JTE HCMUTE
ISSN: 2615-9740

JOURNAL OF TECHNICAL EDUCATION SCIENCE
Ho Chi Minh City University of Technology and Education
Website: https://jte.edu.vn
Email: jte@hcmute.edu.vn

An Investigation into Moisture Content of Textile Fabrics: Effects of Blending Ratio, Drying Temperature, Curing Time, Dyes, Detergents, and Softeners

Tuan Anh Nguyen[1*], Ngoc Phuong Luong Thi[1], Anh Tuyet Tran Thi[2]
[1]*Ho Chi Minh City University of Technology and Education, Vietnam*
[2]*Hansol Vina Co. Ltd, Vietnam*

[*]Corresponding author. *Email: nta@hcmute.edu.vn*

ARTICLE INFO

Received:	11/12/2024
Revised:	03/01/2025
Accepted:	22/01/2025
Published:	28/05/2025

KEYWORDS

Moisture content;
Textile fabric;
Drying temperature;
Curing time;
Chemical agent.

ABSTRACT

The moisture content of textile fabrics plays a critical role in determining the quality and performance of garments, directly affecting their durability, comfort, and overall suitability for different end uses. Understanding how moisture content varies across textile types is essential for both manufacturers and consumers, as it impacts wearability, maintenance, and product longevity. This study develops into the primary factors that influence moisture content in a variety of fabrics, including the origin of the material, weave structure, environmental temperature, drying duration, and the effects of chemical agents like detergents and fabric softeners. Through the controlled experiments, the authors assessed the variables influence moisture content under diverse conditions. The results underscore the importance of fabric composition, with natural fibers like cotton exhibiting higher moisture content compared to synthetic counterparts. Temperature and humidity also play a significant role, as do variations in drying time. Additionally, chemical treatments, particularly the use of detergents and softeners, were found to alter the moisture levels, with noticeable differences depending on the type of fabric treated. These findings offer valuable insights for the textile industry, presenting strategies to optimize moisture content during production and processing. Accordingly, manufacturers can enhance garment quality while promoting sustainable resource utilization, thereby benefiting both businesses and consumers.

Doi: https://doi.org/10.54644/jte.2025.1742

1. Introduction

The moisture content of textile fabrics is a critical factor influencing both the production process and the final quality of textile products [1], [2]. As an essential material property, moisture plays a pivotal role in determining the physical characteristics of fabrics, such as strength, elasticity, durability, and comfort [3] - [5]. Inadequate moisture control can lead to a variety of issues, such as mold growth, fiber degradation, dimensional instability, and uneven dye uptake, which ultimately compromise product quality and customer satisfaction [6], [7]. The global textile and garment industry is witnessing an increasing demand for high-quality fabrics that cater to a diverse range of applications, from everyday apparel to specialized uses in healthcare, sportswear, and industrial settings. To meet these demands, manufacturers must focus on developing strategies to optimize fabric properties, including moisture management [8]. Understanding the factors that influence fabric moisture content is an essential step toward achieving this goal. These factors include environmental conditions, such as temperature and humidity, as well as intrinsic properties of the fabric, like fiber composition, weave structure, and chemical treatments applied during production [7].

This study focuses on investigating the key factors affecting the moisture content of textile fabrics [9]. Specifically, it examines the effects of fabric composition, weave type, environmental temperature, drying time, and chemical treatments such as detergents, fabric softeners, and dyes [10]. By employing experimental and analytical approaches, the research aims to provide a deeper understanding of how these variables interact and influence fabric moisture. Through controlled experiments using natural and synthetic fabrics, the study seeks to identify patterns and relationships that can inform best practices in textile production. Furthermore, the findings aim to support manufacturers in improving product quality, reducing waste, and enhancing production efficiency.

2. Materials and methods

The various woven fabrics with spun yarns used in the experiments include cotton (CTN), polyester (PET), cotton-polyester blends (CVC: 60/30 and TCT: 35/65), and polyester-viscose-spandex blends (PVS). The system features a maximum capacity of 110g and a readability of 0.01g.

Chemical agents such as laundry detergents and fabric softeners, branded as OMO and COMFORT respectively, provided by Unilever, along with direct dyes (synthetic indigo), were selected to examine their impact on moisture content. Each fabric sample was pre-treated under controlled conditions (23ºC, 65% RH for 24 hours) to ensure consistency across tests. The study focused on the following factors:

- Drying temperature: Samples were subjected to varying temperatures in a controlled chamber to assess the effect on moisture content in the temperature range of 50°C to 160°C.
- Curing time: Fabrics were dried for different durations to measure moisture loss rates.
- Fabric composition: Natural and synthetic textiles were compared based on moisture absorption and content.
- Weave type: Differences in moisture behavior were observed for woven and knitted fabrics.
- Chemical agents: Selected fabrics were treated with laundry detergent and fabric softener, to evaluate their effects on moisture characteristics
- Dyeing process: Samples were dyed using varying concentrations to analyze impact of dye retention on moisture content.
- Moisture measurement standards: International standards like ISO 139 and ASTM D2654 were referenced to validate the accuracy of the experiments. The moisture content refers to the amount of water present in a fabric, expressed as a percentage of its dry weight, reflecting its ability to absorb moisture from the environment under normal conditions. Besides, moisture retention is measured as the percentage of water remaining in the fabric relative to its initial weight after processes.

The compact and reliable moisture analyzer (Ohaus MB23) is used for measuring moisture content in various samples. A lab dyeing machine with 24 cups (SandoLab, Copower) and a washing machine (Miele) were used to investigate the effect of dyes, detergents and softeners. All treatments were according to the dyeing recipe (

3. Results and discussion

3.1. Change in moisture content of textile fabrics with drying temperatures

Moisture content (%) of fabric refers to the amount of water that the fabric fibers can absorb or retain when exposed to humid air or other environmental conditions. It is typically expressed as a percentage of the fabric weight. This moisture level depends on the type of fibers, the fabric's structure, and environmental factors such as temperature and humidity.

The graph in **Figure 1** illustrates the relationship between moisture content (%) and temperature (°C) for three materials: CTN (cotton), PVS (a blend of polyester, viscose, and spandex), and PET (polyester). It's important to note that the values shown represent the percentage of weight lost due to moisture evaporation, not the moisture content retained by the fabric. CTN shows the highest moisture loss with increasing temperature, starting around 1.71% at 40°C and reaching almost 6.52% at 100°C. This significant moisture loss indicates that cotton holds a large amount of water, which evaporates as the temperature rises. This is consistent with known hygroscopic properties of cotton fibers. PET exhibits the least moisture loss, starting near 0.40% at 40°C and only reaching about 1.44% at 100°C. This suggests that PET retains less moisture, with very little being lost due to evaporation, highlighting its high resistance to absorbing and retaining water. PVS has moderate moisture loss, starting around 0.87% at 40°C and rising just above 3.02% at 100°C. Being a synthetic blend, PVS retains less moisture than cotton, and its moisture loss rate reflects this, although it absorbs slightly more moisture than pure PET.

These findings underscore the different behaviors of natural and synthetic fibers regarding moisture loss, with natural fibers like cotton being more hygroscopic and therefore losing more moisture through evaporation, while synthetic fibers and their blends are more resistant to moisture uptake and loss.

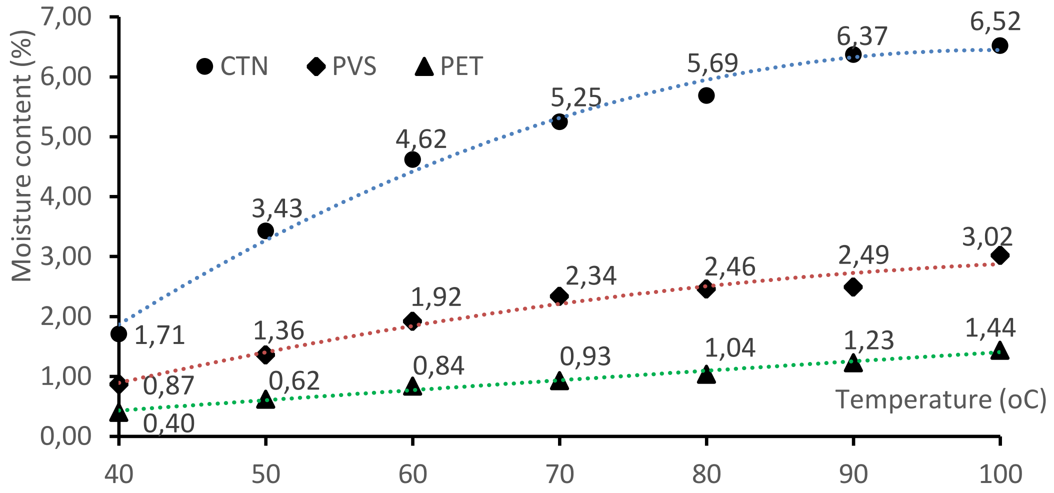

Figure 1. *The relationship between weight loss (%) and temperature (°C) for CTN (cotton), PVS (a blend of polyester, viscose, and spandex), and PET (polyester) over a 3-minute drying period*

3.2. Change in moisture content of textile fabrics with curing times

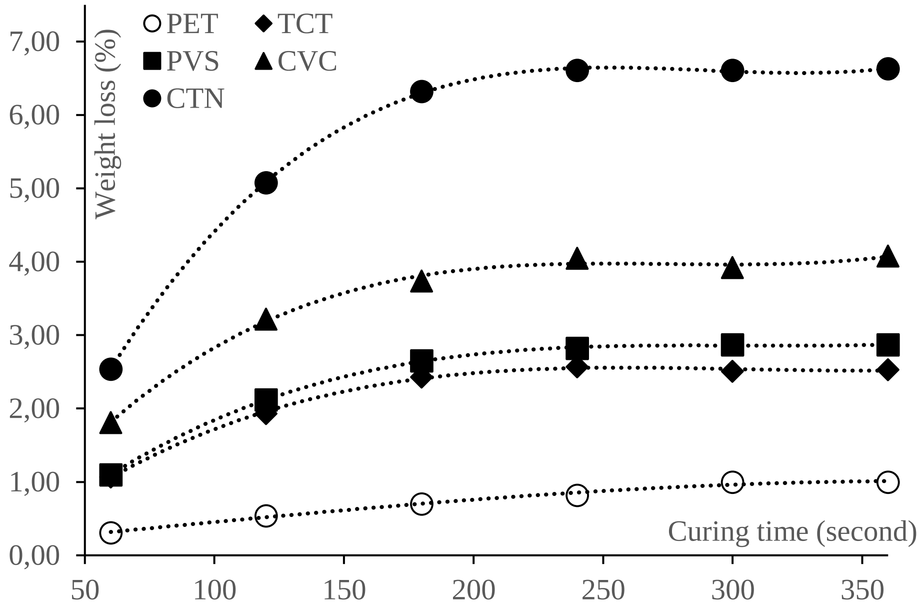

Figure 2. *Curves of weight loss against curing time (50 - 350 min) for PET (100% polyester), PVS (80% polyester + 15% viscose + 5% spandex), TCT (70% polyester + 25% cotton), CTN (100% cotton) and CVC (60% cotton + 40% polyester) at 110°C*

Figure 2 demonstrates the general trends in weight loss (%) over curing time. All fabric types show an increase in weight loss as curing time increases. This is likely due to the evaporation of moisture or the breakdown of certain chemicals under heat treatment. PET fabric exhibits the lowest weight loss compared to other fabrics, which aligns with its chemical properties as it is heat-resistant and absorbs little moisture. The weight loss for PET is primarily due to surface evaporation rather than structural moisture loss. In contrast, CTN fabric shows the highest weight loss as curing time increases, indicating its high capacity for water absorption and moisture evaporation from its natural fibers. Polyester-cotton blended fabrics (i.e., TCT and CVC) exhibit weight loss levels between PET and CTN. Among these blends, CVC fabric loses more weight than TCT, reflecting the higher proportion of cotton and its associated moisture-holding characteristics. PVS fabric, on the other hand, demonstrates relatively stable weight loss compared to other blends, likely due to the combined properties of viscose and spandex.

Fabrics with higher polyester content (such as PET and TCT) display lower weight loss due to polyester's low water absorption and high thermal stability. In contrast, fabrics with higher cotton content (such as CTN and CVC) show higher weight loss because of cotton's natural moisture-absorbing properties. The tendency for the weight loss rate to stabilize (stop increasing) at longer curing times, as observed in the graph, can be explained as follows: during the early stages of heat treatment, water on the surface and within the fabric evaporates quickly. However, as the remaining moisture decreases significantly, the evaporation rate slows down due to insufficient moisture, leading to a near-equilibrium state in weight loss.

Furthermore, for polyester and polyester-blended fabrics, prolonged exposure to high temperatures caused the polymer structure to stabilize, resisting further degradation. This is because the breaking of chemical bonds in these fibers is insignificant at typical treatment temperatures. For natural fibers, initial weight loss includes both moisture evaporation and slight decomposition of organic substances. Once all moisture - including free water and bound water within the fiber structure -has evaporated, no further weight loss occurs, especially for polyester fabrics. This stabilization phenomenon is significant in the textile industry as it helps determine the optimal processing time for fabrics, avoiding wasted energy or degraded product quality.

3.3. Impact of detergents and softeners on moisture of textile fabric

Three different samples, including CTN (100% cotton), PET (100% polyester), and PVS (70% polyester, 25% viscose, 5% spandex), were bleached with detergents under the same conditions. The moisture content of the bleached samples was examined at 80°C for 3 minutes, as reported in **Table 1**. The standard moisture content of raw cotton is known to be approximately 8%. However, due to various fabric processing stages, including treatments such as mercerizing and bleaching, the actual moisture content measured in this study is reduced to about 4-6%. Clearly, the moisture content of the cotton sample significantly decreased from 5.8% to 4.5% after bleaching, while that of the polyester sample remained at 1.3%. A slight increase in moisture occurred in the polyester samples blended with viscose and spandex. This can be explained by the fact that when using a bleaching agent, changes in surface properties may increase or decrease the penetration of water molecules into the fiber structure. This phenomenon occurred more prominently in cellulose fibers due to greater damage caused by the detergent compared to polyester fibers. Additionally, the moisture levels of softened samples were similar to those of bleached samples. This suggests that softening agents also affected the moisture content of textile fibers, as the softeners could form a protective layer around the cotton fibers, preventing moisture from reaching the cellulose structure. The reduction in electrostatic charge on the fabric surface caused by the softeners led to a decrease in both moisture content and breathability.

Table 1. *Moisture content of CTN (100% cotton), PET (100% polyester), and PVS (70% polyester, 25% viscose, 5% spandex) at 80^{o}C for 30 minutes before and after bleaching and softening*

Sample	**Moisture content** (%)					
	Repeat	**1**	**2**	**3**	**Mean**	**Standard derivation**
CTN	Untreated	5.75	5.90	5.80	**5.82**	0.08
	Bleached	4.50	4.60	4.52	**4.54**	0.05
	Softened	4.80	4.75	4.79	**4.78**	0.03
PET	Untreated	1.34	1.36	1.35	**1.35**	0.01
	Bleached	1.33	1.31	1.32	**1.32**	0.01

	Softened	1.34	1.35	1.33	**1.34**	0.01
PVS	Untreated	2.45	2.49	2.47	**2.47**	0.02
	Bleached	2.50	2.52	2.51	**2.51**	0.01
	Softened	2.51	2.53	2.52	**2.52**	0.01

3.4. Impact of dye concentration on moisture of cotton fabrics

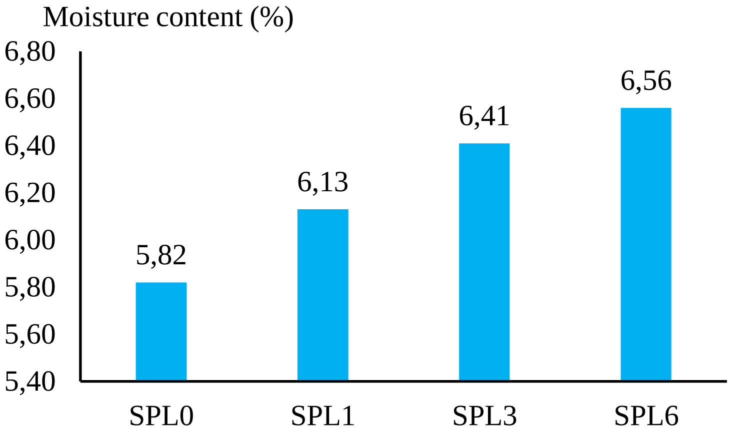

Figure 3. *Moisture content of cotton fabrics dyed with 0%, 1%, 3%, and 6% of indigo dye (corresponding to SPL0, SPL1, SPL3, and SPL6, respectively)*

Figure 3 illustrates the moisture content (%) of fabrics dyed with varying dye concentrations (0%, 1%, 3%, and 6%, represented as SPL0, SPL1, SPL3, and SPL6, respectively). SPL0, the undyed fabric, has a baseline moisture content of 5.82%, while SPL1, SPL3, and SPL6 show higher moisture levels of 6.13%, 6.41%, and 6.56%, respectively. Clearly, moisture content increases with dye concentration, indicating that fabrics absorb more moisture as they take in more dye. This is likely due to the dye molecules enhancing the fabric's ability to retain water through their chemical structure and interaction with cellulose fibers.

4. Conclusions

The study has successfully achieved its key objectives, from analyzing factors influencing fabric moisture to conducting practical experiments and evaluations. It identified the effects of temperature, time, weave type, fabric composition, and chemical treatments on moisture content and release properties. These findings not only provide a strong theoretical foundation but also offer practical solutions to improve moisture content, thereby enhancing the quality of textile products. Key measures, such as controlling production environments, selecting appropriate materials, and adopting advanced treatment methods, have shown high applicability. These results not only improve product quality but also bolster Vietnam's textile industry competitiveness globally. Furthermore, the research promotes sustainability by improving resource efficiency, reducing drying times, conserving energy, and lowering carbon emissions. This work supports innovation in functional textiles, enhancing performance for applications like sportswear and protective gear, while advancing sustainable practices in the textile industry.

Acknowledgments

The authors would like to express their gratitude to Ho Chi Minh City University of Technology and Education (HCMUTE) for its support.

Conflict of Interest

The authors declare no conflict of interest

JTE HCMUTE
ISSN: 2615-9740

JOURNAL OF TECHNICAL EDUCATION SCIENCE
Ho Chi Minh City University of Technology and Education
Website: https://jte.edu.vn
Email: jte@hcmute.edu.vn

Data Availability Statement

The data supporting the findings of this study are openly available at the corresponding author under DOI: https://doi.org/10.54644/jte.2025.1742.

REFERENCES

[1] Y. P. Angelova, "Factors influencing the laser treatment of textile materials: An overview," *Journal of Engineered Fibers and Fabrics,* vol. 15, p. 1558925020952803, 2020.
[2] B. Saville, *Physical testing of textiles*. Elsevier, 1999.
[3] P. Venkatraman, "Fabric properties and their characteristics," *Materials and technology for sportswear and performance apparel,* pp. 53-86, 2015.
[4] K. Slater, "Comfort properties of textiles," *Textile progress,* vol. 9, no. 4, pp. 1-70, 1977.
[5] S. Palanisamy, V. Tunakova, J. Militky, and J. Wiener, "Effect of moisture content on the electromagnetic shielding ability of non-conductive textile structures," *Scientific Reports,* vol. 11, no. 1, p. 11032, 2021.
[6] C. Duprat, "Moisture in textiles," *Annual Review of Fluid Mechanics,* vol. 54, no. 1, pp. 443-467, 2022.
[7] F. Wang, W. Shi, Y. Lu, G. Song, R. M. Rossi, and S. Anaheim, "Effects of moisture content and clothing fit on clothing apparent 'wet'thermal insulation: a thermal manikin study," *Textile research journal,* vol. 86, no. 1, pp. 57-63, 2016.
[8] I. Schwarz, D. Rogale, S. Kovačević, and S. F. Rogale, "A multifunctional approach to optimizing woven fabrics for thermal protective clothing," *Fibers,* vol. 12, no. 4, p. 35, 2024.
[9] B. Das, A. Das, V. Kothari, R. Fanguiero, and M. d. Araujo, "Moisture transmission through textiles," *AUTEX Research Journal,* vol. 7, no. 2, pp. 100-110, 2007.
[10] M. Umair, T. Hussain, K. Shaker, Y. Nawab, M. Maqsood, and M. Jabbar, "Effect of woven fabric structure on the air permeability and moisture management properties," *The Journal of The Textile Institute,* vol. 107, no. 5, pp. 596-605, 2016.

Nguyen Tuan Anh, PhD. In 2004, the author received Bachelor of Engineering in Garment Technology at Ho Chi Minh City University of and Technology and Education. Then, he became a lecturer in Textile Materials at this university. Since 2007, he got Master of Science in Textile and Garment Technology at Hanoi University of Science and Technology. In 2014, he got PhD in Energy and Optoelectronic Materials at National Taipei University of Technology (Taiwan). His current work focuses on Polymeric and Textile Materials. Email: nta@hcmute.edu.vn. ORCID: https://orcid.org/0000-0003-2607-6671

Luong Thi Ngoc Phuong is a student in the Bachelor's program in Garment Technology at the Faculty of Fashion and Tourism (FFT), Ho Chi Minh City University of Technology and Education (HCMUTE), with the student ID 20109159. She contributed to this work as part of her thesis under the supervision of Dr. Tuan Anh Nguyen. Email: phuongluong2k2@gmail.com. ORCID: https://orcid.org/0009-0006-7031-1527

Tran Thi Anh Tuyet is a student in the Bachelor's program in Garment Technology at the Faculty of Fashion and Tourism (FFT), Ho Chi Minh City University of Technology and Education (HCMUTE), with the student ID 20109177. She contributed to this work as part of her thesis under the supervision of Dr. Tuan Anh Nguyen. She is working as technical staff at Hansol Vina Co. Ltd. Email: ttat2k2@gmail.com. ORCID: https://orcid.org/0009-0006-9302-5267