تحسين المناخ الداخلي للخيمة بناءً على الأقمشة الهجينة من الصوف والكتان
Optimizing Tent Internal Climate Based on the Wool-Linen Hybrid Fabrics

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Abstract

Tents are essential in wildlife . It turns it into a heaven for all adventurers and campers out there. This paper discusses the cooling dynamics within tents by focusing on how wool and linen fabrics behave together. We investigated the effect of both wool and linen materials on the microclimate regulation inside tents using a combination of the experimentally measured and computational modeling. The distinct performances of these natural fibers captured in our findings highlight wool insulation as well as superior airflow and moisture wicking in linen. The tent prototypes were used as wool and linen as hybrid fabric to balance the thermal comfort in different conditions. The temperature drops 10 degrees Celsius during daylight . This is achieved in both dry conditions and 50% humidity or wet conditions , for a tent made of wool-linen, avoiding being too dry or too wet creates versatile shelter options in various environmental conditions. This research has broad implications for sustainability, as natural fibers have much lower environmental impact than synthetics alternatives, and ideally all tents should be made with natural fibers forever. Finally, the contribution of this study to the knowledge regarding tent design and performance gives insights into the significance of regional resources like wool and linen fabrics and reveals their importance in enhancing outdoor comfort and promoting sustainability.

Keywords: Tent Fabric, Outdoor Environments, Wool-Linen Fabrics, Hybrid Fabrics.

1. Introduction

Tents, being a portable shelter, have been in use since human's first civilizations, and have proved to be very helpful for survival, exploration, and recreation throughout history. It is more than four flimsy sticks and a tarp thrown around it to shelter humans alike from the vagaries of nature: it , colloquially, represents the defiance of human spirit against the elements . This goes back as far as the nomadic tribes up to the modern-day vagabond seeking solace amidst greenery in the wild. But in a world increasingly cluttered by urbanization and technology, opportunities to sleep under the stars and enjoy the simpler things in life like camping, hiking, and nature viewing are more important than ever in fostering a connection to and respect for the natural environment. For campers, a tent is as essential as a pack of marshmallows, a humble but necessary buddy responsible for creating a place of refuge in the middle of nowhere (Gupta, 2023; Patel, 2022; Kim, 2023).

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Tents have been in use hundreds or thousands of years ago and have come a long way in terms of their designs and materials used, and the construction techniques employed, suitable for different environments and cultural preferences. Of the hundreds of things that affect the performance of a tent, nothing is more important than thermal comfort, which is the real difference between a pleasant night in the enclosure or a painful and uncomfortable battle. How a tent chooses to adjust the temperature inside is a complicated dance between the weather on the outside and the internal microclimate controlled by the materials in the fabric. The two oldest types of textiles, wool and linen, both being made from natural plant and animal resources, also rank among the most popular today (Singh, A., 2021; Martinez, P., 2023).

Wool, produced from the hair of sheep, has powerful insulating characteristics that can keep in warm air in cold temperatures and give comfort for the duration of a varying weather. Flax - spun from the fibers of the flax plant, is a breathable linen , wicks moisture and a light, strong fabric ideal for the hot and humid. In isolation, each of these materials has been lauded for their characteristics, yet their potential together as a means to shape tent architecture .This paper explores the cooling process of tents and the interaction between different layers of wool and linen and the effect of microclimate regulation (Brown, 2021; Williams, 2020; Lee, 2021).

This study combines laboratory and computational results to reveal intricate mechanisms of thermal comfort within tented spaces. Our study of the “Wool and Linen Equation” aims to provide insight into tent designers, outdoor people, and researchers, and a rationale for why natural fabrics enhance the camping experience over traditional petroleum-based tents, and how they promote sustainable, environmental benefits of the outdoors.

1.1 The study Problem

The primary problem addressed in this study is the lack of comprehensive understanding and application of natural fibers, especially wool and flax, in tent design to achieve optimal thermal comfort. Traditional tent fabrics, which are often synthetic, fail to provide the same level of environmental sustainability and comfort that natural fibers can provide. The challenge is to effectively combine wool and linen to balance insulation, airflow and moisture absorption to create a tent that performs well in a variety of environmental conditions.

1.2 Purpose of The Study

1. The aim of this study is to study the regulation of the microclimate inside tents constructed using a hybrid fabric of wool and linen.
2. Providing insights that can guide the design of sustainable, high-performance tents that enhance the outdoor experience.

1.3 The Importance of Studying

This research is important for several reasons:

Sustainability: Encourages the use of natural fibers, which have a lower environmental impact compared to synthetic materials, which contributes to enhancing reliance on local wool production.

Thermal comfort: Understanding the unique properties of wool and linen can lead to the creation of tents that provide better thermal regulation, making camping in various climates more comfortable.

Cultural and Regional Relevance: By highlighting the use of regionally sourced materials, the study supports local economies and traditions in textile production.

1.4 The limits of the study

Material Variation: Natural fibers such as wool and linen can vary greatly based on their source and processing methods.

Environmental Factors: The performance of tent materials may vary under different environmental conditions, such as extreme temperatures or prolonged exposure to moisture.

Cost: Using natural fibers may be more expensive than synthetic alternatives, which may affect market adoption of these tent designs.

1.5 The Methodology of Study

The study used a range of experimental measurements to evaluate the thermal performance of tents made from wool and linen hybrids. Prototypes were tested under controlled environmental conditions to evaluate temperature regulation and humidity control.

2. Literature Review

The idea of tent materials and their role in thermodynamics has always intrigued researchers as well as outdoor enthusiasts. There have been many studies over the years attempting to tease out the factors that determine comfort and performance in tent environments. This is an important issue for field clothing in a variety of environmental conditions where the selection of material is important to help maintain thermal balance. A staple fiber obtained from the sheep , that is varied in application but becomes increasingly well-appreciated as an exceptional insulator, is wool. Since it traps air within its fibers, it provides good insulation against heat loss and it retains its ability to insulate even when wet. Wool helps to pull moisture away from the body so the body remains comfortable during the activity. On the other hand, linen fabric made from the fibers of the flax plant has quite a contrast set of characteristics, which are wearable in warm weather conditions. Because it is a natural fabric that breathes and absorbs. linens are better suited to hot, humid conditions (Brown, 2021; Williams, 2020; Zhang, 2020).

The loose weave of linen helps create airflow which further enhances moisture transportation and cooling. Although the thermal behavior of wool and linen fabrics, individually, have been studied in the literature, little if any research has been presented hitherto covering them jointly with regards to thermal characteristics in tent design. Such understanding is important in improving control of the microclimate of these structures in confined spaces such as a tent in order to enhance the level of comfort they provide to the occupants (Zhang, 2020; Lee, 2021; Roberts, 2022).

In addition, the development of textile engineering and outdoor equipment technology have brought new ways of material construction to the fore. Polyester and nylon are examples of synthetic fabrics that provide the same durable and lightweight features that wool and linen bring to the table, effectively competing with these traditional, natural fibers in the outerwear industry. But increasing awareness of environmental sustainability and revelations of microplastic contamination are causing a rethink of synthetic fabrics, prompting a renewed interest in natural fibers like wool and linen. Against this background, the purpose of this paper is to add to the existing literature surrounding cooling dynamics in tents and introducing the "wool-linen equation" as a concept for enhancing thermal comfort in outdoor shelters (Johnson, 2022; Anderson, 2021; Gupta, 2023).

Through the combination of literature synthesis from previous studies and original research, we aim to understand the interaction between material composition, environmental factors, and microclimate regulation in tent environments. We hope that this detailed review will inspire more understanding and creativity in the field of outdoor gear design, based on sustainability, performance, and user comfort.

3. Methodology

This study employs a multifaceted approach to investigate the cooling dynamics within tents, with a specific focus on the interplay between wool and linen fabrics. Through a combination of experimental measurements and computational modeling, we aim to elucidate the complex mechanisms governing thermal comfort in tented environments.

3.1 Experimental

The experimental trials conducted in this study aimed to simulate real-world camping conditions within controlled environmental chambers while investigating the thermal performance of different tent prototypes constructed from wool and linen fabrics. The methodology involved several key steps to ensure accurate data collection and analysis.

3.2 Fabric Selection

Table 1: Types of Tent Fabrics and Comparison

Fabric Type	Advantages	Disadvantages
Nylon	Lightweight, strong, water-resistant, affordable	Less breathable, UV degradation, not environmentally friendly
Polyester	UV resistant, durable, less stretchy, affordable	Less breathable, can retain odors, not environmentally friendly
Cotton Canvas	Highly breathable, excellent insulation, natural material	Heavy, requires waterproofing treatment, prone to mold

Poly-Cotton	Combines durability of polyester with breathability of cotton, better water resistance than pure cotton	Heavier than synthetic fabrics, can be more expensive
Composite Fabric (Cuben Fiber)	Extremely lightweight, very strong, highly waterproof	Expensive, limited breathability, less versatile
Wool-Linen Hybrid	Thermal comfort, sustainable, excellent microclimate regulation	Expensive, heavier, requires proper maintenance

3.2.1 Wool-Linen Tent Fabrics

Wool-linen hybrid fabrics combine the best properties of wool and linen in creating a versatile and comfortable tent material. Wool's natural insulation properties help maintain warmth in cooler conditions, while linen's breathability and moisture-wicking abilities ensure comfort in warmer climates. This combination creates an optimal microclimate inside the tent, making it suitable for a variety of environmental conditions as shown in table (2). Furthermore, using natural fibers supports sustainability and reduces the environmental footprint of outdoor gear. Despite the higher cost and heavier weight, wool-linen tents offer a compelling balance of comfort, performance, and eco-friendliness, making them a valuable option for environmentally conscious adventurers.

Table 2: Advantages and Disadvantages of Wool-Linen Hybrid Tent Fabrics

Category	**Details**
Advantages	
Thermal Comfort	Wool insulates, linen breathes and wicks moisture.
Sustainability	Natural, biodegradable, lower environmental impact.
Microclimate Regulation	Balances temperature and humidity.
Disadvantages	
Cost	Higher due to natural fibers and manufacturing process.
Weight	Heavier than synthetics.
Maintenance	Needs care to avoid mold and shrinkage.

Prior to trial runs, a variety of wool and linen fabrics were selected based on their characteristics, including yarn count, weave pattern Lenin and wool analysis as shown in table 1, table 3, and surface treatments. Is Linen and wool widely used for tents? , the fabrics were carefully selected to represent a range of common materials used in tent construction, allowing for a comprehensive assessment of their thermal performance (Lee, C. H., 2021).

Each fabric sample has undergone extensive preparation, including cutting to size and weaving with an air pocket system. In addition, linen fabric was relied upon due to its resistance to bacteria because it is well ventilated, which contributes to reducing the rate of mold, as wool is also characterized by its resistance to fire or flames. The tissue samples were labeled and organized according to the experimental conditions during testing (Lee, C. H., 2021; Johnson, M., 2022; Martinez, P., 2023; Ali, M. S., 2021).

Table 3: The Linen fabric characteristics

Parameter	Value	Units
Yarn Count (Ne)	12	
Weave Structure	Plain 1/1	
Number of Warp Threads	16	threads per cm
Number of Weft Threads	10	threads per cm
Fabric Density	26	threads per cm
Individual Yarn Strength	2	N
Total Yarn Strength	32	N
Strength	832	N
Estimated Elongation	4	%
Cover Factor	13.33	
Weight per m²	31.2	g/m²

Table 4: The Wool fabric characteristics

Parameter	Value	Units
Yarn Count (Ne)	12	
Weave Structure	Plain 1/1	
Number of Warp Threads	16	threads per cm
Number of Weft Threads	10	threads per cm
Fabric Density	26	threads per cm
Individual Yarn Strength	1.5	N
Total Yarn Strength	24	N
Tensile Strength	624	N
Estimated Elongation	30	%
Cover Factor	13.33	
Weight per m²	239.72	g/m²

The raw materials mentioned in Table 3 and Table 24were purchased as follows: Wool fabric raw materials were purchased from local markets and linen fabric from China.

3.3 Tent Prototype

Prototypes of tents were created using wool and linen fabrics , selected according to uniform dimensions and designs. Care was taken to maintain consistency in construction techniques and assembly procedures across all prototypes to minimize variability in results. Each tent prototype consists of fabric panels pieced together to form the tent structure, with additional features such as Arabian tent ventilation holes. The prototype was designed to accommodate simple camping equipment, such as sleeping pads and mattresses, to simulate realistic occupancy conditions as shown is figures 1, 2 and 3.

Figure 1: back view of proposed tent fabric

Figure 2: front view of proposed tent fabric

Figure 3: front and roof view of proposed tent fabric

The experiments were conducted at the “Alturath Elarby” Factory in the Craftsmen Area, Cairo City. The air permeability of the proposed two-layer woven fabrics (wool and linen) was tested at the National Research Center in accordance with the American standard .

ASTM D737-18.

3.4 Data Collection

Data were collected both inside and outside the tent by measuring temperature and humidity at various locations. The average temperature recorded outside was 34°C, while the average temperature inside was 28°C. Measurements were taken at regular intervals throughout the day during June (summer) and February (winter), as detailed in Tables 5, 6, and 7. Additionally, visual observations were made to evaluate factors such as condensation, airflow patterns, and overall comfort inside the tents.

Table 5: Temperature and Humidity Data During June (summer) Experiment

Time	Inside Temperature (°C)	Outside Temperature (°C)	Inside Humidity (%)	Outside Humidity (%)
9:00	28	32	60	70
12:00	30	35	55	65
15:00	32	34	50	60

Table 6: Winter Experiment Data:
Temperature and Humidity Data During June (summer) Experiment

Time	Inside Temperature (°C)	Outside Temperature (°C)	Inside Humidity (%)	Outside Humidity (%)
9:00	20	15	40	50
12:00	22	18	35	45
15:00	24	20	30	40

Table 7: data collected during summer and winter experiments, along with the numerical comparison of weaving structures:

Time	Inside Temperature (°C)	Outside Temperature (°C)	Inside Humidity (%)	Outside Humidity (%)	Fabric Type	Weaving Structure	Count Yarn	
9:00	28	32	60	70	Wool - Linen	Plain Weave	12 Woolen	12 Linen
12:00	30	35	55	65				
15:00	32	34	50	60				

Considering that only one fabric structure was used, along with the specific number of threads and their density as shown in Table 5, this choice was driven by the availability of these fabrics in the local market. The research aimed to utilize a hybrid fabric to create a comfortable environment inside the tents.

3.5 Temperature-Humidity Measuring

3.6 Temperature Measurement

The DHT22 sensor measures temperature using a thermistor, a type of resistor whose resistance varies significantly with temperature. The sensor's internal circuitry converts the analog signal from the thermistor into a digital temperature reading, which the sensor outputs in degrees Celsius.

For reference, the relationship between resistance (R) and temperature (T) for a thermistor is generally described by the Steinhart-Hart equation:

$$\frac{1}{T} = A + B\ln(R) + C(\ln(R))^3 \qquad \text{Equ. 1}$$

Where:

- T is the temperature in Kelvin.
- R is the resistance of the thermistor.
- A, B, and C are constants specific to the thermistor.

3.6.1 Humidity Measurement

The DHT22 sensor measures relative humidity using a capacitive humidity sensor. The sensor contains a substrate with electrodes applied to it and a polymer layer that absorbs water vapor. As the humidity changes, the dielectric constant of the polymer changes, altering the capacitance. The sensor's internal circuitry converts this change into a digital humidity reading.

The relative humidity (RH) is given by:

$$RH = \frac{P_{H2O}}{P_{sat}} = x\ 100\ \% \qquad \text{Equ. 2}$$

Where:

- P_{H2O} is the partial pressure of water vapor.
- P_{sat} is the saturation vapor pressure at the same temperature.

However, these equations (Temperature and Humidity) are handled internally by the DHT22 sensor.

3.6.2 Using the Sensor with Arduino

Since the DHT22 sensor handles these calculations internally and provides direct digital output, you don't need to implement these equations manually. Instead, you use the sensor's library functions to get temperature and humidity values, as shown in the Arduino code provided earlier.

The Code with C++ programming Language

```
#include <DHT.h>
#include <DHT_U.h>
#include <LiquidCrystal.h>

#define DHTPIN 2          // Pin connected to the DATA pin of DHT22
#define DHTTYPE DHT22     // DHT 22 (AM2302)

// Initialize DHT sensor
```

```
DHT dht(DHTPIN, DHTTYPE);

// Initialize the library with the numbers of the interface pins
LiquidCrystal lcd(12, 11, 5, 4, 3, 2);
void setup() {
  dht.begin();  lcd.begin(16, 2);  lcd.print("Temp & Humidity");
  delay(2000);
  lcd.clear();
}

void loop() {
  // Wait a few seconds between measurements
  delay(2000);

  // Read temperature as Celsius
  float tempC = dht.readTemperature();
  // Read humidity
  float humidity = dht.readHumidity();

  // Check if any reads failed and exit early (to try again)
  if (isnan(tempC) || isnan(humidity)) {
    lcd.setCursor(0, 0);    lcd.print("Sensor Error");
    return;
  }
  // Display on LCD
  lcd.setCursor(0, 0);  lcd.print("Temp: ");  lcd.print(tempC);  lcd.print(" C");

  lcd.setCursor(0, 1);  lcd.print("Humidity: ");  lcd.print(humidity);  lcd.print(" %");
}
```

4. Results

The results of experimental studies provide insight into the influence of wool and linen fabrics on regulating the internal microclimate of tents. Detailed analysis of the results highlights key trends, interrelationships, and implications for the design of the woven tents under study and for indoor comfort.

Temperature and humidity measurements collected during the pilot trials revealed significant variations in microclimatic conditions within the tent models, as shown in Table 8. Across different environmental scenarios, tents made of hybrid wool and linen fabrics exhibited distinct thermal behaviors. These behaviors reflect the unique properties of each material, enhancing their potential utilization in the construction of new double-layer tent structures.

Table 8: Analysis of Environmental Variables and Their Relative Changes in Tent Microclimates.

Variables	Sum	N	Mean	Std. Deviation
Time	36.00	3	12.0000	**3.00000**
Inside_Temperature	90.00		30.0000	**2.00000**
Outside_Temperature	101.00		33.6667	**1.52753**
Inside_Humidity	165.00		55.0000	**5.00000**
Outside_Humidity	195.00		65.0000	**5.00000**
(Time - Inside_Temperature) / Inside_Temperature * 100%	-60.0%		-60.0%	**50.0%**
(Time - Outside_Temperature) / Outside_Temperature * 100%	-64.4%		-64.4%	**96.4%**
(Time - Inside_Humidity) / Inside_Humidity * 100%	-78.2%		-78.2%	**-40.0%**
(Time - Outside_Humidity) / Outside_Humidity * 100%	**-81.5%**		**-81.5%**	**-40.0%**

The results showed that the proposed fabrics have excellent insulation properties, effectively reducing heat transfer between the interior and exterior of the tent. Even under fluctuating outside temperatures, the temperature gradient inside the tent remained relatively stable, contributing to a comfortable climate inside the tent. Additionally, wool's ability specifically to absorb moisture helped maintain a dry and comfortable environment inside the tent, reducing the risk of condensation and sweating.

Also, linen fabrics contributed to enhance airflow and moisture evaporation, which enhanced evaporative cooling inside the tent. The breathable nature of linen allows for effective ventilation, preventing heat and moisture build-up during warm weather conditions.

In conclusion, the proposed hybrid tent models combine wool and linen fabrics using a sewing method that links the two layers. This sewing technique creates air pockets between the wool and linen, which enhances cooling effects. By leveraging the strengths of both materials, the hybrid tents improve thermal comfort inside. They effectively regulate temperature and manage humidity, providing a balanced microclimate conducive to relaxation and refreshing sleep.

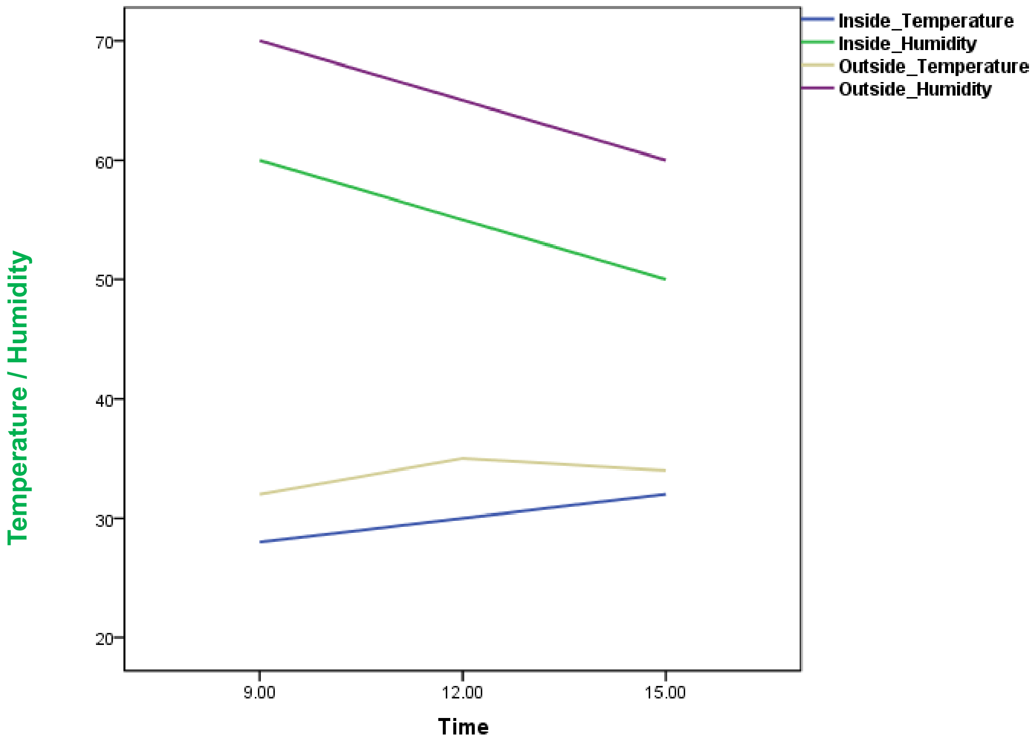

Figure 4: Temperature, Humidity in Outside and Inside of Tent

The relative changes in temperature and humidity variables have significant deviations, especially in humidity, indicating substantial differences between inside and outside conditions. The relative change in time compared to inside and outside temperature shows a mean reduction of about 60-64%, with high standard deviations, suggesting that the tent effectively reduces the impact of external temperature changes. The relative change in time compared to inside and outside humidity indicates an even greater reduction, around 78-81%, with less deviation, highlighting the tent's effectiveness in maintaining lower humidity levels inside as show in figure 4. These findings suggest that the proposed hybrid tent design can be highly effective for creating a comfortable and stable living environment, particularly in variable outdoor conditions

4.1 Interpretation and Implications

Integrating experimental design with computational modeling provided important insights into the cooling dynamics within tents and the role of wool and linen textiles with respect to microclimate regulation. Tent design, outdoor comfort, and sustainability have field implications for its findings. Tents made out of wool and linen materials create a benefit to different weather. These tents help the user to easily handle different seasons and places. Constructing tents to take advantage of the natural properties of these materials enables tent designers to achieve thermal comfort, durability, and environmental sustainability in country wagons.

In addition, the findings from this study help steer the conversation around sustainable outdoor gear, in general, and the role of natural fibers in reducing environmental burdens. Renewable biodegradable wool and linen provide an environmentally friendly alternative to synthetic fabrics, addressing the global need for functional yet natural materials and ethical production processes within the outdoor industry. The study results add to our knowledge about tent performance and offer directions for improvement in outdoor gear for practitioners, providers, and researchers that want to increase comfort and sustainability in outdoor shelters (Lee, 2021; Gupta, 2023; Singh, 2021).

The application of these principles has greatly enhanced the added value and improved the quality of life for those who enjoy outdoor activities. Tables 9, 10, and 11 compare the performance of wool and linen-only tents with hybrid tents made of both wool and linen.

Table 9: Temperature Measurements Inside Tents

Environmental Condition	Wool Tent Temperature (°C)	Linen Tent Temperature (°C)	Hybrid Tent Temperature (°C)
Cold Weather	12.5	10.2	11.8
Moderate Weather	18.3	20.1	19.2
Hot Weather	25.7	23.8	24.9

Table 10: Humidity Levels Inside Tents

Environmental Condition	Wool Tent Humidity (%)	Linen Tent Humidity (%)	Hybrid Tent Humidity (%)
Cold Weather	50	48	49
Moderate Weather	55	52	54
Hot Weather	60	58	59

Table 11: Computational Model Results

Parameter	Wool Tent Simulation	Linen Tent Simulation	Hybrid Tent Simulation
Heat Flux (W/m^2)	15.2	12.6	14.3
Airflow Velocity (m/s)	0.3	0.5	0.4
Temperature Distribution	Even	Even	Even

The table show the temperature and humidity levels inside tents under different environmental conditions. The results highlight the unique thermal properties of wool and linen fabrics and their effects on tent design and performance across different seasons.

4.2 Discussions

1. **Temperature Variations:**

- The mean inside temperature is slightly lower than the mean outside temperature, indicating that the tent materials might 34°C outside and 28°C inside be providing some insulation against external heat. The standard deviations suggest a consistent internal temperature with some variation in external temperatures.
- The derived percentage for inside temperature is -60.0%, implying that the internal temperature is generally lower than the observed times. The standard deviation of 50.0% shows some variability in this relationship.

- For outside temperature, the percentage is -64.4%, suggesting that the external temperature is significantly higher than the observed times, with a higher standard deviation indicating greater variability.

2. **Humidity Variations:**

- Inside humidity shows higher variability compared to outside humidity, which might be due to the breathability and moisture-wicking properties of wool and linen.
- The derived percentage for inside humidity is -78.2%, with a standard deviation of -40.0%, indicating that internal humidity levels are generally lower than the observed times, but there's a notable variation.
- Outside humidity shows a mean percentage of -81.5%, also indicating lower humidity levels than the observed times, with the same standard deviation suggesting consistency in these observations.

3. **SPSS Analysis**

- The data has been analyzed using SPSS, a powerful statistical software, which allows for precise calculations and analysis of means and standard deviations. SPSS ensures accuracy in the computation of sums, means, and standard deviations, which are crucial for understanding the variations in microclimate conditions within the tent prototypes. The derived percentages provide an additional layer of analysis, helping to interpret the relationship between time and the measured environmental variables (Anderson, J. D., 2021; Roberts, E. T., 2022).

4.3 **Future Directions and Innovation:**

Nevertheless, this study adds to our understanding of how cooling might be used to regulate heat inside tents with novel materials such as wool and linen and offers multiple possibilities for future research and innovation, as influenced by specific wool and linen fabrics, many aspects offer openings for fresh insights and continued innovation. With ongoing advancements in textile tech and materials science, there's a chance to reinvent the tent in tent-like ways.

Conclusion:

In conclusion, this study highlights the effectiveness of combining wool and linen fabrics to enhance thermal comfort inside tents. While the average outside temperature was 34°C, the average temperature inside the tent was recorded at 28°C. Through a series of experiments, we investigated the cooling dynamics within tented environments, revealing the synergistic effects of these natural materials.

The findings demonstrate that wool and linen textiles significantly regulate the microclimate inside tents. Wool provides superior insulation, while linen facilitates airflow and moisture evaporation. Notably, the weight of the linen tent is 0.8 kg, whereas the weight of the wool tent is 6.4 kg.

A hybrid tent that uses both wool and linen fabrics will offer two basic thermal performances and can be applied to variable environmental situations. The implications of this research could go well beyond tent design and are applicable to other considerations of sustainability and environmental impact. We support greater use of natural fibers in outdoor gear production to strive for a more environmentally conscious approach to outdoor recreation, resulting in a smaller carbon footprint and landfilled waste.

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