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Determination of prickle effect detection thresholds in Llama fiber knitted fabrics

Summary

The study delves into determining the detection thresholds for the prickle effect in Llama fiber knitted fabrics, crucial for fabric acceptability assessment, by consumers of garments made from natural fibers. Employing standard evaluation methods involving moistened skin and perception scoring, coupled with the identification of objectionable (coarse) fiber content as a pivotal variable, the research using 41-invited panelist elucidates the intricate interplay between fiber characteristics (diameter) and prickle perception. Despite efforts to mitigate hairiness through finishing processes, the study unveils the nuanced impact of fiber protrusion on the prickle effect, necessitating a comprehensive evaluation approach. Through pairwise comparisons and perception scales, the study unveils strong associations between prickle perception and expression degrees, reaffirming panelists' sensitivity in detecting subtle variations. Statistical analyses underscore significant differences in coarse fiber content and diameter between paired samples, further corroborating panelists' discernment. It can be clearly concluded, from this analysis, the prickle effect detection thresholds in llama fiber fabrics range from 2.36 to 2.42% in coarse fiber differences and from 0.11 to 1.63 microns in fiber diameter difference, in the 95% of the tested cases or more probability. In conclusion, the study delineates critical thresholds (2.36%) for prickle detection in Llama fiber fabrics, offering invaluable insights for fabric evaluation and refinement processes, and emphasizing the heightened sensitivity of finished fabric samples in prickle perception.

Keywords: South American camelids fibre, itches level, knitted garments, user skin perception

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Introduction

A recent study concludes that increasing the use of animal-origin textile fibers can reduce textile pollution and promote sustainability in fashion, offering specific actions to boost their market competitiveness (Frank et al, 2023). One such action would be to reduce the content of objectionable fibers in South American camelid fiber, for which a minimum threshold of prickle effect must be established at which the prickle effect is perceived.[1]

The prickle effect upon hand finger pressure determines the acceptability or rejection by the potential user in Llama fiber fabrics (Frank et al., 2012).[2] However, the most commonly used standard evaluation of the prickle effect is conducted at the forearm level with moistened skin, adding a perception score to determine the difference between pairs of fabric samples used.[3] On the other hand, it is know that the variable that best explains differences in the prickle effect is the objectionable fiber or coarse fibre content (Frank et al., 2007), and its significant value was determined for unfinished knit fabrics at 3.2%.[2] Subsequent work with finished knit fabrics (reduced pilosity by burning) placed these values much lower (anecdotal information).

However, fabrics made with Alpaca-Llama fiber yarns exhibit significant pilosity (hairiness) due to the centrifugal force effect of the continuous spinning machine, which ejects the thicker and stiffer fibers outward, a phenomenon reduced by finishing,[1] but this finishing process shortens the protruding fibers (to around 2 mm or even less) and increases the prickle effect due to the reduced or absent bending of the all shortened protruding fibers or specially the coarse end-evoked fibers.[2,4]

The objective of this study was to determine the prickle effect at the forearm level by comparing the "prickles-does not prickle" effect of paired samples and assigning perception degrees within each level of prickle effect, and to examine their relationships with differences in coarse fiber content and mean fiber diameter.

Materials and methods

Eighteen (18) samples of knitted fabric, each measuring 10x10 cm with an average yarn count of 8 tex, were used. These fabrics were machine-knitted with a domestic machine at a tightness factor of 13 tex½/cm. Each fabric was strongly humidified (>85%), frozen under a freezing microtome, and shaved the surface to remove protruding hairiness, simulating the flame finishing process (singeing), and clearly giving the appearance of a non-hairy fabric. The yarn originated from 9 fleeces of Argentine Llamas of different fleece types but of the same age, with half of fleece being dehaired and the other half not (Frank et al., 2007).

Forty-one (41) voluntary panelists of different genders, ages, and social statuses participated. A knitted fabric made from dehaired Vicuña fiber with a content of <0.2% coarse fibers was used as a reference or training fabric on one forearm, while the other forearm was moistened, and the fabrics to be evaluated were placed in pairs, one after the other, and then repeated in reverse order. The panelist's visual observation was prevented by covering the fabrics with a patch fabric and identifying them with a non-consecutive number. Out of the 1475 possible comparisons, 1190 (80.7%) were considered, discarding the rest due to various reasons, including false ties and/or extreme evaluations (outliers).

The survey, to which the panelists were subjected, included pairwise comparisons: "itches more than" (3), "itches less than" (1), and "no perceived difference or tie" (2) according to Frank et al.[2] Additionally, within each pair of compared samples, panelists

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were asked to express a prickliness perception scale as follows: 0: imperceptible difference; 1: barely perceptible difference; 2: somewhat perceptible difference; 3: intensely perceptible difference; 4: excessively perceptible difference.[4] First of all, the scale was succinctly explained to each panelists, allowing them a preliminary trial with training fabric sample.

The comparison between pairs with the prickle effect score was tested using the ANOVA non-parametric Friedman test. Degrees of perception within each prickle effect level were compared using a contingency table tested by Pearson's chi-squared and Maximum Likelihood (G2) tests. A Z score was determined for each table cell and its probability interpreted, considering the sign (+ or -). With this meaning: a negative Z score indicates that exceeding the observed frequency is unlikely (with a p-value); a positive Z score indicates that exceeding the observed frequency is very likely (with a p-value).

Objectable or coarse fiber contents (CoDiff) and fiber diameter (DMDiff) were compared using paired data T-tests, with a variance reduction test concerning independent comparisons. The final differences or thresholds (in CoDiff and DMDiff) are expressed as confidence intervals (CI) for $p \leq 0.05$. Statistical analyses were performed using R language under the InfoStat program platform.[5]

Results and discussion

The Pearson's chi-squared test (*28,209.34*, $p<0.001$) and MV-G2 test (*35,404.41*, $p<0.001$), with a Pearson's Contingency Coefficient of 0.71, demonstrate a strong association between prickle effect (prick/does not prick, dislike/like) and the degrees in which it is expressed. Prickle effect 1 is associated 100% ($p<0.001$) with Degree 0, while at the other extreme (3), it is distributed between Degree 1 and 2 (38% and 46%, respectively, $p<0.001$), which aligns with the tie (2) (Table 1). Very few pairwise sample comparisons resulted in a Grade of Perception of excessively perceptible (4), only 0.02%, and from degrees 3 of prickliness or 'itches more than'. It is important to clarify here, however, that the very high or very low perception values were specifically tested among the panelists individually and, when they were rare in frequency (considering there were 41 panelists), those data were discarded from the analysis in the contingency tables. It is important to emphasize for clearer comprehension, that the underlined frequency values indicate a negative Z score. For example, Prickle 2 or tie indicates that it is highly unlikely ($p<0.001$) for the observed frequency (10%) to be exceeded at any time. Similarly, in 2; 3, this low occurrence frequency of 3% is unlikely to be exceeded in 99.999% of the times a similar survey is conducted with these same samples.

In the comparisons between Degrees using the Friedman test, 77% were significant at least at $p<0.05$, with similar results in the paired sample comparisons (both between CoDiff and DMDiff). Nevertheless, to evaluate and detect possible ties, non-significant comparisons ($p>0.05$) were also included in the contingency table (Table 1).

Table 1 Contingency table between perception degrees within prickle groups (prick/does not prick, *dislike/like*) in pairwise prickle expression comparisons

Prickliness	Perception grades				
	0	1	2	3	4
1	1.00***	0.00***	0.00***	0.00***	0.00***
2	0.10***	0.60***	0.27ns	0.03***	0.00***
3	0.00***	0.38***	0.46***	0.15***	0.01***

References: underlined values correspond to a negative Z score; non-underlined values correspond to a positive Z score; ***$p \leq 0.001$; ns: non sig. ($p \geq 0.05$).

The differences between pairs of samples when establishing the percentage of coarse fibers (CoDiff), with the combination of perception grades that were significant in pairwise comparisons ($p<0.05$), yield a mean difference of at least 2.36% (CI: 2.31 – 2.42%, $p<0.05$). The differences in diameters between significant samples (DMDiff) establish a mean difference of at least 0.87 µm (CI: 0.11-1.63 µm, $p<0.05$). This means that at least between a 2.31 to 2.42% difference in coarse fibers is the difference was perceived by the panelists, indicating that this is the threshold from zero that the panelists can infer as the minimum percentage of coarse fibers expressed in weight/weight. The same interpretation can be made regarding the micron differences in mean diameter between the compared samples.

For a clearer interpretation of the variables obtained by the invited panelists, the results were graphed in Figure 1. The mean CoDiff values are lower than the value of 3.2%, and the mean DMDiff, however, is similar to the 1.01 µm determined by touch with the hand and without finishing with similar Llama samples, in a previous work by the Group.[2] Regardless of the differences due to the treatment of the tested fabric (finished *vs* unfinished), this difference in sensitivity to detecting fabric prickle also indicates what was observed previously, namely, that the glabrous skin on the front of the hand and fingers has less touch sensitivity than the skin on the inner forearm, due to its greater thickness.[6]

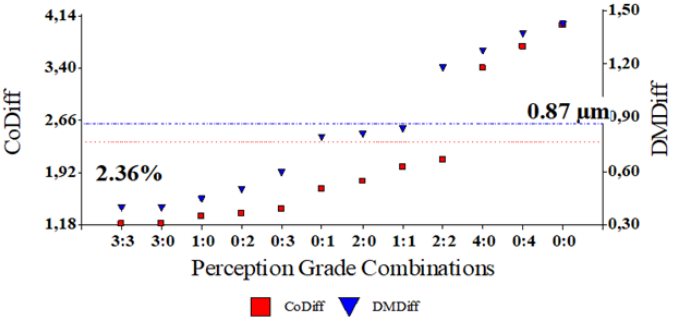

Figure 1 Differences between pairs of samples (threshold; 2.36%) when establishing the percentage of coarse fibers (CoDiff) and the difference in fibre diameters (DMDiff) (threshold: 0.87 µm) with the combination of perception degrees that resulted significant in pairwise comparisons.

The paired data T-tests reduced the variance (0.59) compared to if the comparisons had been independent, justifying the use of the paired test.[5] It is important to emphasize this because in some cases, the pairs of samples did not follow the logic of the design, which established comparing dehaired vs. non-dehaired samples from the same fleece. These difference means fall within the interval (2.0-3.4%) of the 7th optimal pass obtained by the dehairing machine in previous studies.[7]

Conclusion

It can be clearly concluded that Prickle Effect Detection Thresholds in Llama Fiber Fabrics they range from 2.36 to 2.42% in coarse fiber differences and from 0.11 to 1.63 microns in fiber diameter.

It is concluded also, that the perception grades of a 5-level scale allow differentiation of the prickle effect of fabric samples made of Llama fibers on the forearm, with an average level of coarse fibers 1% lower (2.36%) compared to the manual perception of unfinished samples (3.2%).

The sample with finishing placed on the forearm is more sensitive to the degree of prickle than the tactile perception when comparing dehaired and non-dehaired samples randomly, using a vicuña fabric sample, which ensures no prickle, as a reference sample.

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Conflicts of interest

Authors declare that there is no conflict of interest.

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