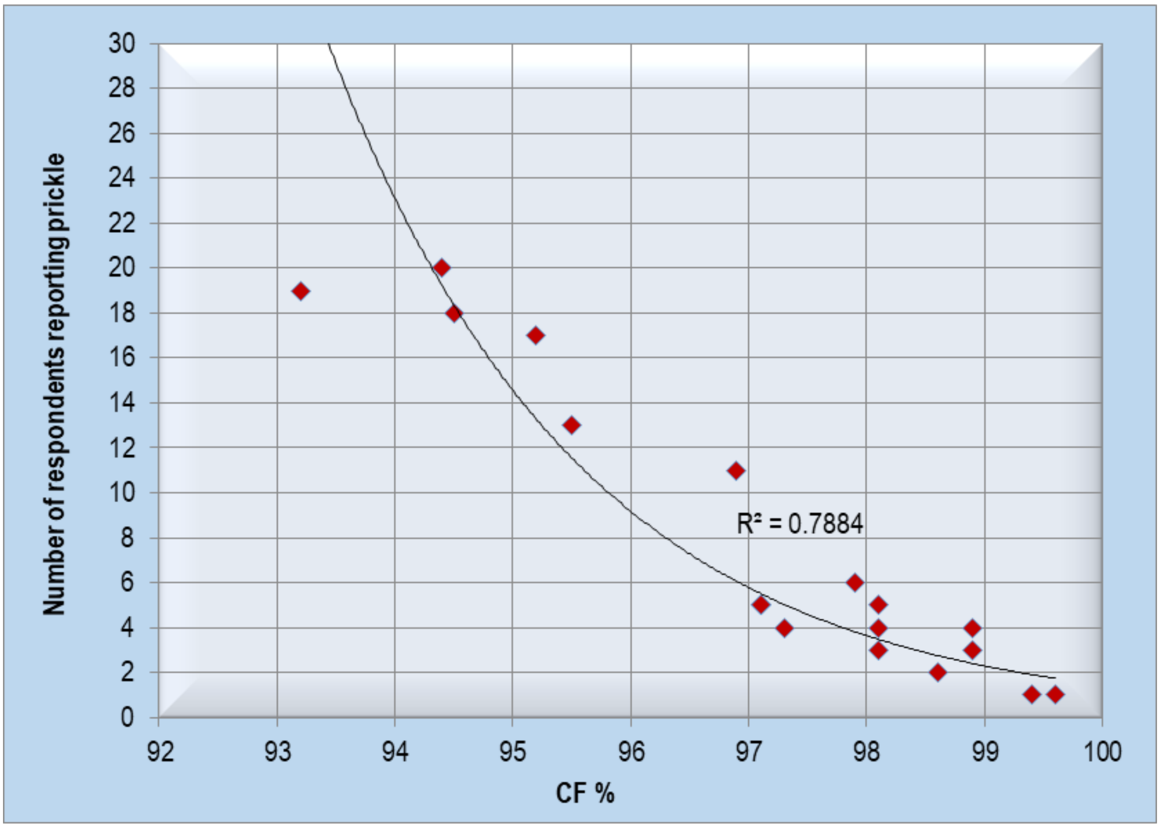

FIGURE 5: NUMBER OF RESPONDENTS EXPERIENCING PRICKLE SENSATION VS COMFORT FACTOR (CF)

was indicated by the differences in the calculated yarn linear density (Tex) shown in Table 1. It was not surprising therefore, when some sleeves/samples knitted from fine wool still registered some prickle. This shortcoming in this section of the results indicates the value of standardised scouring and spinning when similar tests are conducted.

Since the CF is calculated from the MFD, the number of panellists reporting prickle was found to respond, as expected, to the value of CF. The higher the CF value, the less the number of panellists reported prickle on such samples. High values of CF are expected to be an indication of preferred comfort (lack of prickle). In addition to prickle hand, appeal and preference of the participants regarding the wool samples were evaluated through sensory evaluation. Figure 5 shows the results on these attributes, the exceptions were still found where some of the samples recorded comfortable were not preferred by the panellists. This is believed to have been due to the lack of standardisation of the sample preparation processes.

The softness, referred to as hand in Figure 6, appeal and preference indicates a relatively close relationship, though variations can also be noticed. From the results illustrated in Figure 6, samples 15 and 16 were the most preferred, even though the levels of appeal and hand were relatively low. On the other hand, sample 13 was more appealing to the panellists relative to the preference and hand scores. These variations are a result of manual processing of samples by local weavers in Lesotho. It is believed that the removal of impurities from the greasy wool samples was not standard in all samples and, therefore, not uniform. The spinning tension could have contributed to the variations seen in the results. The finest sample had a fibre diameter of 16.9 µm and CF of 99.4 %. The prickle score for this sample shows that 4.1 % of the panellists

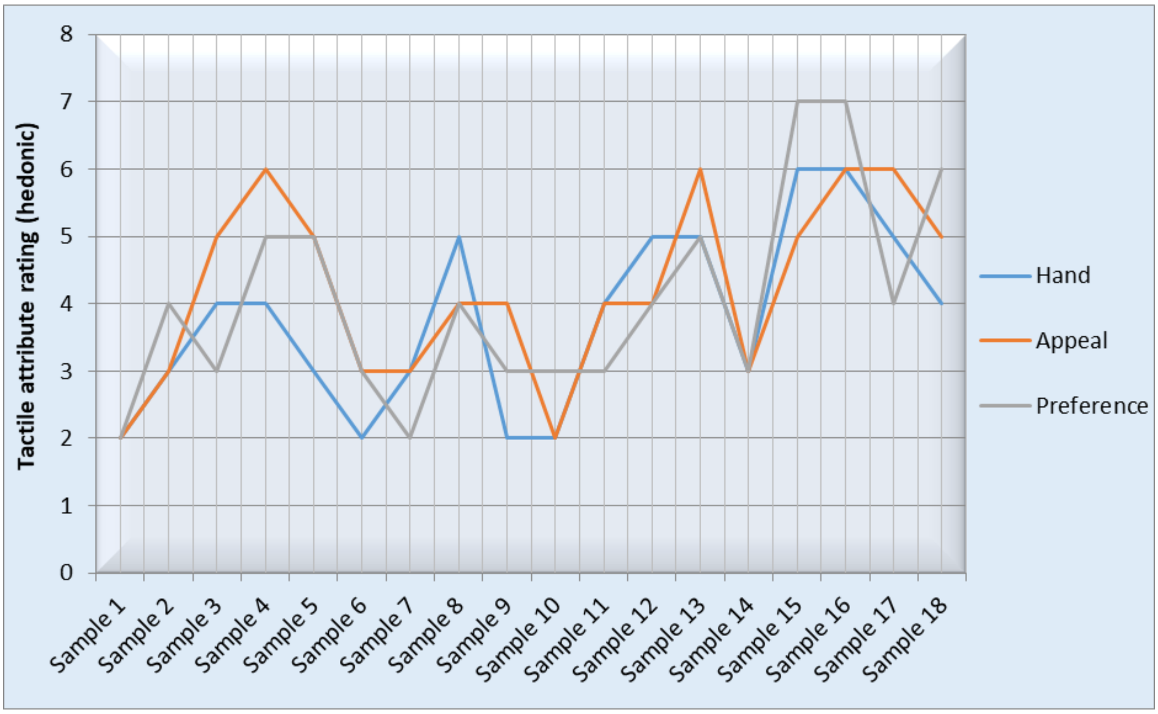

FIGURE 6: OTHER COMFORT AND PREFERENCE ATTRIBUTES ON LESOTHO WOOL

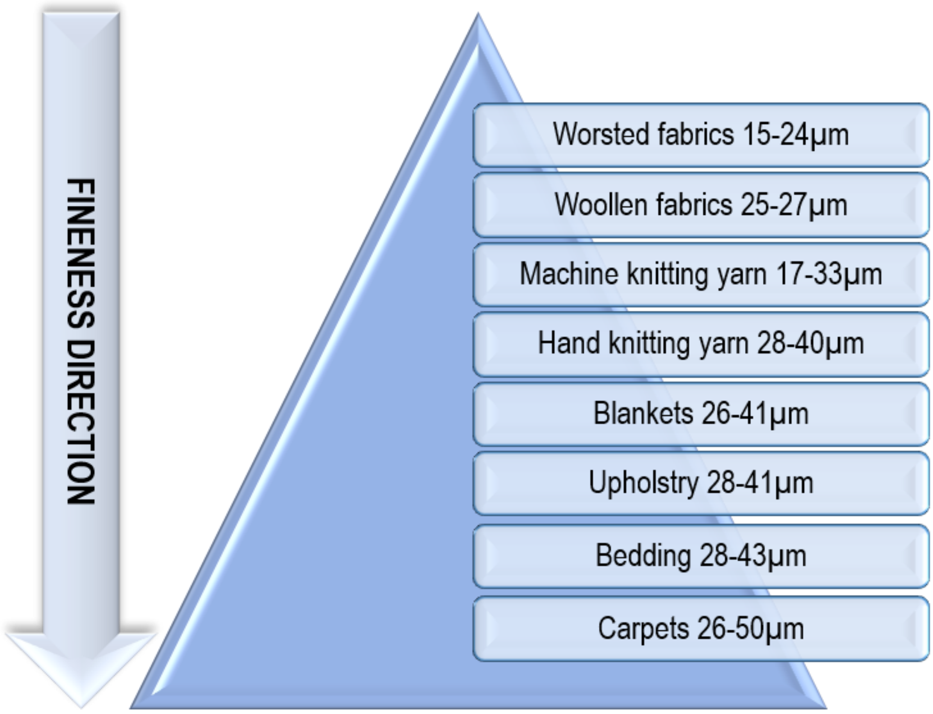

FIGURE 6: WOOL SUITABLE APPLICATION AS DETERMINED BY FINENESS

found sensed prickle evoked by the sleeve made from this sample. The subjective assessment could have also played a role in the variation since the participant's age ranges and gender also varied. This is believed to have a certain influence on the levels of sensitivity of the skin as a sensory organ (Dhand & Aminoff 2015).

Limitations

Wool samples used for this study were taken from one season of shearing so the study is only representative of the different MFD ranges for 2013/2014, as such the results cannot be generalised for the entire country's wool production. Spinning all samples to the same nominal linear density (tex) was difficult using hand spinning (Table 1), this was also evident in the low levels of evenness in the yarn produced. It is also possible that the impurities were not uniformly reduced. These inconsistencies presented problems when investigating the effects of the CF and /or MFD on the subjectively assessed comfort of the knitted sleeves.

CONCLUSIONS AND IMPLICATIONS

The extent to which the panellists perceived the prickle sensation differed notably from one sample to the other based on the different MFD and CF. The responses of the panellists indicate that even though the finer samples (with low MFD) evoke less prickle while coarser samples. However, there were some unexpected responses that led to the conclusion that the processing (scouring and spinning) of the fibres into sleeves was not standardised, which contributed to the level of prickle in some samples.

According to Petrie (1995), the properties of wool determine not only its price but also the products for which it is suitable. Figure 7 shows the broad applications of wool according to fibre diameter. Figure 6 shows that the fibre diameter required for making worsted fabrics is within the fineness range from about 17 µm to 27 µm, representing the range within which Lesotho wool falls. The woollen and worsted processing systems are used to produce clothing fabrics, including garments worn next to the skin. Lesotho wool has yet to be scientifically assessed for suitability in clothing, blankets, upholstery, and other household items.

Processing techniques used in sample preparation contributed to the sensory evaluation results. Since the processing of wool samples was the only factor not held constant, it is believed to have interfered with the results.

RECOMMENDATIONS

Wool product development that is responsive to the existing needs is recommended. The process will help in the exploration of more suitable products that Lesotho wool can be used for since it involves trying out a number of processes and variations of wool with various MFD readings until the best product has been developed and sensory evaluation for acceptability; suitable processing techniques will also be discovered. Further studies on specific factors affecting the MFD is also recommended.

REFERENCES

Allafi, F., Hossain, M.S., Lalung, J., Shaah, M., Salehabadi, A., Ahmad, M.I. & Shadi, A., 2020, ‘Advancements in applications of natural wool fibre. Review’, *Journal of Natural Fibres* 19(2), 497-512.

Asad, R.A., Yu, W., Zheng, Y.H. & He, Y., 2015, ‘Characterisation of prickle tactile discomfort properties of different textile single fibres using an axial fibre-compression-bending analyser (FICBA)’, *Textile Research Journal* 85(5), 512-523.

Baxter, P. & Wear, J., 2022, A profile of New Zealand crossbred wool clip in both greasy and–scoured forms in the 2017-18, 2018-19, and 2019-20 Seasons, *Journal of Natural Fibres* 19(13), 5588-5604.

Bishop, G.H., 1948, ‘The skin as an organ of senses with special reference to the itching sensation’, *Symposium on the skin: Annual meeting of the American academy of* *dermatology and syphilology proceedings*, Chicago, December, 8, 1947.

Botha, A.F., 2005, 'The fibre diameter distribution, particularly the coarse edge, of South African wool, and its effect on textile performance', PhD Thesis, Department of Textile Science, Nelson Mandela Metropolitan University.

Boulais, N. & Misery, L., 2008 'The epidermis: a sensory tissue', *European Journal of Dermatology* 18(2), 119-127.

Civille, G.V. & Dus, C.A., 1990, 'Development of terminology to describe the hand-feel properties', Sensory Spectrum Incorporated. Chatham, New Jersey.

CSIRO, 1994 '*Textile News',* 16, February*, 3*.

Crucianelli, L. & Ehrsson, H.H., 2023, 'The role of the skin in interception: A neglected organ', *Perspectives on Psychological Science* 18(1), 224-238.

Dhand, A. & Aminoff, M.J., 2013, 'The neurology of itch: Review article', *Brain: A Journal of Neurology,* 137, 313-322. doi: 10.1093/brain/awt158.

Downar, J., Crawley, A.P., Mikulis, D.J. & Davis, K.D., 2002, 'A cortical network sensitive to stimulus salience in a neutral behavioral context across multiple sensory modalities', *Journal of Neurophysiology* 87(1), 615-620.

Gengler, I., 2006, 'When people are the instrument: Sensory evaluation methods', *ASQ Statistics Division Newsletter* 27(4).

Frank, E.N., Prieto, A., Castillo, M.F., Seghetti Frondizi, D., Mamani Cato, R.H. & Hick, M.V.H., 2021, 'The prickle effect comes from fabrics made of South American camelid (alpaca and lama) fibres. Mechanical and/or genetic solutions, A review', *European Journal of Applied Sciences*.

Gonzalez, E.B., Sacchero, D.M. & Easdale, M.H., 2020, 'Environmental influence on Merino sheep wool quality through the lens of seasonal variations in fibre diameter', *Journal of Arid Environments* 181, 104248.

Ikoma, A., Steinhoff, M., Yosipovitch, G. & Schmelz, M., 2006, 'The neurobiology of itch', *Nature Reviews Neuroscience* 7, 235-247.

Hu, J., Li, Y., Ding, X. & Hu, J., 2011, 'The mechanics of buckling fibre in relation to fabric -evoked prickliness: A theory model of single fibre prickling human skin', *The Journal of the Textile Institute,* 102(12), 1003-1018.

Hu, X., Chen, Z. & Sun, F., 2023, 'Digitization of fabric comfort: a multidimensional evaluation strategy to human perceptions of sensorial, thermal and acoustic comfort in clothing', *International Journal of Clothing Science and Technology* 35(1), 162-175

Kennins, 1992, 'The cause of prickle and the effect of some fabric construction parameters on prickle sensation', *Wool Technology and Sheep Breed* 40(1), 19-24.

Li, Y., 1998, 'The wool sensory properties and product development', *Textile Asia,* May.

Lim, K.M., 2021, 'Skin epidermis and barrier function', *International journal of molecular sciences* 22(6), 3035.

Mahar, T.J., Wang, H. & Postle, R., 2013, 'A review of fabric tactile properties and their subjective assessment for next-to-skin knitted fabrics', *Journal of the Textile Institute* 104(6), 572-589.

Malau-Aduli, A.E.O. & Deng, A.D.J., 2010, 'Wool comfort factor variation in Australian crossbred sheep', *Journal of Animal Science* 88, 860.

Malengier, B., Vasile, S. & Langenhove, L.V., 2021, 'Determination of comfort indices of fabrics using fabric touch tester (FTT)', *2nd physics and materials science international symposium (PhyMaS 2.0) proceedings,* Shah Alam, Malaysia, January, 27, 2021, pp. 2368 (1).

Maqalika, P.E., 2020, 'Database and guide for Lesotho wool and mohair production and quality', PhD Thesis, Department of Textile Science, Nelson Mandela University, viewed 13 September 2024, from https://www. core.ac.uk.

McGregor, B.A., Stanton, J., Beilby, J., Speijers, J. & Tester, D., 2015, 'The influence of wool fibre diameter, fabric attributes and environmental conditions on wetness sensations of next-to-skin knitwear', *Textile Research Journal* 85(9), 912-928.

Mekbib S.B., Olaleye A.O., Mokhothu M.N., Johane M., Tlali S.B. & Godeto T.W., 2011, 'Assessment of the adaptive capacity of the Machobane farming system to climate change in Lesotho', *African Technology Policy Studies Network*, Nairobi.

Mokhethi, S., 2016, 'Cashing in on Lesotho wool and mohair exports', *Country report:* D*oing business in Africa*.

Naebe, M., Lutz, V., McGregor, B.A., Tester, D. & Wang, X., 2013, 'Predicting comfort properties of knitted fabrics by assessing yarns with the wool comfort meter', *The Journal of the Textile Institute* 104(6), 628-633.

Naylor, G.R.S., Veitch, C.J., Mayfield, R.J. & Kettlewell, R., 1992, 'Fabric evoked prickle', *Textile Research Journal* 62(8), 487-493.

Naylor, G.R.S., 1992, 'The role of coarse fibres in fabric prickle using blended acrylic fibres of different diameters', *Wool Technology and Sheep Breeding*, CSIRO Division of Wool Technology, Geelong Laboratory, Belmont.

Naylor, G.R.S. & Phillips, D.G., 1997, 'Skin comfort of wool fabrics', *International wool and textile organisation technology and standards committee meeting report*, Boston, USA, December 1997.

Naylor, G.R.S., 2000, 'Adding value to the top: Measurement of diameter characteristics of fibre ends as a tool for improved prediction of fabric skin comfort', *International wool textile organisation; technology and standards committee meeting*, Christ Church, Australia, 2000.

Naylor, G.R.S., 2010, 'Fabric-evoked prickle in worsted spun single jersey fabric, Part 4: Extension from wool to Optim™fine fibre', *Textile Research Journal* 80, 537-547.

Petrie, O.J., 1995, 'Harvesting of textile animal fibres', *FAO Agricultural Services Bulletin* 122.

Ramsay, D.J., Fox, D.B. & Naylor, G.R.S., 2012, 'An instrument for assessing fabric prickle propensity', *Textile Research Journal* 82(5), 513-520.

SGS, 2011, 'Laboratory fleece measurements', *Wool Testing Services Info Bulletin* 5.2b, viewed 13 September 2024, from https://www.sgs.com/agriculture.

Vetharaniam, I., Tandon, S., Plowman, J.E. & Harland, D.P., 2018, 'Investigating mathematical methods for high-throughput prediction of the critical buckling load of non-uniform wool fibers', *Textile Research Journal* 88(9), 1002-1012.

Wang, G.H. & Zhao, T., 2007, 'Effect of rating scales and test parts of body on the evaluation results of fabric-evoked prickle', *Wool Textile Journal* 4.

Yue, L., Lu, Z., Guo, T., Liu, J., Yang, B. & Yuan, C., 2023, Proteome analysis of alpine merino sheep skin reveals new insights into the mechanisms involved in regulating wool fiber diameter, *International Journal of Molecular Sciences* 24(20), 1227.