Using Microfibers to Optimize the Functional Properties of Janitorial Staff Uniforms

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Abstract

Janitorial workers encounter many difficulties during their work, one of which is ensuring that their uniforms are both comfortable and functional during their working periods. The current uniforms are used regardless of moisture management, breathability, and durability. This research targets to enhance the functional properties of janitorial staff clothing by applying Microfiber blends in the weft yarns. By varying the ratios of Microfiber and Cotton in the weft yarns, the study seeks to improve the uniforms' comfort, durability, and overall performance. Four fabric samples were produced in this research based on the weft blend ratios of Microfiber and Cotton. Different weft arrangements were used as follows: 75% Cotton: 25% Microfibers, 50% Cotton: 50% Microfibers, 25% Cotton: 75% Microfibers, and 100% Microfiber, with Cotton used as warp yarns in all samples. To confirm the fabrics functionality, laboratory tests were performed according to the ASTM standards. Fabric tensile strength and elongation, abrasion resistance, thickness, weight per square meter, air permeability, water permeability and stain resistance were all measured, and results were statistically analyzed and discussed. Most of the samples achieved the desired outcomes. In addition to fabric tests, a set of designs for male and female janitorial uniforms were made.

Keywords

Breathability, Janitorial Uniforms, Microfiber, Functional Properties, Functional Clothing

الملخص

يواجه عمال النظافة العديد من الصعوبات أثناء عملهم، أحد هذه الصعوبات التأكد من أن زيهم الرسمي مريح وعملي أثناء فترات عملهم. يتم استخدام الزي الرسمي الحالي بغض النظر عن خواص الرطوبة والتهوية والمتانة. يهدف هذا البحث إلى تعزيز الخصائص الوظيفية لملابس عمال النظافة من خلال تطبيق نسب خلط مختلفة بين لحمات الميكروفيبر مع القطن. تسعى هذه الدراسة إلى زيادة راحة الزي الرسمي ومتانته وأدائه العام. ، تم إنتاج أربع عينات من الأقمشة باستخدام ترتيبات مختلفة من اللحمة والتي تؤدي إلى نسب خلط متنوعة بين الميكروفيبر والقطن على النحو التالي: ٧٥٪ قطن: ٢٥٪ ميكروفيبر، ٥٠٪ قطن: ٥٠٪ ميكروفيبر ، ٢٥٪ قطن: ٧٥٪ ميكروفيبر ، و ١٠٠٪ ميكروفيبر ، مع استخدام القطن كخيوط سدى في جميع العينات. تم إجراء الإختبارات المعملية وفقًا لمعايير ASTM للتأكد من الخواص الوظيفية للأقمشة تحت الدراسة. تم قياس قوة الشد والاستطالة للقماش، ومقاومة التآكل، والسمك، والوزن لكل متر مربع، ونفاذية الهواء، ونفاذية

الماء ومقاومة البقع، وتم تحليل النتائج إحصائيًا ومناقشتها. وقد حققت معظم العينات النتائج المرجوة بالإضافةالى اختبارات النسيج تم عمل مجموعة من التصميمات لزى عمال النظافة للذكور والإناث.

الكلمات المفتاحية
نفاذية الهواء، عمال النظافة، الميكروفيبر، الخواص الوظيفية، الملابس الوظيفية

Introduction

Clothing inherently limits the wearer's movement and activity. (Chuan Tang, et al, 2023) Clothing is a basic need for individuals. In the past, it was primarily seen as a means to satisfy a different and authentic appearance. But today the need for aesthetic appeal is tied to the functional purpose instead. Functional clothing became an essential and important requirement for consumers of ready-made garments. The need for clothing has evolved beyond merely protecting from weather conditions or providing warmth, there is now a demand for garments that perform functions for the body, such as wicking away perspiration to provide a comfortable feeling, controlling humidity, and regulating temperature. Functionality means the appropriate and suitable use for the needs of the human body. (Khallah, Mariet Younan Abdelmalak, et al, 2024)

Notably, the clothing of cleaning workers is affected by surrounding conditions, the nature of their work, and direct contact with the environment, such as dust, biological materials, microorganisms and climate. In order to improve the performance of cleaning workers, it is imperative to take into account the functional aspects and choose the optimal technical specifications for the materials used, making sure that the clothing is appropriate for the job. Setting technical guidelines for employees' attire that complement the attributes of the workplace is essential for achieving high-quality job performance and ensuring the employees' physical and mental well-being. To make sure to guarantee that fabrics are appropriate for the intended use, it is crucial to highlight the functional performance of the materials used to clean workers' clothing and to establish construction specifications for these materials. (Eman Fouda, et al., 2016)

Research Problem

Current uniforms of Janitorial workers suffer from lack both comfort and functionality, as they fall short in terms of breathability, moisture management, and durability.

Research Importance

- Investigating the application of Microfiber blends to improve the functional characteristics of janitorial staff uniforms.
- Enhancing the uniforms of janitorial workers from the aspect of comfort, durability, and overall performance.

Research Objectives

Improve the functional properties of janitorial workers clothing by producing fabrics with different weft blend ratios of Microfibers and Cotton based on different weft arrangements.

Research Hypothesis

- Using different weft blend ratios of Microfibers and Cotton based on different weft arrangements affects the functional properties of the fabric.
- The specifications of the fabrics influence the quality of the function performance.

Research Delimitation

Janitorial uniforms within companies and institutions.

Research Terminology

Janitorial Uniforms:

This refers to a type of clothing worn by a group of workers (men and women) who clean rooms and public areas in various institutions such as hotels, hospitals, universities, and schools. (Eman Fouda, et al., 2016)

Functional performance:

The actual use of work attire in the work environment, through which essential job requirements for usage can be derived and the attributes defining the quality of work attire can be identified. (Khalil, Rasha Wagdy, 2021)

Functional Clothing:

Functional clothing refers to garments designed to meet the specific demands of the wearer's tasks, providing the necessary performance requirements under unusual conditions. This enhances the individual's efficiency in their assigned duties. Functional clothing is crucial for the success of various tasks for individuals such as (craftsmen, patients, and athletes), as it boosts their confidence and independence. It plays a significant role in satisfying the physiological and psychological needs of the wearer.
(Khallah, Mariet Younan Abdelmalak, et al, 2024)

Functional Requirements:

Functional requirements refer to the necessities that ensure the design elements provide comfort during work, accommodate the required range of motion, ensure safety, and offer ease of use in terms of putting on and taking off. Additionally, the material must be suitable for the activity in terms of weight, texture, and sweat absorption.

Workers' Clothing:

Workers' clothing is used in the work environment, where it is essential to consider the type of fabric and design to avoid work-related hazards. (Habhab, and Johar, 2022)

Research Methodology

The research followed an experimental approach, creating fabric samples with different blend ratios and developing a series of designs for Janitorial Uniforms.

Literature Review

Functional clothing is designed to address specific user requirements. Research into functional clothing in Western countries was accelerated during World War 2. leading to ongoing development with advancements in technology and fabric innovation. This has increased demands for enhanced clothing functionality, prompting the emergence of new research domains within functional clothing. Based on distinct functionalities, functional clothing can be categorized into 6 types: Protective functional clothing, medical functional clothing, sportswear, fashionable attire, versatile clothing assemblies, and garments designed for specific needs. (Li, Shuyang, et al., 2022)

The cleaning profession requires workers to wear uniforms for a long period of time while performing cleaning tasks in an environment that demands clothing capable of withstanding physical movement. One of the most important standards that must be fulfilled in apparel is the functional performance of the uniforms worn by workers, as this shows how well the uniforms are designed to fit the environment. The worker is influenced by the surrounding environment while the working hours any physical exertion or movement. Therefore, it has become so important to focus on developing the cleaning workers' uniforms in terms of design, materials, and care methods, considering that the uniform accompanies the workers for more than six hours daily. This has an essential impact on their work efficiency to meet their physiological, social, economic, psychological, and functional needs. (Ali, Sahar Ali Zaghloul, et al., 2024)

Functional requirements for garment design:

Two important considerations for garment design are:

1. **Accommodation for limited mobility:** This makes sure the wearer can move comfortably to perform daily activities.
2. **Comfort and health:** The garment should be comfortable to wear for long periods and avoid causing any skin irritation, blood flow restriction, or other health problems. (Marija Nakić and Slavica Bogović, 2019)

Making something look good isn't the only goal when making functional clothing. Functional clothing design is a true fusion of science and art, and it all starts with a thorough understanding of the needs of the wearer. This combination guarantees functional clothing meets the many and different requirements of users, without sacrificing aesthetics or comfort.

At the core of functional clothing design lies understanding the human user. Designers must consider how the clothes will be worn and the specific needs of the user, especially when tackling problems in extreme environments. This translates into focusing on four key aspects:

- **Comfort:** The garment should be comfortable to wear for extended periods, allowing for ease of movement and reducing irritation.
- **Durability:** The clothing needs to withstand the rigors of the environment and the user's activities.
- **Protection:** It should offer adequate protection from the elements or potential hazards encountered in the harsh environment.
- **Dimensional Stability:** The garment should maintain its shape and size throughout wear and washing to ensure proper functionality. (Jekal, Mee, 2018)

The world of fashion sees a wave of innovative designers taking the challenge of **functional clothing**. These forward-thinking creators aren't just focused on aesthetics; they're solving real problems for people with unique needs. (Ross, Tania Allan., 2017)

Clothes that are worn actually indicate the wearer's profession and help them perform their job better. Functional clothing meet standardized criteria ensuring safety, protection, and comfort tailored to the wearer's specific needs for his occupation.

(Salem, Sherine Salah El-Din Ali, and Mohamed Alaa, 2023)

Designing functional clothing includes creating high-performance garments capable of withstanding dangers and stress. (Habhab and Johar, 2022)

Requirements for Janitorial Uniforms:

Dust Proof:

The uniform design must be tight enough to prevent dust from penetrating, especially around the cuffs and collars. The fabrics which are used should not have openings or holes that allow dust or dirt to pass through to the worker's body. The uniform should be resistant to static electricity to avoid attracting dust, which leads to quick soiling and retention of dust in the clothing.

Maintaining Appearance:

This can be achieved by ensuring:

- Colorfastness: The uniform should keep its color even after being washed several times and exposed to light, sweat, and friction.
- Dimensional stability: The uniform should endure repeated washing at high temperatures without any change in dimensions.
- High resistance to wrinkling, so it does not need to be ironed after washing.
- Resistance to staining.
- Resistance to pilling, which affects the looking of the uniform.
- The uniform should be non-transparent.

Comfort During Work:

This can be achieved by ensuring:

The uniform is easy to put on and take off (wearability). The uniform has a soft texture to the skin, not rough, the design of the uniform allows to move during work, the uniform can absorb sweat and evaporate it. Research has shown that the higher the ability of the clothing to manage sweat, the higher the worker's performance efficiency.

Good Stitching and Resistance to Thread Slippage:

The uniform should have high-quality stitching that resists thread slippage.

(Rania Mostafa Kamel Abdel-Aal; Shadia Salah Hassan Metwally Salem, 2013)

Safety:

Despite the need for clothing to be comfortable, it can be a reason for health issues due to the use of textile products and the lack of health awareness among individuals. They might lack some information about the best types of textiles that protect the body from diseases or the practices that should be followed in order to maintain workers' health. The safety of workers' clothing has several factors, including protection from chemicals, flame resistance, electrical resistance, resistance to microorganisms and insects, and resistance to skin friction.

Durability and Lifespan:

The lifespan of a garment is the period during which the product can be used and be beneficial. The ongoing effectiveness of the used fabrics determines how long clothes will last. Durability is one of the most essential mechanical properties due to its effective role in determining the fabric's resistance to various stresses and wear and its impact on functional performance. Workers' clothing is actually exposed to different factors that can cause damage and wear, with different chemicals having a significant ability to damage clothing, affecting its lifespan. This severely impacts workers' health. High levels of sturdiness and durability are necessary for the fabrics to withstand frequent washings and use, which will extend their lifespan. High durability is necessary to withstand the activities of cleaning staff.

Ease of Use (Care):

Care describes to the methods and techniques used to remove stains from textile products and maintain their appearance as close to their original state as possible. The lifespan of the product, accumulated dirt on fabrics are major factors leading to damage, as stains attract decay and insects. Important considerations for fabrics are used in workers' clothing to ensure ease of use; including maintaining their dimensions after repeated washing, resistance to shrinkage, retaining their shape during use, resistance to soiling, and colorfastness. (Eman Fouda, et al., 2016)

Because materials play a crucial role in cleaning workers' uniforms, they must be selected carefully to ensure they meet the functional needs of the wearer. One of the most important properties is moisture management, which contributes to comfort. Microfiber, for example, is known for its ability to wick away sweat and provide a comfortable wearing experience.

Microfibers

Microfiber is a fiber with a linear density of less than one denier, or less than one dtex. Its fineness is four times that of Wool, three times that of Cotton, twice that of Silk, and once that of human hair. (Ahmed, S. A. M., 2022) It is a synthetic ultra fine fiber that can be made from Acrylic, Polyester or Nylon. (El Hadidy, W. E. A., 2022). The very fine linear density results in exceptionally lightweight fibers. (Ahmad, F., et al., 2023)

Production of Microfibers

There are some methods that can be employed for production of Microfibers:

1- Dissolved spinning
2- Split spinning
3- Direct spun spinning
4- Super drawing technique
5- Sheath core spinning technique (El-Gamal, A. M. M. A. M., 2016)

Microfiber Polyester

Microfiber yarn allows for producing very dense fabrics with minimal spaces between the fibers. The extended fiber surface area creates more pores. These pores help in transporting vapor out due to their excellent capillary action. The finer the fiber, the greater the surface area that directs to higher vapor transmission. In addition, the intense density of the pores improves the thermoregulation properties of the produced fabric. (Sampath, M. B., and M. Senthilkumar, 2009)

Properties of Microfiber

Microfiber resists shrinkage and offers long lasting durability due to its high strength. Fabrics woven from Microfibers are exceptionally soft, almost like silk. They have a luxurious feel due to the dense weaving of thousands of super-fine fibers. Microfiber fabrics resist mildew, wrinkles, shrinkage, stretching, most stains and abrasions. The produced fabric is breathable and offers insulating characteristics. It passes perspiration and body oils away from the body, providing a dry surface when touching the skin. (El Hadidy, W. E. A., 2022)

Fabrics produced from Microfiber Polyester possess the following characteristics:

- High coverage and lightweight
- Excellent drape and softness
- High absorbent surface
- Exceptional comfort
- Silky hand
- Reduced pilling
- Good breathability
- High dimensional stability (Kale, R. D. "Microfiber, 2010)

Previous Studies

Study (Ali, Sahar Ali Zaghloul, and Al-Aboudi, Noha bent Abdulaziz Abdullah, 2024): Titled: Development of Cleaning Workers' Uniforms in Saudi Arabia in Design and Technology to Achieve Sustainability.

This research highlights the features and characteristics of the fabrics used in making uniforms for cleaning workers and to select the best ones in eyes of health and functionality. It also aims to provide design solutions for improving the uniforms of sanitation worker in the Kingdom of Saudi Arabia to meet their needs. The study has gathered opinions from experts on the proposed designs and established scientific foundations for cleaning worker uniforms. The research has employed a descriptive-analytical method with application. The result has shown that both the specialists and consumers in the sample has accepted the proposed design solutions.

Study (Rania Mostafa Kamel Abdel-Aal; Shadia Salah Hassan Metwally Salem, 2013): Titled: Design and Production of Cleaning Workers' Uniforms in Light of Job Requirements and Modern Technology.

The aim of the research is to produce uniforms for cleaning workers that meet their functional requirements, enhance the overall appearance of the cleaning workers, achieve economic efficiency in the implemented products, and meet technical aspects in the uniforms. It also aims to adapt materials, techniques, and uniform components to provide protection and safety for the cleaning workers. The research relies on the descriptive analytical method with application. The research sample consisted of 10 cleaning workers at King Abdulaziz University in Jeddah. The research tool was a product evaluation form used to answer the research questions and verify its hypotheses. The results of the research have shown that the proposed products are suitable for cleaning workers and achieve aesthetic, technical, functional, and economic aspects, while providing protection and safety during work. One of the designs was selected to be generalized for the workers at the College of Home Economics at King Abdulaziz University.

Study (Wedian Talaat Madian, 2022): Titled: Requirements to Design Sustainable Functional Clothing for Low-Risk Security in National Projects**.**

This research aims to investigate the design requirements for sustainable, low-risk private security uniforms, aligned with the nation's sustainability goals for national projects. The study proposes uniform designs for private security personnel in low-risk facilities. A survey involving 26 private security personnel was conducted through personal interviews to identify the required functional and aesthetic requirements for optimal performance. Based on the survey results, a set of uniform designs for low-risk private security personnel was proposed, considering the Egyptian climate and environment while incorporating sustainability aspects. A questionnaire was administered to specialists to assess the suitability of the proposed designs for the required performance, addressing the research objectives and axes. The color combination that received the highest acceptance rate among specialists was also adopted.

Implementation and Experiments

The research samples were produced at the Textile Design Center, Faculty of Applied Arts, Helwan University. The specifications of the machine used for producing the samples are detailed in Table (1), while Table (2) outlines the Dobby machine specifications, and the produced samples specifications are provided in Table (3). The weft yarn arrangement was used as a variable parameter in the study, and table (4) illustrates the ratios of the weft blend.

TABLE (1) SPECIFICATIONS OF THE MACHINE USED FOR THE PROUCED FABRICS

No.	Item	Specifications
1	Loom Type/ Model	ITEMA/ R9500
2	Manufacturing Country	Italy
3	Manufacturing Year	2014
4	Machine Width	190 cm
5	Machine Speed	300 picks/ min.
6	Weft Insertion Method	Rapier
7	Weft Selector	8 Fingers
8	Ends/cm	36
9	Reed Used	12 dents/ cm
10	Denting	3 ends/ dent
11	Width of Warp Threads	163.1 cm (Without Selvedges)
12	Selvedge Width	1 cm Each Side

TABLE (2) DOBBY MACHINE SPECIFICATIONS

No.	Item	Specifications
1	Dobby Model	STAUBLI
2	Number of Harnesses	20
3	Number of Used Harnesses	16
4	Threading Type	Straight

TABLE (3) BASIC SPECIFICATIONS OF THE FABRICS UNDER STUDY

No.	Property	Specifications
1	Material of Warp Yarn	Cotton
2	Material of Weft Yarn	Cotton, Polyester Microfiber
3	Warp Yarns Count	30/1 Ne.
4	Weft Yarns Count	30/1 Ne., 150 Denier (288 Fibers)
5	Warp Sett	36 ends/cm
6	Weft Sett	42 picks/cm

TABLE (4) THE WEFT ARRANGEMENTS AND PERCENTAGES FOR THE PRODUCED SAMPLES

Sample No.	Weft Yarn Arrangement	Weft Blend Ratio
1	3 Cotton: 1 Microfiber	75% Cotton: 25% Microfiber
2	1 Cotton: 1 Microfiber	50% Cotton: 50% Microfiber
3	1 Cotton: 3 Microfiber	25% Cotton: 75% Microfiber
4	Microfiber	100% Microfiber

Weave Structure Used

The samples under study were produced using a twill 2/2 weave structure. Figure (1) pictures the weave structure.

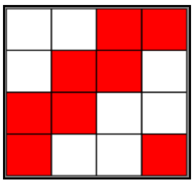

FIGURE (1) WEAVE STRUCTURE USED FOR PRODUCED SAMPLES

Tests Applied to the Study Samples

Laboratory tests were conducted to evaluate the comfort and functional properties of the samples under study. Table (5) depicts tests and standards applied to fabric.

Table (5) Tests and Standards Applied to Research Samples

No.	Applied Test	Standard Specification
1	Tensile Strength and Elongation	ASTM D5034 - 08
2	Weight Loss Due to Friction	ASTM D4966 - 10
3	Fabric Thickness	ASTM D1777 - 96
4	Fabric Weight	ASTM D3776 - 79
5	Air Permeability	ASTM D737 - (2012)
6	Water Permeability	ASTM D4491 (1999a)
7	Stain Resistance	ASTM D130-1990

A series of designs for cleaning workers' uniforms was created using Artificial Intelligence (AI) software. Some designs originated from initial concept sketches, while others were generated by entering detailed descriptions.

The AI sites that were used:

https://www.promeai.pro/blender

https://coolors.co/594f3b-776258-b7aba7-f7f3f5-f6f3f7-d2d3e5-adb2d3

The proposed designs for cleaning workers' uniforms.

Figure (2) Designs from (1) to (4)

Design (5)

Design (6)

Design (7)

Design (8)

Figure (3) Designs from (5) to (8)

	
A men's suit for street cleaners and beautification workers is an orange jacket with orange and gray sleeves, pockets and zippers. It is a jacket that can withstand hard work and is resistant to dirt. The trousers are gray in color and have side pockets and at the knees are equipped with a piece of cloth to protect the worker when sitting or to prevent him from being exposed to any injury.	A suitable design for men and workers in city cleaning. It is a smaller jacket with gray cuts and 4 large pockets for carrying things while working. The jacket is comfortable and suitable for different climates. The pants are green in color and have cross-cuts at the bottom that are yellow. They have large side pockets and are comfortable to use.
Design (9)	Design (10)
	
Two designs for cleaners in cities and streets, in blue and orange colors and gray cuts. These colors were chosen to suit the summer weather and the heat of the sun, as well as effort and hard work. The designs are suitable and comfortable, and have pockets to facilitate work and carrying things while working. The shirt has zippers, not buttons, for ease of wearing.	A men's suit for street cleaners and beautification workers is an orange jacket with orange and gray sleeves, pockets and zippers. It is a jacket that can withstand hard work and is resistant to dirt. The trousers are gray in color and have side pockets and at the knees are equipped with a piece of cloth to protect the worker when sitting or to prevent him from being exposed to any injury.
Design (11)	Design (12)

Figure (4) Designs from (9) to (12)

Design (13)

A new design for cleaning use in cities. It is a green jumpsuit with orange trim, and the back and lower legs are also orange. It has side pockets. The design is suitable for work, effort-bearing and comfortable at the same time.

Design (14,15)

Figure (5) Designs from (13) to (15)

Results and Discussions

Data Results

Table (6) represents the results of the laboratory tests applied to the produced fabrics.

TABLE (6) LABORATORY TESTS RESULTS

Sample No.	1	2	3	4
Tensile Strength (N)	431	559	940	1125
Elongation (%)	11	27	41	42
Weight Loss Due to Friction (%)	5	3	2	0
Fabric Thickness (mm)	0.3385	0.3283	0.3156	0.3155
Fabric Weight (g/m²)	158.8	159.2	157.3	157.7
Air Permeability (cm³/cm².sec)	12.9167	9.603	7.316	5.799
Water Permeability (L/sec.)	1.2295	1.293	1.277	1.288
Stain Resistance	2	2	1	3

Data Analysis for Tests Results

Influence of Weft Ratios on Fabric Tensile Strength in Weft Direction

The following model examines the relationship between Microfiber weft blend ratios and fabric tensile strength in weft direction through the linear regression equation and R-squared value. The results show a strong correlation between Microfiber weft blend ratios and fabric tensile strength in weft direction.

LINEAR REGRESSION EQUATION AND R-SQUARED VALUE FOR FABRIC TENSILE STRENGTH IN WEFT DIRECTION:

$Y = 9.852X + 148$, $R^2 = 0.9653$

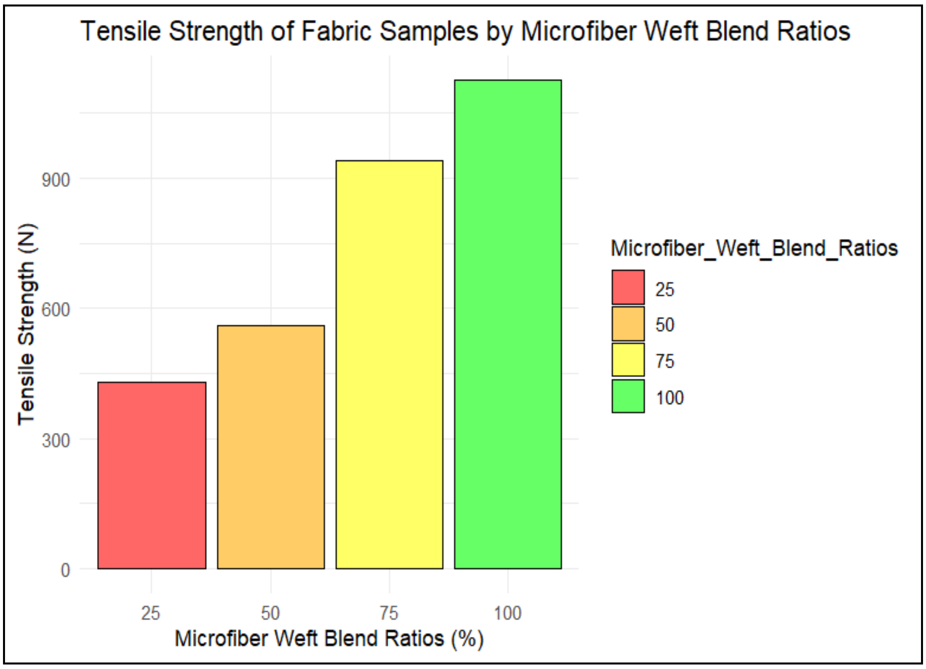

FIGURE (6) RELATIONSHIP BETWEEN MICROFIBER WEFT BLEND RATIOS AND FABRIC TENSILE STRENGTH IN THE WEFT DIRECTION

Figure (6) depicts that there is a strong positive correlation between the Microfiber ratio and the tensile strength, this means that as the Microfiber percentage increases, the tensile strength in weft direction increases. This is because Microfibers in the produced samples are made from polyester, which is known for its high tensile strength. In addition, the Microfibers have a higher surface area that allows for better bonding between the fibers, and thus enhances the fabric's ability to resist tensile forces.

Influence of Weft Ratios on Fabric Elongation in Weft Direction

The following model illustrates the linear regression equation and R-squared value for fabric elongation in weft direction. It can be explained that there is a strong positive correlation between the content of Microfiber and fabric elongation in weft direction.

LINEAR REGRESSION EQUATION AND R-SQUARED VALUE FOR FABRIC ELONGATION IN WEFT DIRECTION:

$y = 0.428x + 3.5$, $R^2 = 0.9019$

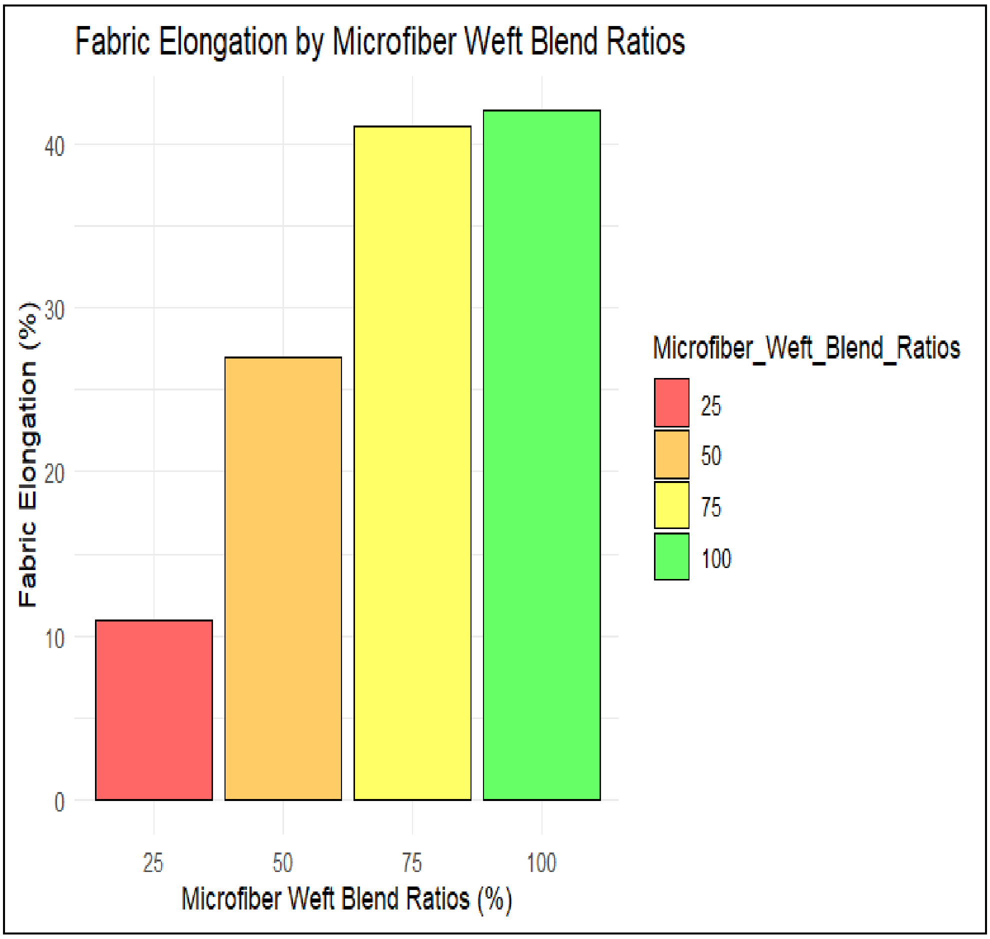

FIGURE (7) RELATIONSHIP BETWEEN MICROFIBER WEFT BLEND RATIOS AND FABRIC ELONGATION IN THE WEFT DIRECTION

Figure (7) portrays the relationship between weft blend ratios and fabric elongation in the weft direction. It is obvious that there is a strong positive correlation between the Microfiber ratio and the fabric elongation, this means that as the Microfiber percentage increases, the fabric elongation in weft direction increases too. This is because the Microfiber has a smoother surface that reduces rubbing between the fibers when the fabric is elongated, and this smooth surface allows the fibers to slide more easily, guiding to greater elongation.

Influence of Weft Ratios on Fabric Abrasion Resistance

The following model characterizes the linear regression model for the fabric abrasion resistance. The analysis suggests that increasing the percentage of Microfiber in the weft blend significantly improves the fabric's abrasion resistance.

LINEAR REGRESSION EQUATION AND R-SQUARED VALUE FOR FABRIC WEIGHT LOSS AFTER 5000 CYCLES:

$y = -0.064x + 6.5$, $R^2 = 0.9846$

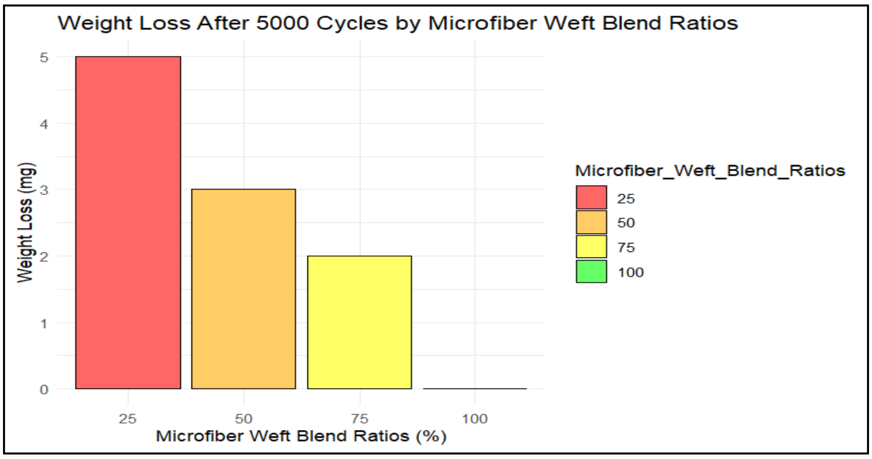

FIGURE (8) RELATIONSHIP BETWEEN MICROFIBER WEFT BLEND RATIOS AND WEIGHT LOSS AFTER 5000 CYCLES

Figure (8) picture that there is a strong negative relationship between Microfiber weft blend ratios and weight loss after 5000 cycles. This means that the increase in Microfiber content decreases the weight loss after 5000 cycles that leads to improvement in the fabric abrasion resistance. This could be attributed to the fine fiber structure that allows fibers to create a smooth and dense surface in the fabric. This smooth surface, unlike coarser fibers, decreases rubbing during abrasion, which in turn reduces the rate of fiber to wear.

Influence of Weft Ratios on Fabric Thickness

The following model provides an insight into the relationship between Microfiber weft blend ratios and fabric thickness through the linear regression equation and R-squared value. A strong inverse relationship can be observed between the Microfiber weft blend ratio and fabric thickness.

LINEAR REGRESSION EQUATION AND R-SQUARED VALUE FOR FABRIC THICKNESS:

$y = -0.0003x + 0.3449$, $R^2 = 0.9004$

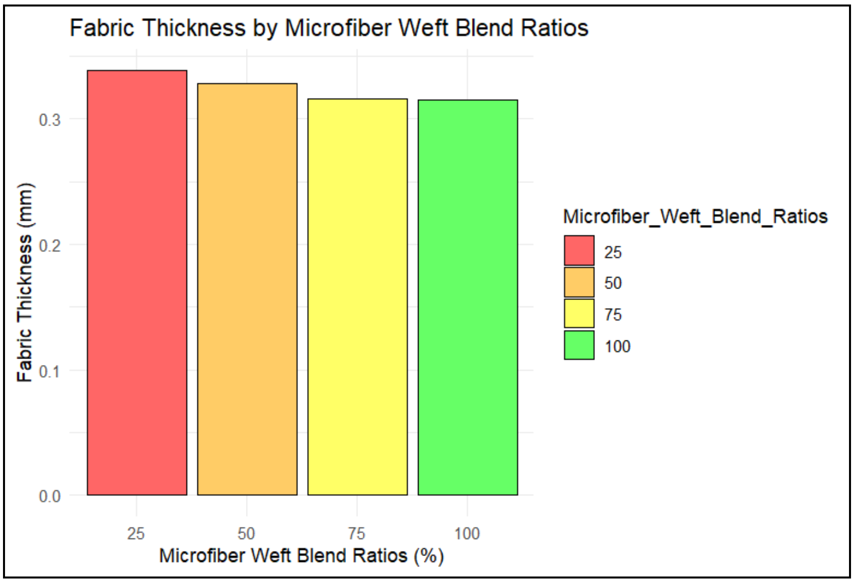

FIGURE (9) RELATIONSHIP BETWEEN MICROFIBER WEFT BLEND RATIOS AND FABRIC THICKNESS

It can be noticed from Figure (9) that there is an inverse relationship between the Microfiber weft blend ratios and fabric thickness (as the as the Microfiber weft blend ratio increases, the fabric thickness marginally decreases). This could be explained that the Microfibers have a finer diameter. These finer fibers tend the fabric to be more compact and tighter because the fibers occupy less space.

Influence of Weft Ratios on Fabric Weight

The following model investigates the relationship between Microfiber weft blend ratios and fabric weight across the linear regression equation and R-squared value. It can be noticed that there is a medium correlation between variables.

LINEAR REGRESSION EQUATION AND R-SQUARED VALUE FOR FABRIC WEIGHT:

$$y = -0.0208x + 159.55, \qquad R^2 = 0.561$$

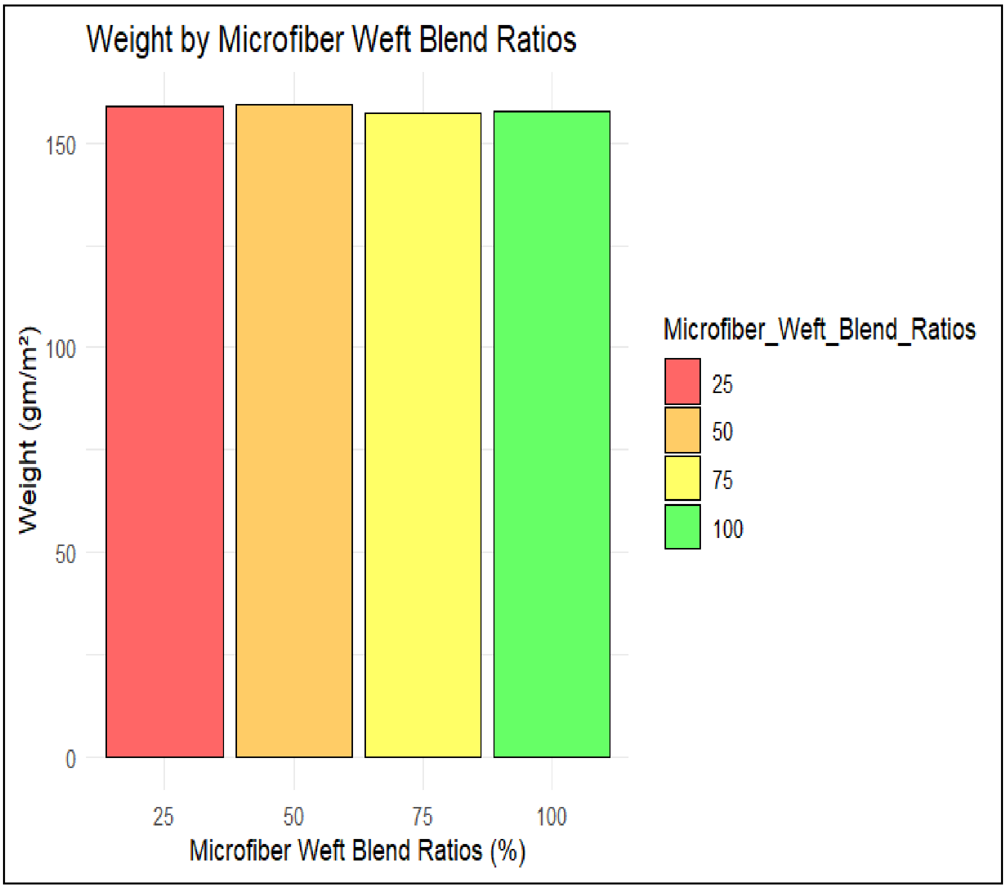

FIGURE (10) RELATIONSHIP BETWEEN MICROFIBER WEFT BLEND RATIOS AND FABRIC WEIGHT

Figure (10) shows that there is a moderate relationship between the Microfiber weft blend ratios and fabric weight. This is due to the compensating effect of the Cotton blend which balances out the weight differences as Microfiber content changes.

Influence of Weft Ratios on Fabric Air Permeability

The following model illustrates the relationship between Microfiber weft blend ratios and fabric air permeability using the linear regression equation and R-squared value. The results show a strong negative correlation between Microfiber weft blend ratios and fabric air permeability.

LINEAR REGRESSION EQUATION AND R-SQUARED VALUE FOR FABRIC AIR PERMEABILITY:

$$y = -0.0946x + 14.819, \qquad R^2 = 0.9718$$

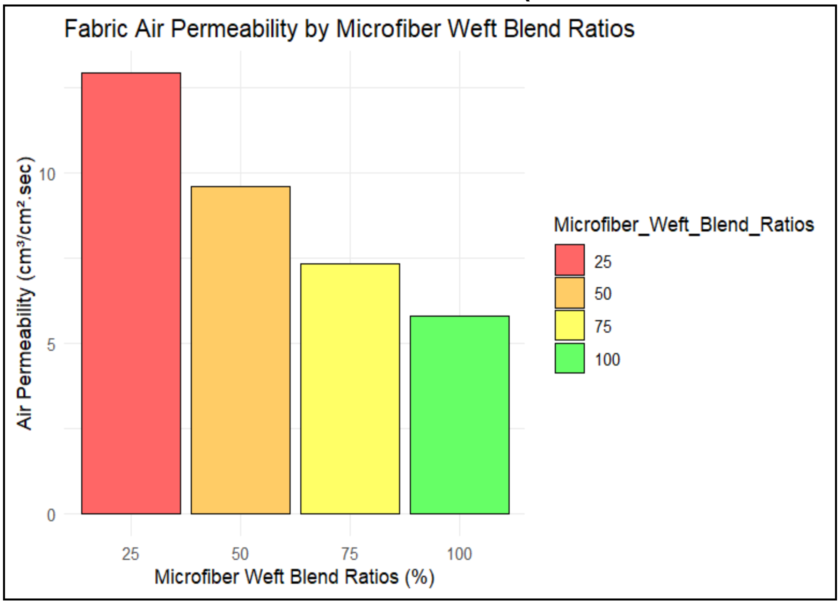

FIGURE (11) RELATIONSHIP BETWEEN MICROFIBER WEFT BLEND RATIOS AND FABRIC AIR PERMEABILITY

It can be found from Figure (11) that there is an inverse proportional relationship between Microfiber weft blend ratios and fabric air permeability. This can be attributed to the finer diameter of Microfiber compared to Cotton. This fineness leads to more compact yarn with small pore size, consequently the amount of air passes through the fabric decreases.

Influence of Weft Ratios on Fabric Water Permeability

It can be found from the linear regression equation and R-squared value shown in the following model that there is a fair positive correlation between Microfiber weft blend ratios and fabric water permeability.

LINEAR REGRESSION EQUATION AND R-SQUARED VALUE FOR FABRIC WATER PERMEABILITY:

$y = 0.0006x + 1.2322$, $R^2 = 0.4967$

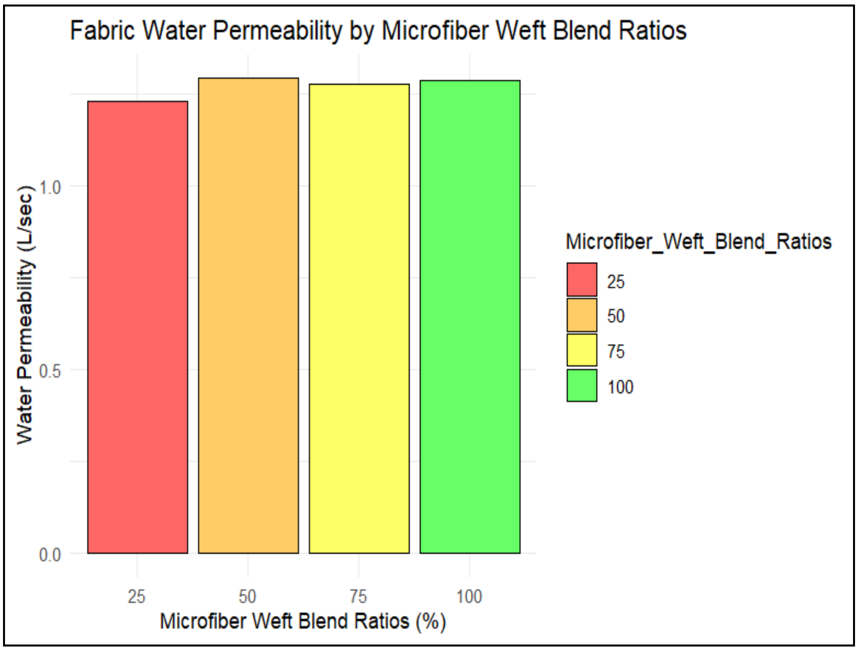

FIGURE (12) RELATIONSHIP BETWEEN MICROFIBER WEFT BLEND RATIOS AND FABRIC WATER PERMEABILITY

Figure (12) picture a moderate relationship between Microfiber content and fabric water permeability. This can be explained that the increase in the Microfiber content decreases the pore sizes which leads to a denser fabric, thereby, reducing the passage of water through the fabric.

Influence of Weft Ratios on Fabric Stain Resistance

Table (7) indicates the relationship between Microfibers weft blend ratios and the degree of stain release (removal), where the results are based on the appearance of the fabric after staining, with ratings from (1) to (5), as (1) is Poor, (2) is Fair, (3) is Good, (4) is Very Good, and (5) is Excellent.

TABLE (7) RESULTS OF FABRIC STAIN RESISTANCE TEST

Sample No.	Microfibers Weft Blend Ratios	Stain Release (Removal)
1	25	2
2	50	2
3	75	1
4	100	3

It can be observed from the findings that Sample (4) with (100%) Microfiber scored a degree of (Good) for stain removal. This may be due to the compact structure of the Microfiber that could make it more difficult for stains to penetrate deeply, hence leading to easier removal. Besides, Sample (1) and (2) recorded a degree of (Fair). This could be attributed to the higher content of Cotton that tends to absorb stains more readily. Conversely, Sample (3) which has (75%) Microfiber was the least effective in stain removal despite the high content of Microfiber. This could be due to other factors impacting the fabric such as variations in fiber properties that can affect performance.

Conclusion

- The tensile strength in weft direction increases as the Microfiber percentage increases (100% Microfiber). This is because Microfibers in the produced fabrics are made from polyester that is known for its high tensile strength.
- The fabric elongation in weft direction increases as the Microfiber percentage increases (100% Microfiber). This is because the Microfiber has a smoother surface, and this smoothness allows the fibers to slide more easily, directing to greater elongation.
- The increase in Microfiber content (100% Microfiber) improves the fabric abrasion resistance. This might be explained by the fine fiber structure that gives the fabric a smooth surface, and this smooth surface reduces rubbing during abrasion, hence lowering the rate at which the fiber wears.
- The fabric thickness marginally decreases as the Microfiber weft blend ratio increases (100% Microfiber). This could be attributed to the fine fiber diameter that tends the fabric to be tighter and more compact.
- There is a reasonable correlation between the Microfiber weft blend proportions and the fabric weight. This is because, when the Microfiber content varies, the Cotton blend's compensatory action equalizes the weight variations.

- The fabric air permeability decreases as the Microfiber weft blend ratio increases (100% Microfiber). This is owing to the fine fiber diameter of Microfiber which leads the yarn to be more compact with small pore sizes, accordingly, decreasing the amount of air passes through the fabric.
- The fabric water permeability fairly increases as the Microfiber content increases (100% Microfiber). This is because the higher percentage of Microfiber results in smaller pores that decrease in the amount of water that passes through the fabric.
- Sample (4), consisting of (100%) Microfiber, scored a degree of (Good) for stain removal. This may be attributed to Microfiber's compact structure, which makes it more difficult for stains to cling to the fibers, thereby facilitating easier and faster removal.
- The specifications of fabrics enhance the functional performance of the garment, The garment should be comfortable, durable, offer protection from the environment, and maintain its shape and size after wear and washing, these specifications enable the garment to meet its essential requirements.

Recommendations

- Using higher content of Microfiber (75% or 100%) in the weft yarns to enhance properties like tensile strength, abrasion resistance, and stain resistance.
- For uniforms in environments requiring high breathability, a moderate Microfiber blend (50% microfiber) is suggested.
- Designing fabrics with different blends depending on the specific tasks and environmental conditions faced by janitorial workers.

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