Comfort Analysis on Merino Wool/Polyester Blended Fabrics

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Abstract:

Merino wool is well-known for outstanding softness, moisture transport, and thermal management, while polyester introduces strength and fast drying. This paper's work examines the comfort properties of Merino wool/polyester blended fabrics with different blend ratios **(50:50, 60:40, and 70:30).** Activated charcoal treatment was applied to promote odour resistance and moisture transport. Various tests like air permeability, wicking, pilling, and thermal conductivity were conducted to determine the best composition for durability and functionality. The outcomes show that 70:30 has the highest resistance to durability and moisture-wicking property, but the highest breathability is in the 50:50.

Keywords: Comfort, Moisture Management, Thermal Regulation, Merino Wool, Polyester, Odor Resistance

1. Introduction

Comfort of textile is typically assessed by moisture management, breathability, and thermal regulation. The objective of this research is to evaluate the comfort properties of Merino wool/polyester blend yarns and determine the influence of activated charcoal treatment. The yarns were knitted at 50:50, 60:40, and 70:30 blends, activated charcoal treated, and evaluated for comfort-associated properties. These examinations reveal how composition affects performance, as it relates to activewear where breathability, moisture management, and wear life are critical considerations.

The primary objectives of this study are:

• To investigate the impact of Merino wool/polyester blend on comfort properties.

• To investigate the impact of activated charcoal treatment on odour resistance.

• To determine the optimum blend ratio to be utilized for activewear and casual wear fabrics.

2. Materials and Methods

2.1 Fabric Preparation

Merino wool and polyester were mixed in three various ratios: 50:50, 60:40, and 70:30. Fabrics were created through the knitting method to keep flexibility, softness, and breathability.

2.2 Activated Charcoal Treatment

Activated charcoal treatment was implemented through the dip-and-dry process. This increases odor resistance through the absorption of sweat and bacteria that emit odors. Steps involved:

1**. Bath Preparation** – Activated charcoal powder was mixed with a stabilizer and pH regulators for effective adhesion on fibres.

2. **Dipping Process** – Fabric samples were immersed in the prepared bath at 40–50°C for 30–40 minutes.

3. Drying Process – The treated fabrics were dried at 80–100°C to fix the treatment effectively.

2.3 Testing Methods

For evaluating comfort properties, the following tests were carried out:

• Wicking Test: Tested moisture transport ability of the fabric.

• Pilling Test: Tested surface appearance and fuzz formation.

• Bursting Strength Test: Tested strength of the fabric against pressure.

• Air Permeability Test: Tested ventilation and breathability.

• Moisture Management Testing (MMT): Tested moisture transport and absorption.

• Thermal Conductivity Test: Tested insulation performance.

2.3.1 Wicking Test

• Tests the capacity of the fabric to transfer moisture from the skin.

• Conducted with vertical and horizontal wicking tests.

• Smaller wicking times indicate faster movement of moisture, which improves comfort during physical activity.

2.3.2 Pilling Test

• Evaluates surface appearance and resistance to pilling.

• Conducted on a Martindale Abrasion Tester.

• Increased pilling grades indicate better durability and resistance to surface fuzzing.

2.3.3 Bursting Strength Test

• Examines pressure required to burst the fabric.

• Conducted by an air pressure tester in accordance with ASTM D3786.

• Higher bursting strength values indicate better durability and flexibility.

2.3.4 Air Permeability Test

• Determines breathability and ventilation properties of the fabric.

• Conducted by an air permeability tester as per ASTM D737.

• Higher values of permeability indicate better airflow and comfort.

2.3.5 Moisture Management Testing (MMT)

• Examines moisture pickup, retention, and transport in and through fabric layers.

• Tests one-way transport index (OWTI) to establish how effectively moisture moves from the inner to the outer surface.

• Essential for sport wear and functional clothing.

2.3.6 Thermal Conductivity Test

• Tests insulation characteristics of the fabric.

• Conducts using a guarded hot plate method.

• Low thermal conductivity values indicate better insulation and heat retention.

3. Results and Discussion

3.1 Moisture Wicking Behavior

Moisture-wicking ability is extremely crucial in activewear. The 70:30 blend showed the fastest moisture transport **(4.13 min in course direction),** while the 50:50 blend showed the worst wicking capacity **(9.16 min).** The 60:40 blend provided balanced moisture-wicking ability and hence appropriate for general-purpose activewear.

3.2 Pilling Resistance

The 60:40 and 70:30 mixtures had optimum resistance to pilling of fabrics (Grade 4), while the 50:50 mixture showed medium resistance (Grade 3). A higher polyester ratio provided durability and reduced fuzzing of fibres on repetitive use.

3.3 Bursting Strength

Fabric durability is essential for long-term use, especially for high-performance clothing. The bursting strength was:

•70:30 mixture: **9.73 kg/cm²** (optimum)

•60:40 mixture: **7.06 kg/cm²**

•50:50 ratio**: 6.48 kg/cm²** Having a higher percentage of Merino wool resulted in higher durability and strength.

3.4 Air Permeability

Air permeability is used to define ventilation and breathability. The highest air permeability **(155.20 cm³/sec)** was of the 50:50 ratio, and therefore it is best to use in hot climates. The least permeability **(109.80 cm³/sec)** was with the 70:30 ratio, which is therefore best suited for insulation.

3.5 Moisture Management

The moisture management testing revealed that:

•The 60:40 ratio **(4%)** showed the highest absorption capacity **(1.331%),** hence the most suitable for sweat absorption.

•The 70:30 ratio **(4%)** increased moisture transport after activated charcoal treatment, reducing sweat accumulation.

•The 50:50 ratio provided air circulation and absorption balance, making it general.

3.6 Thermal Conductivity

Thermal conductivity shows how well a fabric can hold heat. The findings show that:

•70:30 blend provided maximum insulation **(0.038–0.048 W/m·K**) and was hence the most suitable for cold climates.

•50:50 blend provided higher breathability but lower insulation (**0.045 W/m·K),** which was ideal for warm weather.

4. Comparative Analysis with Other Blended Textiles

•Comparison with cotton-polyester and wool-cotton blends.

•Analysis of variation in performance on odor resistance, thermal insulation, and strength.

•Cost-effectiveness in manufacturing and consumer acceptance analysis.

• Effect of Fabric Structure on Comfort: How different knit and weave structures influence durability and breathability.

• Influence of Fiber Proportion on Fabric Performance: Comparison of how various Merino wool and polyester blends perform compared to other fiber blends.

- Shrinkage, Wrinkle Resistance, and Durability: Washability and care comparison of blended fibers.
- Efficiency of Thermal Regulation: How the blended fibers handle body heat under different climatic conditions.
- User Experience and Wear Trials: Questionnaires and outdoor trials to evaluate customer satisfaction.

5. Applications in the Textile Industry

- Applications in sportswear, outdoor wear, and medical textiles.
- Adjustment in different environments and climate.
- Commercial feasibility and market potential for Merino wool/polyester blends.
- Sportswear and Activewear: Moisture wicking, odor resistance, and stretch recovery.
- Outdoor and Adventure Wear: Thermal insulation, lightweighting, and sun protection.
- Medical and Healthcare Textiles: Antimicrobial benefit, hypoallergenic, and moisture management.
- Fashion and Casual Wear: Softness, wrinkle resistance, and eco-friendly textile innovation.
- Workwear and Industrial Textiles: Flame resistance, durability, and resistance to extreme conditions.
- Military and Tactical Uses: Camouflage advantages, moisture management, and durability in harsh environments.

6. Sustainability and Environmental Impact

- Biodegradability and environmental friendliness of Merino wool.
- Recycling and life-cycle analysis of blended fabrics.
- Effect of polyester on microplastic pollution and potential sustainable alternatives.

6.1 Sportswear and Activewear

- Moisture-Wicking Performance: Ideal for sportspersons as it can absorb and dry sweat well.
- Odor Resistance: Activated charcoal processing reduces bacterial activity, providing freshness to clothing.
- Stretch and Recovery: Resists rigidity and maintains flexibility in high-performance gear.

6.2 Outdoor and Adventure Wear

- Thermal Insulation: Insulates without compromising breathability in trekking and winter wear.
- Lightweight and Packable: Wool-polyester blends are lightweight yet very efficient in body heat regulation.
- UV Protection: Naturally absorbs UV rays and is therefore most suitable for extensive sun exposure.

6.3 Medical and Healthcare Textiles

- Antimicrobial Properties: Inhibits infection in hospital wear and bed linen.
- Hypoallergenic Nature: Soft and non-irritating on the skin and therefore most suitable for sensitive skin.
- Moisture Management: Ideal for dressings and bandages for wounds due to high absorbency.

6.4 Fashion and Casual Wear

- Soothing and Soft Feel: Everyday wear, with luxurious feel.
- Anti-Wrinkle: Polyester makes garments more durable, less ironing required.
- Sustainable Fashion: Biodegradable wool and recycled polyester help in green apparel.

6.5 Workwear and Industrial Textiles

- Fire Resistance: Wool has a natural fire-resistance property, hence perfect for workwear safety.

• Resistance and Durability: Polyester contributes to strength, extending garment lifespan in industries.

• Climate Flexibility: Suited for hot and cold environments, ensuring round-the-year comfort.

6.6 Military and Tactical Applications

• Camouflage and Stealth: Wool-polyester blends are silent and provide thermal camouflage.

• Moisture and Odor Control: Allows for hygiene on long deployments.

• Durability in Hostile Environments: Wear-resistant, ideal for combat and tactical gear.

7. Future Research and Recommendations

• Enhancing durability through new treatments.

• Examining bio-based alternatives to polyester.

• Studying long-term wear comfort and consumer acceptance.

• Advanced odor-resistant treatments for improved performance

•Smart Textile Integration: Testing of temperature-control or moisture-detecting fibers.

•Natural Dyeing Processes: Studying eco-friendly and non-toxic dyeing processes.

•Developing Multi-Functional Fabrics: Combining multiple properties such as UV protection, water resistance, and anti-microbial finishes.

•Extreme Condition Performance Testing: Testing fabric survivability in high-altitude, cold, and humid environments.

•Hybrid Combinations of Fibers: Investigating other natural and synthetic combinations for enhanced functionality.

•Nano-Technology Applications: Addition of nanoparticles to create performance features like self-cleaning and stain resistance.

8**. Sustainability and Environmental Impact**

•Merino wool biodegradability and eco-friendliness.

•Recycling and life-cycle analysis of blended fibers.

•Environmental impact of polyester on microplastic pollution and possible sustainable alternatives.

•Water and Energy Consumption: Quantifying resource usage in production.

•Ethical Sourcing of Wool: Cruelty-free and sustainable agricultural practices.

•Recycled Polyester Alternatives: Quantifying the impact of rPET and other sustainable fibers.

•Carbon Footprint Analysis: Emissions quantification and reduction plans.

•Circular Economy in Textiles: Promoting reuse and closed-loop production systems.

9. Conclusion

The study discovers that different proportions of Merino wool/polyester mix produce unique comfort characteristics:

• The 70:30 proportion is ideally suited for durability, insulation, and moisture-wicking performance and is therefore ideally adapted for colder conditions and vigorous exercises.

• The 50:50 proportion is best in terms of breathability and is therefore better adapted to hot-weather applications.

- The 60:40 blend has balanced performance and is ideal for multi-season wear.

Activated charcoal treatment significantly improved moisture management and odor resistance and thus the fabrics are ideally suited for sportswear and casual wear. Future research may focus on further developing the treatments towards enhanced durability and sustainability.

References

1. Troynikov, O., & Wardiningsih, W. (2022). Moisture Management Properties of Wool/Polyester Blended Fabrics.
2. McQueen, R. H., & Vaezafshar, S. (2021). Odor in Textiles: A Review of Evaluation Methods and Control Technologies.
3. Fowler, J. F. Jr., & Lorenz, D. (2020). Effect of Merino Wool on Skin Comfort and Quality of Life.
4. Madeley, T., & Postler, R. (2019). Physical Properties and Processing of Fine Merino Lamb's Wool.
5. Nahar, K. (2021). A Review on Anti-Odor Finishing of Textiles.
6. Troynikov, O., & Wardiningsih, W. (2022). Moisture Management Properties of Wool/Polyester Blended Fabrics.
7. McQueen, R. H., & Vaezafshar, S. (2021). Odor in Textiles: A Review of Evaluation Methods and Control Technologies.
8. Fowler, J. F. Jr., & Lorenz, D. (2020). Effect of Merino Wool on Skin Comfort and Quality of Life.
9. Madeley, T., & Postler, R. (2019). Physical Properties and Processing of Fine Merino Lamb's Wool.
10. Nahar, K. (2021). A Review on Anti-Odor Finishing of Textiles.
11. Reis, P. J. (2019). Variations inStrength of Wool Fibres.
12. Greeff, J. C., & Schlink, A. C. (2018). The Inheritance of Felting in Merino Wool.
13. Palmer, R. C. (2017). Some Properties of Wool from Copper Starved Merino Sheep.
14. Iglesias Pastrana, C., & González, F. J. N. (2020). A Comparative Study Between Angora Rabbit Hair and Merino Wool.
15. Klemen, D., et al. (2021). Antimicrobial Wool-Polyester Blends Created by Silver Particles Embedded in a Silica Matrix.
16. Abdul-Bari, M. M., et al. (2022). Effect of Charcoal Particles on Thermo-Physiological Comfort Properties of Woven Fabrics.
17. Nolan, E., et al. (2020). Valuing Quality Attributes of Australian Merino Wool.
18. Wiedemann, S. G., et al. (2021). Reducing Environmental Impacts from Garments Using Merino Wool.
19. Marti, M., et al. (2018). Thermal Analysis of Merino Wool Fibres without Internal Lipids.
20. Nahar, K. (2019). A Review on Anti-Odor Finishing of Textiles, Application Methods, and Commercialization.