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EXPERIMENTAL ASSESSMENT OF PERMEABILITY FOR DIFFERENT MULTILAYERED TEXTILE COVERINGS

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Abstract: *The aim of the paper was the research on the distribution of moisture through the mattress cover materials in real conditions and the variation of moisture accumulated by different test methods.*
In the analysis of moisture transfer processes through textiles it is necessary to distinguish between the transport of moisture in the form of vapor (molecule) and the liquid state (drop). Thus, several tests (permeability, drip, wetting) were used to highlight the way of sorption of multilayer knits for mattress covers. The purpose and novelty of the research is the use of multilayer textile supports from different and associated raw materials varied in the textile ensemble with the special destination, influencing differently the values of water vapour permeability and vaporization The results demonstrated the influence of raw material and the other specifications on vapour permeability and absorption capacity of multilayer knitwear. Textile coverings with polyester, bamboo and viscose in composition showed the highest permeability and low vaporization index. Future research will characterize the thermophysiological comfort of the investigated supports by other indices that characterize the functionality of the products.

Key words: *matresses, water vapour resistance, drop test, moisture, surface*

1. INTRODUCTION

In recent years, attempts have been made to explore technologically innovative sleeping surfaces for an active life and real attracting health. To have a waterproof material with good water vapour transmission ability on mattress cover, the textiles used should meet pre-established criteria regarding the characteristics of the component materials. So, these water absorption management properties have been tested and improve sleeping comfort significantly compared to ordinary high-quality mattress fabrics. The quality of the mattress cover and the sleeping surface determine the comfort of sleeping, they must allow air to flow. Many of the physical properties of knitted materials that influence the comfort properties of products have been investigated, so the type of fibre, yarn density, weight, and thickness, fabric porosity of the textile backing are important [1,2]. A priority in the creation of textile materials is to ensure the comfort parameters and thus the functions of the textile products are fulfilled considering their destination. Moisture management in the textile material can decide the destination of the finished product [2].

There are studies that assess the influence of the dyeing and finishing processes of textile substrates on vapour permeability and implicitly on the other characteristics of thermophysiological comfort, air permeability and thermal insulation [3]. Some studies evaluate the influence and measurement of the effects of mattress types on sleep quality, skin temperature and estimation of subjective evaluation. Average skin temperature, deep sleep, sleep efficiency, sleep latency and subjective assessments were significantly affected with mattress cover types [4, 5]. Other scientific studies address the change in vapour permeability following the process of doubling textiles with woven or non-woven chemical layers, being recommended depending on the season.The thickness of the material and the structure of the assembly of layers influences the vapour permeability [6].

This article examines the thermophysiological impact/sorbtion properties through the water vapour permeability of multilayer mattress covers with different fibrous compositions, thickness, weights and structures. Studies in the literature describe different textile structures to reveal thermophysiological comfort, but multilayer types assembled by binding materials are little addressed. It is thus proposed to investigate the behavior of multilayered textiles was highlighted by the calculation and graphical interpretation of the characteristics regarding the transport capacity of moisture in the vapour state.

2. EXPERIMENTAL DESIGN

In this experimental study, the permeability resistance properties of textile cover, were analized according to the type of raw material. Elevan types of multilayers knitted samples, with different compositions, shown in Table 1, were investigated.

Table 1: *Characteristics of tested multilayers fabrics (fabric specifications)*

Multi layered sample	**Fibrous composition of the layers**	**Yarn density [tex]**	**Fabric structure**	**Fabric weight [g/m^2]**
MS1	PES 167Dtex/PES 150Den/Filler yarn PES1200 Den	16.7/16,6/133,3	single jersey	230
MS2	PES 20/1 Ne/PES 150Den/Filler yarn 3000Den	20/16,6/333,3		268
MS3	PES 150 Den/PES 150 Den/Filler yarn 1200 Den	16.6/16,6/133,3		243
MS4	Cotton 24/1 Ne+PES 150 Den/Filler Yarn 1200 Den	24/16,6/133,3		270
MS5	PES 20/1Ne +PES 150 Den/Filler yarn 300 Den	20/16.6/33.3		216
MS6	PES 150 Den/PES 150 Den/Filler yarn 1200 Den	16.6/16.6/133.3		265
MS7	Bamboo20/1Ne+Viscose20/1Ne/Filler yarn1200 Den	20/20/133.3		285
MS8	Wool 20/1 Ne +PES 20/1 Ne/Filler Yarn 1200 Den	20/20/133.3		270
MS9	PES 167 Dtex +Viscose 20/1Ne/Filler yarn 1200 Den	16.7/20/133.3		225
MS10	PES 150 Den +Viscose 29.5tex/Filler yarn 1200 Den	16.6/29.5/133.3		235
MS11	Cotton 24/1 Ne +PES 150 den/Filler yarn 1200 Den	24/16.6/133.3		252

The multilayer covers were tested by meeting specific standards. The determinations were performed according to the standards in force STAS 12751-89 Determination of wetting capacity. The drop method and STAS 90005-79 Measurement of water vapour permeability of textiles. The method used to obtain the data needed to determine and evaluation of absorption resistance of multilayers fabrics and is determined by controlling these indicators, this method with Herfeld glasses. Absolute and relative water vapor permeability Pv [g] Pv [%] and index vaporization μ [g/m² h] were used as direct indicators to assess the vapour transfer by diffusion. The vapour permeability assessment is carried out by the calculation of the mass difference recorded by the test assembly, investigating both the front and back of the sample. For calculation of steam transfer indicators were used the parameters specified below.

Vapour permeability is calculated using the formula [6]:

$$Pv = M_i - Mf \qquad [g] \text{ and} \qquad \textbf{(1)}$$

$$Pv = (M_i - Mf) * 100 \quad [\%] \qquad \textbf{(2)}$$

Vaporization coefficient (μ) is calculated using the formula [7]:

$$\mu = Pv / S * t \quad [g/m^2 h] \qquad \textbf{(3)}$$

Where: S – vaporization surface [m²] and t – vaporization time [hours]

The drip test allows to determine the amount of water taken from the textile support / water absorption in a given time. After determining the mass of the dry samples of m_{us} [g] textile material, they are placed for 10 seconds over the liquid dripping on the glass, then determining the mass of the wet samples m_{ud} [g]. Water absorption capacity / CA [%] is obtained with the relation (4):

$$CA = (m_{ud} - m_{us})/m_{us} \quad [\%] \qquad \textbf{(4)}$$

The drip method is also used, which by timing the time elapsed from the start of dripping on the textile material and until the diffusion of water droplets ceases is the wetting time (s) and is the evaluation of wetting.

3. RESULTS AND DISCUSSION

The partial results obtained from the test performed according to the standardized method, namely the absolute and relative values of the calculated vapour permeability at which the samples were evaluated, are presented in Table 2.

Table 2: *Absolute and relative values of water vapour permeability for 24 and 48 hours*

Multilayered sample no.	**Surface type**	**Pv 24h [g]**	**Pv 48h [g]**	**Pv 24h [%]**	**Pv 48h [%]**
MS1	Face up/ Face down	3.37/3.41	6.92/6.92	3.27/3.32	6.72/6.75
MS2	Face up/ Face down	3.13/3.12	6.53/6.48	3.06/3.04	6.37/6.31
MS3	Face up/ Face down	3.23/3.26	6.69/6.78	3.17/3.18	6.58/6.61
MS4	Face up/ Face down	3.23/3.32	6.70/6.67	3.13/3.22	6.51/6.48
MS5	Face up/ Face down	3.26/3.21	6.68/6.61	3.21/3.12	6.57/6.41
MS6	Face up/ Face down	3.38/2.75	6.88/6.31	3.30/2.66	6.73/6.10
MS7	Face up/ Face down	3.30/3.29	6.73/6.80	3.21/3.16	6.56/6.54
MS8	Face up/ Face down	3.12/3.28	6.57/6.78	3.05/3.19	6.44/6.60
MS9	Face up/ Face down	4.81/3.38	8.22/6.94	4.68/3.25	8.00/6.69
MS10	Face up/ Face down	3.29/3.31	6.80/6.81	3.21/3.24	6.63/6.66
MS11	Face up/ Face down	3.32/3.45	6.19/7.08	3.25/3.35	6.07/6.88

The relative permeability to 24 h is higher for chemical fiber samples, given that natural fibers with high hygroscopicity lead to the pores being covered with the drops of water absorbed (fig.1 and 2).

Figures 3 and 4 represent the variation of the absolute vapour permeability for the samples studied.

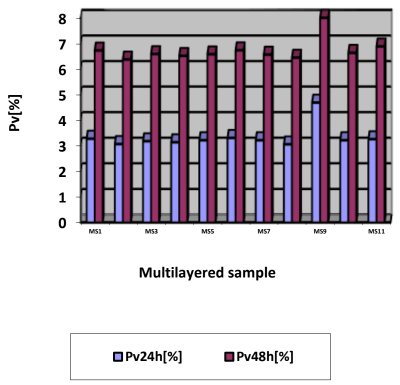

Fig 1. *Graphical representation of the variation of relative water vapour permeability for the samples face up, after 24 and 48 hours*

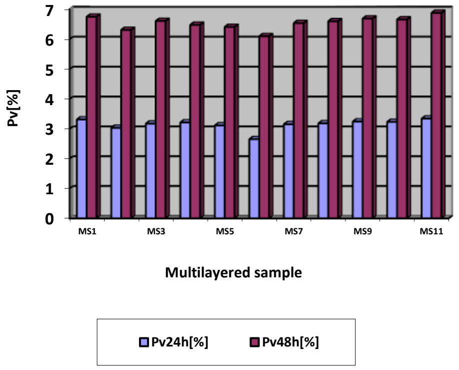

Fig 2. *Graphical representation of the variation of relative water vapour permeability for the samples face down after 24 and 48 hours*

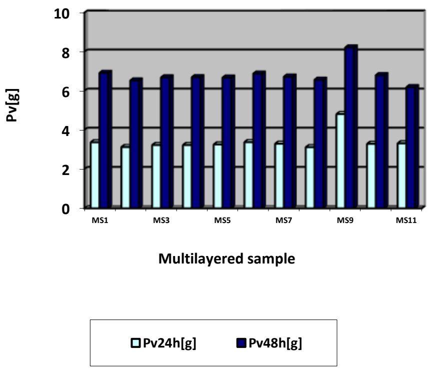

Fig 3. *Graphical representation of the variation of absolute water vapor permeability for the samples face up, after 24 and 48 hours*

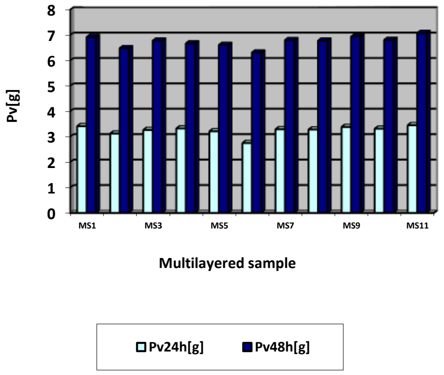

Fig 4. *Graphical representation of the variation of absolute water vapour permeability for the samples face down, after 24 and 48 hours*

It is observed that the highest vapour permeability has the multilayer textiles of polyester 150den, but also of polyester and viscose the front layer surfaces of 8 % and 6.73%, the smallest being in the MS6 and MS2 samples the back-layer surface (6.31% and 6.10%). Data from the literature are confirmed due to the viscose fiber with higher hygroscopicity [6].

In samples containing front layer cotton, the permeability decreases over time, due to the hydrophilicity of the moisture-absorbing material resulting in pore blockage and decreased diffusion transmission, due to the capillary-porous structure [7]. It should be noted that the vapor permeability which represents the ability to transfer perspiration is in a negative relationship with the weight of the samples and the density of the textile support, so MS5 and MS9 specimens with the lowest masses have the highest permeabilities.

Table 3 shows the results after the drip test of water uptake and wetting capacity, the values calculated as the average of six determinations, and the calculated values of the evaporation coefficient.

Table 3: *Vaporisation index values, water absorption capacity and wetting time of multilayer covers*

Multi layered sample	Surface type	μ 24h [g/m^2 h]	μ 48h [g/m^2 h]	CA [%]	Wetting time [s]
MS1	Front layer/ Back layer	27.94/ 28.28	13.98/14.14	6.07/6.45	1/1
MS2	Front layer/ Back layer	25.95/25.87	13.01/12.93	5.44/5.26	2/2
MS3	Front layer/ Back layer	26.78/27.03	13.39/13.51	7.97/9.45	1/1
MS4	Front layer/ Back layer	26.78/27.53	13.39/13.76	4.97/5.03	2/7
MS5	Front layer/ Back layer	27.03/26.62	13.51/13.31	6.07/6.98	1/2
MS6	Front layer/ Back layer	28.03/22.80	14.01/11.40	6.26/6.91	2/1
MS7	Front layer/ Back layer	27.36/27.28	13.68/13.64	5.26/5.94	3/2
MS8	Front layer/ Back layer	25.87/27.20	12.93/13.60	3.72/4.42	8/10
MS9	Front layer/ Back layer	39.89/28.03	19.94/14.01	6.67/7.84	2/2
MS10	Front layer/ Back layer	27.28/27.45	13.64/13.72	6.32/8.06	2/2
MS11	Front layer/ Back layer	27.53/28.61	13.76/14.30	5.61/4.93	8/4

The figures 5 and 6 show the changes that occur as a result of calculating the evaporation coefficient.

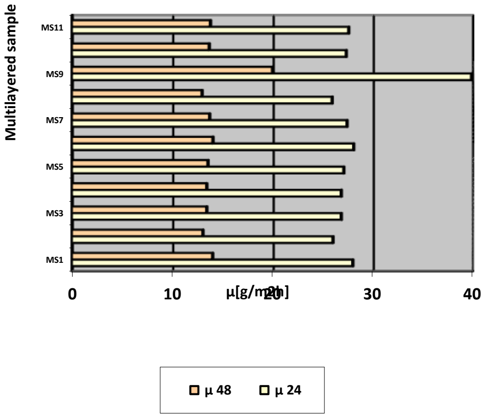

Fig 5*. Graphical representation of the variation of the vaporization index at 24 and 48h for multilayer textiles, face up surface*

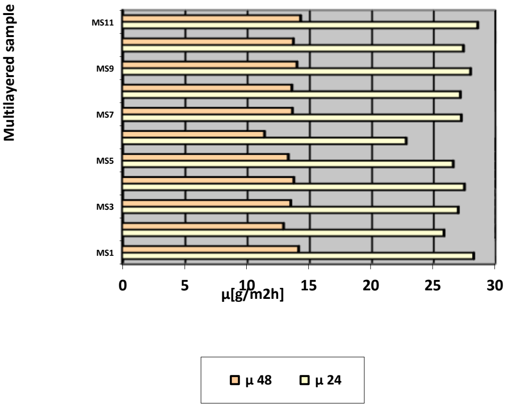

Fig 6*. Graphical representation of the variation of the vaporization index at 24 and 48h for multilayer textiles, face down surface*

The multilayer structure must carry excess moisture to the outside, the values of the evaporation index fall for 24 h and 48h in the range 39.89 [g/m² h](MS9) and 11.40[g/m² h] (MS6), so a decrease of 28.57% between the surfaces makes it down and makes it up.

After analyzing the graphical representation in **fig. 7**, we can observe:

- the highest absorption capacity is shown by the sample MS3 si MS10 back layer (9.06 si 8.45%) and the lowest value for absorption capacity is shown by the sample MS8 and MS4 front layer.
- A certain constant of the absorption capacity is recorded at the samples from polyester/polyester, bamboo/viscose and polyester/viscose (MS5, MS6, MS7, MS9).

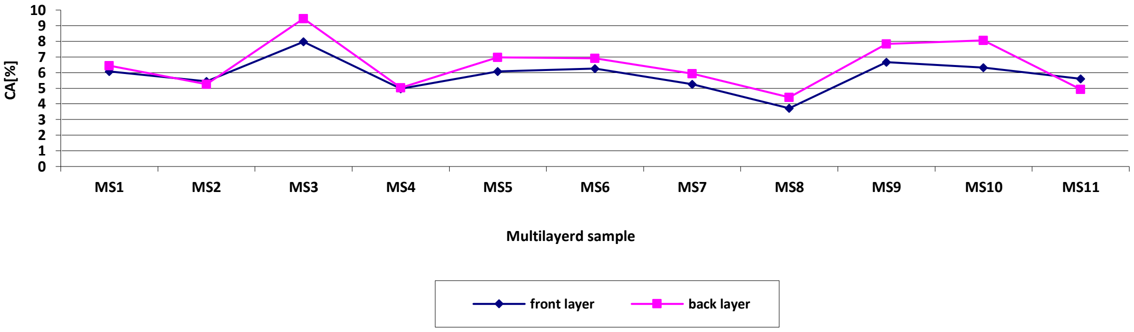

***Fig.7** Influence of the moistening on the absorption capacity of the multilayer textile samples*

4. CONCLUSIONS

The values obtained for the permeability of the multilayers knitted fabrics are different, being mainly influenced by the raw material and thickness used to obtain the mattress fabrics.
The multilayer structure of the cover's impresses comfort of the mattress and remains a dry sleeping environment and having a better hygiene.

The raw materials used for the experimental study are promising for the thermophysiological properties, the best water vapour permeability being conferred by the polyester blend of different types, then the polyester or bamboo with viscose, in a negative relationship with the weight of the evidence. Mattress covers made in this way should carry excess moisture to the outside when there is a certain content that causes discomfort. The following investigations will find suitable solutions for assembling the knitted layers so that the coverings have a remarkable absorption capacity available for each consumer.

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