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Cotton-made cellulose support for anti-allergic pajamas

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ABSTRACT

The cotton used to produce an interlock knitted fabric is alkaline boiled, bleached and after drying, it is grafted with monochlorotriazinyl-beta-cyclodextrin (MCT-β-CD) as a support of an inclusion compound (IC) with natural anti-allergic active principles, in order to improve the curative properties and the comfort. Are used: extract of *Viola tricolor Herb* (VtH), solution of *propolis* (P) and of *menthol* (M), as well as the pharmacologic products: advantan (AD), hydrocortisone (HYD) and pimechrolimus (PI). The dimensions of the active compound molecules were established with software. The textile material grafted with MCT-β-CD and with active principles absorbed in the cyclodextrin cavity is investigated by EDX. The anti-microbial activity of VtH, P and M was tested. Tactile determinations of softness were performed with human appraisers. By assembling the anti-allergic knitted fabric with untreated fabric, therapeutic pajamas were obtained. The manner to process and manufacture the pajamas for patients with contact and atopic (DA) dermatitis (DC) is presented.

1. Introduction

More than 500 million people suffer from different forms of allergies. Allergy is considered an exaggerated immune response of the body to a foreign substance named allergen. Recent researches suggest a continuous rise of different forms of allergies as a consequence of the standard of living due to rapid industrial civilization. Allergy is the excessive and anarchic response of the immune system to the action of an intruder known as allergen, which for most people is harmless (Aalberse & Crameri, 2011; Moldovan, 2000).

Allergic diseases are caused by various environmental factors (Moldovan, 2000; Popescu, 1998). Susceptible individuals are allergic, and are called atopic. In order to become active, the allergen requires overcoming a threshold limit (Aalberse, 2011) and this for a period necessary to initiate an immune response. The presence of an allergen is often stimulated by microbial flora (Rippke, 2004). Available evidence suggests that viral respiratory infection can initiate, maintain and activate exacerbation of allergic conditions in respiratory tract. Allergies are characterized by an innate or adaptive immunity malfunction, with specific symptomatology for the skin (dermatitis), for nasal mucosa (rhinitis), for respiratory tract (asthma) or even high – risk lethal symptoms such as anaphylactic shock (Petrescu, Branisteanu, & Statescu, 2008).

The works presents the stages of producing the textile support with anti-allergic properties, which are used for pajamas manufacturing. The medical information is only used to the extent that it helps understanding the aspects which determine the textile material processing. The stages in realization of the anti-allergic clothing are adapted to the symptoms of DC and DA affected patients. The specialized literature (Aalberse & Crameri, 2011) specifies that, in order to efficiently cure the coetaneous allergic manifestations, it is necessary to apply specific medication, correlated with the utilization of pajamas that provides a coetaneous special comfort at the contact between the sick skin and the clothes.

The allergy prophylaxis is difficult. The discomfort and frustration of patients with allergic dermatitis, lethal cases and the costs of medical assistance represents a problem that motivates it. When the allergen has not been identified, avoiding it from patient proximity is not possible and the measures and medical treatment attenuate the disease symptoms, but cannot solve the malady.

Fig. 1 presents the location where the anti-allergic textile material acts to prevent or to stop the allergy evolution. Thus, at the allergen entrance, by means of lymphocytes T helper (white cells playing the role in phagocytosis), an IgE is formed as an element of cellular memory, which later on is fixed on the mastocite membrane.

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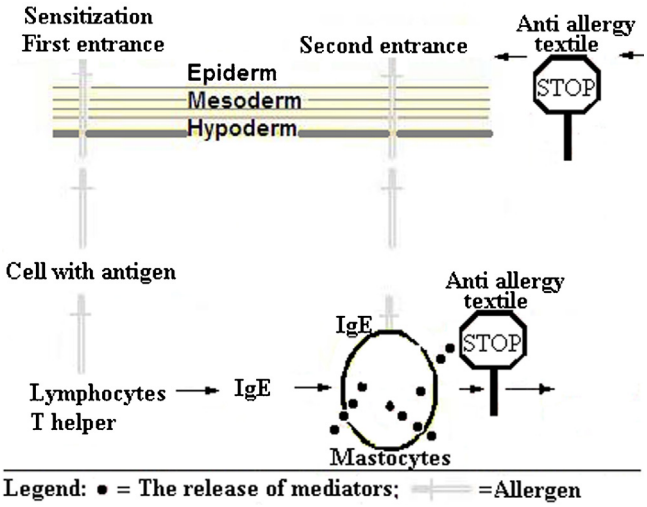


Fig. 1.

Under this situation, the body is sensitized about the presence of an allergen by the formation of antibodies which remember the intruder characteristics. Sensitization is the state of an organism which reacts in a manner different from a normal one. After the second entrance, the allergen is recognized by the specific IgE (Moldovan, 2000; Petrescu et al., 2008) and, together with it, are fixed on the mastocyte membrane, triggering the release of mediators (histamine, cytokines, substances released by nervous fibres that transmit a nervous inflow). The release of mediators initiates the allergic episode as an energetic, uncontrolled and unpredictable reaction. In order to stop the anarchic manifestations, emergency pharmaceutical products are used, such as Theophylline, as well as immune-suppressing products (such as hydrocortisone or newer generations) or active principles from natural products that contain flavonoides (VtH and P). The interaction of flavonoides with chemical mediators is not known in literature. The anti-allergic textile support is a barrier that stops the second entrance (Fig. 1) of allergen through skin or blocks the mediator release from mastocytes by the therapeutic action of the active principle provided by the textile interface.

2. Experimental

2.1. Materials and methods

In our researches one used as a textile support an all-cotton interlock knitted fabric from yarns with fineness Nm = 60/l. The usual reactives for cotton articles preparations are: NaOH, Na_2CO_3, $Na_2S_2O_3$, H_2O_2 and Na_2SiO_3 in commercial form, without additional purification treatments, as well as an anionic surfactant Lavotan (Bezema) and MCT-β-CD (Wacker Chemie).

For the application on the textile support, we have used the alcoholic extract (25%) of VtH (a plant from spontaneous flora of Romania); P – from bees families of Danesti (Vaslui county) collected with a special spoon from the wooden part of the beehive (in 2010); the obtained P is conditioned, weighted and solved in ethanol (98%) at 40 °C and filtered on filter paper. The filtrate is concentrated through evaporation, after which it is solved again in ethanol as a 30% (w/v) solution. – M is found in *Mentha piperita*, but its extraction from plants is performed with a low yield. The synthetic product is used instead, as 30% solution of tablets (Sigma Aldrich) in ethanol.

In order to determine the molecule dimensions of the active compounds from VtH and P, as well as from M, AD and PI, the MarvinSpace ChemAxon 5.4.0.0 software was used.

Studies on toxicity were carried out on VtH and M on mices and Guinea pigs purchased from the "Cantacuzino" Institute of Bucharest. The performed procedure and experiments are practiced in pharmacology to establish the mean lethal dose of a product, denoted by DL_{50} according to OECD 425 standards, and afterwards to establish the therapeutic dose.

The determinations of elemental analysis used EDAX Genesis 2005 equipment (FEI Company from Holland).

For softness determinations, three groups of appraisers were used. The first group from the Faculty of Textiles from Iassy, coded as **TPMI**, consists of 50 persons: teaching personnel, students from the Department of Chemical Finish, and auxiliary personnel with ages between 20 and 29 years, 30 and 39 years, and 50 and 65 years. The second group, coded as **ANR**, consisted of 10 sightless persons from the Association of Sightless Persons, Iasi, aged between 33 and 75 years. The third group consisted of 16 persons from the "Moldova" Theoretical High school for Persons with sight deficiencies of Targu Frumos, coded as **LDV**. The **LDV** group consisted of sightless teaching staff and pupils aged between 13 and 29 and 30 and 35 years, with tactile well-trained through Braille alphabet reading. A questionnaire was filled up for each person, in which three standard softness samples and five knitted fabric samples were used, coded from (1) to (5). The standard sample I is a rough woven fabric (specific weight 110 g/m^2) of mono-filamentary polyester with yarn count Nm-50/1 impregnated with an acrylic resin with softness of 2% (arbitrarily attached). The standard sample II is a wool-type woven fabric(specific weight of 346 g/m^2) with the content of 55% polyester + 45% wool from "Dorobantu" Company of Ploiesti, for which the softness was arbitrarily considered as 50%. The standard sample III, an all-cotton flock knitting for stockings destined for children, whose softness was considered equal to 90%.

For determining the resistance to microbiological deterioration of cotton materials treated with natural active compounds, we prepared an allergic medium by introducing the material samples in soil suspensions media. Soil was sampled at 10–15 cm depth from greenhouse of University of Agricultural Sciences and Veterinary Medicine Iasi. Supplementary, the resistance to microbial attack was tested using microbiological media plates filled with soil according to blotter method. To determine the microorganisms capable to deteriorate the cotton materials, all plates were incubated at 28 °C in a thermostat (Memmert, Germany) for 28 days. Starting from the fifth day, microscopic analyses regarding total microbiota were performed. Isolated microorganisms were used to inoculate plate with nutritive media.

Potato dextrose agar (PDA) in different compositions (classic, with streptomycin and rose-bengal stain) and Czapek Dox were the media used in this research. Streptomycin antibiotic was used to control the reproduction of bacteria and rose-bengal stain was used to limit the growth of fast-growing moulds (e.g. *Rhizopus* spp., *Trichoderma* spp.). spp = genera. Czapek-Dox agar media was used for filamentous fungi identification. Microbiological media plates were prepared using Masterclave 09 plate maker and an aliquot portion of 15 mL of media was poured using APS 320 automated Petri plate filler (AES Laboratoire, France).

After inoculation, the plates were brought subsequently to the laboratory for incubation. The Petri plates used for fungal sampling were incubated for 5–7 days at room temperature (28 °C). After incubation, fungal species were analysed with a light microscopy (1000× magnification) and identified to genus and species level based on morphological and physiological characteristics following the works provided by (Barnett & Hunter, 1999; De Hoog, Guarro, Gené, & Figueras, 2000; Ellis and Ellis, 1997; Ellis, 1971).

3. Results and discussions

3.1. Selection of textile support, the anti-allergic medicine and cyclodextrin

The all cotton interlock knitted fabric was chosen as textile support destined to manufacture a pajamas consisting of a blouse and trousers for allergic patients. The interlock structure is usually utilized for medical knitted fabrics, such as bandages, orthopaedic articles, as well as for under-linen articles: pajamas, under-vest, panties and shirt. The choice was based on the good reactivity of the OH groups from cellulose structure, as well as on the possibility to provide an increased comfort in terms of softness, and a good wettability between the cellulose material and the skin (Radu & Salariu, 2012).

To solve the affection, one needs to administrate a medicine that diminishes the reaction of immunity system. There are two ways to be taken into account when choosing the medicine for allergic dermatitis. According to some opinions, it is necessary to choose some current therapy medicines: mometazone furoat, hydrocortisone butyrate, methyl prednisolon aceponat or pimecrolimus, with their advantages and incriminated pharmacological shortcomings (Akdis et al., 2006; Moldovan, 2000). Other opinions promote the utilization of genuine anti-allergic active principles from traditional pharmacy (Andritoiu & Andritoiu, 2010). The dermatologists hesitate to administrate medicines based on natural products (plants extracts, apicultural products), as their precise chemical composition is not known; at the same time, there are seasonal variations of concentration and topographical variations of the number of chemical compounds contained. The presence of numerous compounds in the incriminated preparations in the case of debilitated organism predisposes to coetaneous reactions hard to anticipate (Petrescu et al., 2008).

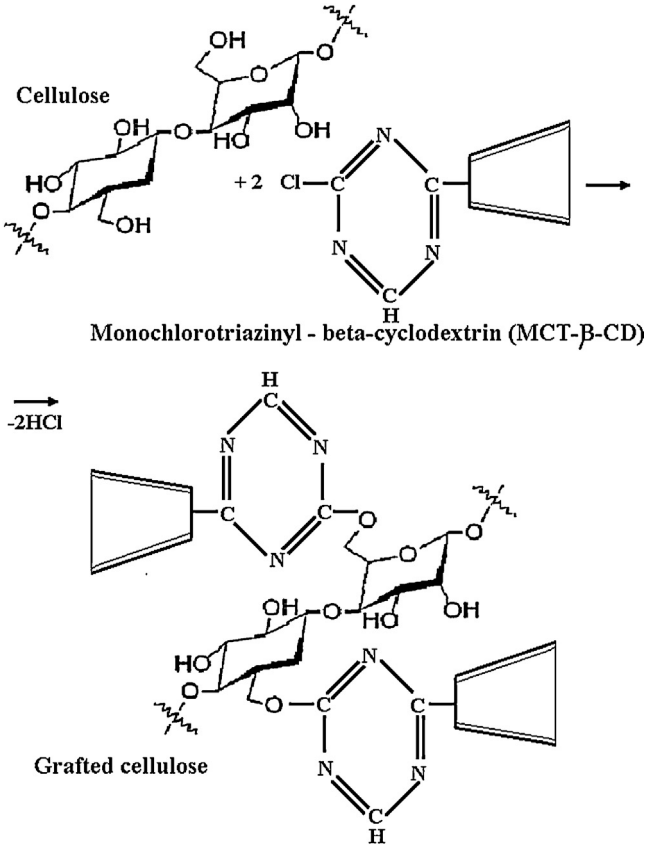
Despite the clinician hesitations to use active genuine principles, the present work analyses the behaviour of a pajamas article that contains active genuine principles. The efficacy of these products has been communicated elsewhere (Radu et al., 2011). P is considered allergenic for 3% of the people (Burdock, 1988; Radu, Salariu, & Oproiu, 2009). In order to avoid the risk, it is mandatory to test the IgE level of the patient, which needs not exceed 100 units. The synthetic M is a unitary substance and it determines a skin refreshing effect, which diminishes the discomfort of the allergic patient.

The cellulose from the all-cotton articles has a good chemical reactivity, favourable for grafting. The Scheme 1 illustrates the reaction of 2nd order nucleophil substitution between cellulose and two molecules of MCT-β-CD. In the reaction take part the tiazine chlorine from MCT-β-CD and the hydrogen from the OH group of cellulose. Each glucose rest from cellulose structure has three hydroxyl groups with chemical reactivity. Depending on the number of OH groups from glucose rest which takes part in the reaction, products with various substitution degree are obtained (Salariu, 2012).

The generated compound absorbs inside the cyclodextrin cavity each of the active principles (VtH, M, P or the medicines AD, HYD). After manufacturing the pajamas, the nocturnal perspiration determines the release of the active principles from the pajamas surface towards the cutis of the allergic patient, whence the therapeutic effect of the used active principle. The cellulose support favourably responds to the requirement to generate a reservoir of anti-allergic medicine, simultaneously with providing an increased coetaneous comfort.

3.2. Evaluation of the dimensions of anti-allergic medicines

Table 1 illustrates the dimensions of the chemical compounds from the active principles or from the anti-allergic medicines,



Scheme 1. The reaction of nucleophil substitution between MCT-β-CD and cellulose.

obtained by using the MarvinSpace ChemAxon 5.4.0.0 software. By comparing the maximum width of the compounds from Table 1 with the size of β-cyclodextrin cavity inner diameter from Fig. 2, one can notice that the solanine, antocyan and pimecrolimus cannot be absorbed inside the cavity, since their width is larger than the mean inner diameter of cyclodextrin cavity, of about 6.3 Å. In the case of flavonoids, the normal width ranges from 4.01 to 6.39 Å,

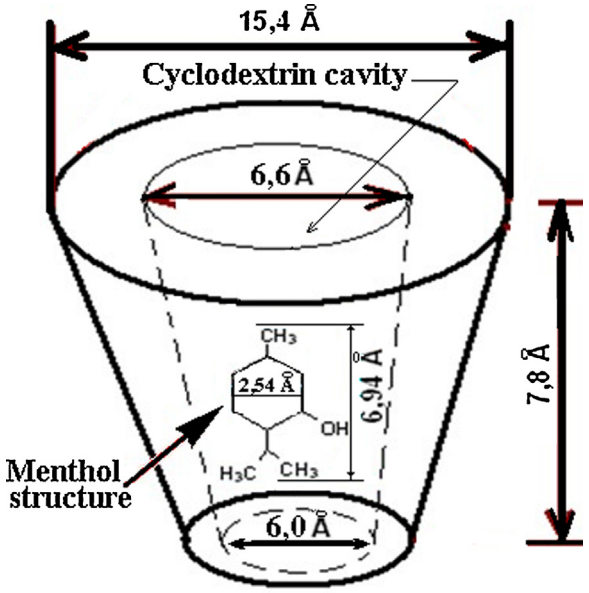


Fig. 2. The relationship between the dimensions of menthol and β-cyclodextrin cavity (Salariu, 2012; Buschmann, Knittel, & Schollmeyer, 2001).

Table 1
The characteristic dimensions of the components from active principles or medicines.

Component	Length (Å)	Maximum width (Å)	Regular width (Å)	Details
Pherulic acid	8.77	4.46	–	Flavonoid component in VtH and P
Flavonoids	10.57	6.39	4.01	Components from VtH and P
Solanine	22.63	11.33	–	Sterolic alkaloid in VtH
Anthocyanin	17.06	11.06	–	Coloured flavonoid from VtH
Menthol	6.94	4.28	2.54	Cooling effect
AD	12.48	5.64	5.64	Methyl-prednisolone is a corticoid used for AD and CD
HYD	12.21	5.69	4.99	Treatment of severe allergy reactions such as anaphylactic shock
PI	14.65	14.78	–	Preventing the immune response

Table 2
Codes of the testing variants of anti-allergic knitted fabric.

Codes	Variants
(1)	Alkaline treated, bleached knit (control)
(2)	Alkaline treated, bleached knitted fabric + grafted with MCT-β-CD
(3)	Alkaline treated, bleached knitted fabric + grafted with MCT-β-CD + treated with VtH
(4)	Alkaline treated, bleached knitted fabric + grafted with MCT-β-CD + treated with M
(5)	Alkaline treated, bleached knitted fabric + grafted with MCT-β-CD + treated with P

therefore they can be absorbed in cyclodextrin. Theoretically, MCT-β-CD is not able to absorb the solanine and antocyan from VtH or PI, their width is larger than cyclodextrin inner diameter. As a flavonoid, antocyan may present a smaller therapeutic importance as compared to the other flavonoids from VtH structure. The tests of controlled release of flavonoids, still unpublished, as well as its efficacy have proved the therapeutic value of VtH, M and P extract.

Fig. 2 illustrates the conformation of the inclusion compound formed between the cyclo-dextrin cavity and the M molecule.

3.3. In vivo tests

After the performed tests [13], the following experimental values for the lethal dose (DL_{50}) were obtained: DL_{50} M = 500 mg/kg body, DL_{50} VtH = 200 mg/kg body, and for P the value DL_{50} P = 400 mg/kg body was taken from specialized literature (Burdock, 1988).

For medicine dosing on the textile material and for anti-allergic tests, the following therapeutic doses (t.d.) were used: t.d.M = 8.203 mg/kg body, t.d.VtH = 4.53125 mg/kg body and t.d.P = 20 mg/kg body. For instance, for a pajamas destined to a person of 60 kg, the VtH quantity applied on the knitted fabric, grafted with MCT-CD is computed with the relation (1):

$$\text{VtH quantity} = 60 \times \text{d.t.VtH} = 60 \times 4.53125 = 271.875 \text{ mg pure product} \quad (1)$$

Knowing that VtH has the concentration of 25% in alcoholic solution, the quantity of 1.087 ml VtH solution is obtained, which is diluted to a concentration that permits the uniform spraying on the entire surface of the textile material that must be anti-allergy treated. Later on, the textile material treated with active principles (VtH, M or P) is mounted by manufacturing at the inside of pajamas according to patient condition, in function of the location of allergic eruptions from the skin. The alcoholic solution for P or M application is calculated similarly.

3.4. Preparation of the textile support

After waxing the yarn and producing the knitted fabric, the textile material (which represents the support for pajamas manufacturing) is subjected to the following treatments:

1. Alkaline boiling at a liquor ratio of 1:30 with 15 g/l NaOH, 5 g/l Na_2CO_3, 1 g/l anionic surfactant Lavotan DSO (Bezema) and 4 g/l $Na_2S_2O_3$, followed by hot (90 °C) and cold washing.
2. Bleaching with boiling hydrogen peroxide for 1 h, at a liquor ratio of 1:30 with 5 ml/l H_2O_2, 2 g/l Na_2CO_3, and 2 g/l Na_2SiO_3.
3. Warm rinsing (40 °C);
4. Drying for 10 min at 80 °C.

The anti-allergic interlock knitted fabric is additionally subjected to the following operations:

5. Grafting with MCT-CD: – padding I with 100 g/l MCT-β-CD; – 90% squeezing; 10 min drying at 80 °C; – padding II with 20 g/l Na_2CO_3, 90% squeezing; – 10 min drying at 80 °C; cure at 160 °C for 10 min; intense washing at 40 °C; 10 min drying at 80 °C.
6. Spraying the active principle on the surface of textile material; fixing at 50 °C for 4 h.
7. Manufacturing the textile material.

Table 2 presents the coded experimental variants used in the next tests.

The reaction between MCT-β-CD and cellulose has been confirmed through EDX elemental analysis. The obtained results are presented in Table 3. The values indicate the nitrogen presence in the grafted knitted fabric sample (2), as well as in the samples grafted and then treated with VtH (3) and P (5) respectively. The nitrogen source is the triazine derivative from MCT-β-CD. The

Table 3
Elemental composition of the knitted fabric samples (EDX).

Variants	Element	Mass percentage (%)
(1)	C	45.12
	N	0.00
	O	54.88
(2)	C	31.41
	N	9.62
	O	58.97
(3)	C	32.64
	N	8.97
	O	58.39
(4)	C	30.89
	N	8.88
	O	60.23
(5)	C	41.48
	N	7.73
	O	50.79

Table 4
Questionnaire for the softness evaluation of anti-allergic knitted fabric.

Standard I (sample) Softness = 2% (rough)	Standard II (sample) Softness = 50% (mild)	Standard III (sample) Softness = 90% (soft)
Variants	Requirements	
	Touch the five samples with your fingers and decide which is the softest and the roughest, assigning percentage values according to the features of standards I, II and III. Arrange the three remaining samples (which have to be reevaluated) in order of increasing softness degree, from the roughest (harsh) to the softest. Assign numerical values to softness degree for the analysed samples, between the two limits (rough and soft).	
(1)	Softness = %	
(2)	Softness = %	
(3)	Softness = %	
(4)	Softness = %	
(5)	Softness = %	

mass percentage of nitrogen in the grafted sample (2) is the highest (9.62%) as compared to that from the grafted samples subsequently treated with VtH (8.9%), with M (8.88%) and P (7.73%). The diminution of the mass percentage for the variants (3–5) as compared to variant (2) indicates the formation of CI cyclodextrin/active principles with large mass.

3.5. Tests on comfort parameters

We have realized a textile support without allergic risk, with an adequate degree of comfort, due to its soft touch and wettability, and with the possibility to graft a certain compound in shape of a reservoir with active substance which releases an anti-allergic substance for a long period. The textile materials with allergic risk include wool and supports of synthetic fibres (Radu et al., 2009). The investigated variants are coded in Table 2. Table 4 presents the questionnaire used by softness test appraisers.

Each appraiser was explained the procedure from the questionnaire. The appraisers tested with their hands the standard samples I, II and III. Then the five textile samples, anti-allergy treated according to the variants from (1) to (5), were presented to appraisers, asking them to determine which sample is the softest and which one is the roughest. Then, by touching them, the remained samples were arranged from the roughest to the softest and each sample was given a softness numerical value by comparison with the value of standards I, II and III. The obtained results are presented in Table 5.

The knitted fabric softness was pursued as a comfort element, sometimes known as handle. In order to get a better handle, the knitted fabric was cleaned from natural impurities of the raw cotton during the operation of alkaline boiling and bleaching with hydrogen peroxide. By subsequent padding of cyclodextrin derivative on the textile surface, drying and curing, the knitted fabric handle becomes rougher. The handle deterioration is due to cyclodextrin application and to special thermal conditions of application (Salariu, 2012). In our work the cure was performed at 160 °C for 10 min, therefore under anhydrous conditions, at a high temperature and a relatively long duration.These conditions were necessary to produce the cyclodextrin derivative reaction with cellulose.

Table 5
Comparative values of softness provided by appraisers after applying the questionnaire.

Evaluating centre	Softness (%)				
	(1)	(2)	(3)	(4)	(5)
TPMI	41.54	38.54	52.14	54.36	58.26
ANR	39.04	40.70	43.30	59.01	60.07
LDV	54.75	52.50	58.12	64.68	63.68

The presented values represent the arithmetic mean per each appraiser group.

As the pajamas were destined to patients, its softness was tested by human appraisers by touching it.

Given the profession, the **TPMI** group (50 appraisers) have to deal with textile materials and their softness characteristic. The number of appraisers determines a good statistic safety. The values presented in Table 5 show in the case of variant (1), which implies alkaline treatment and bleaching with hydrogen peroxide, that the mean value of sample softness is 41.54%. After grafting with MCT-β-CD, the samples (2) have a mean value of 38.54%, hence 3% lower than (1). The grafting conditions at 160 °C in a strongly anhydrous medium imply a diminution of softness. Subsequently, by forming an inclusion compound with VtH, M and P, the softness of the samples (3–5) increases by 13.6% (from 38.54% to 52.14%), 15.82% (from 38.54% to 54.36%) and 19.72% (from 38.54% to 58.26%) respectively. These values show a softening effect due to the utilization of the active principles, which decisively improve the softness and therefore the wear comfort of the anti-allergic knitted fabrics after grafting with MCT-β-CD.

It has been considered that the persons with visual disabilities have a better tactile acuity as compared to sensorial normal persons. From the analysis of data for the **ANR** group, consisting of 10 sightless persons as softness appraisers, one can notice a poor statistical reliability, due to the small number of appraisers, two persons of which were over 70 years. Once ageing, the appraiser cutis gets thicker and the tactile sensitivity is affected; on the other side, the neurological erosion appears. That is why in this case it was considered that the obtained values are susceptible of errors.

The **LDV** group, consisting of 16 sightless appraisers up to 35 years old; the obtained values present a better reliability, as the appraisers are accustomed to the Braille communication system, maintaining a good tactile acuity due to the daily practice. On the other side, the group consists of young appraisers.

For the tested variants, there were differences in the order of softness magnitude. Namely, for the **TPMI** group of appraisers, the highest softness value (58.26%) was obtained for the variant (5) with P, and for (4) variant with M (54.36%). In the **LDV** group, the highest softness of 64.68% was for (4), while for (5) the softness was of 63.68%. Though for the LDV group the statistic reliability is smaller as compared to the **TPMI** group, both groups of observers coincided in their conclusion that VtH, M and P have a net softening effect which compensates for handle roughening due to the cyclodextrin application in the variant (2). The observation is also supported by the application of active principles through spraying a liquid medium with surface plasticizing effect, and the subsequent fixing effect occurs at 50 °C, a temperature which prevents handle deterioration. The temperature of 50 °C was used from the necessity of thermal protection of the active principles.

Starting from these data, we envisage that, in the case of utilization of AD and HYD pharmaceutical products which can be applied on the textile material according to the same procedure, it will be necessary to use a softener.

The concept of comfort is complex and it also implies other elements to characterize the anti-allergic textile support (Rengasamy, 2011). In the performed study, we determined: knitted fabric permeability to water vapours, heat resistance to evaluate the thermal isolation capacity, permeability to air and wettability. The obtained results were presented elsewhere (Ferri, Dotti, Salariu, Radu, & Grigoriu, 2011; Salariu et al., 2011; Salariu, 2012). Namely, it was communicated that the knitted fabrics treated with active principles, except for those treated with M, present a slightly smaller permeability to water vapours (under 8%), therefore the textile support breathing ability is also affected. The manifestation is the result of the hydrophobic characteristics of the compounds present in VtH

and P. The presence of the OH group in the structure of M favours the knitted fabric permeability through its capacity to form hydrogen bonds with water, thus favouring the water vapours sorption and then desorption.

What concerns the thermal resistance of the textile materials, the higher its value, the smaller the heat loss (Gun, 2012). It has been communicated that (Oglakcioglu & Marmarali, 2007), if the thermal resistance is smaller, the thermal energy decreases step by step in the direction of cooling. The smallest value (21.48 mK m^2 W^{-1}) was obtained (Salariu, 2012) for variant (3), for which the specific cooling effect due to M is also known from other applications.

The values obtained for the air permeability are maximal for the knitted fabrics in variants (3–5) treated with active principles. This modification is not due to the utilization of the compounds VtH, M or P, but to the knitted fabric deformation produced by the application of CD and active principles which modify the structure of the knitted fabric, in this case in the direction of increasing the porosity.

The wettability tests determined through the method of capillary ascension by wicking effect, test have shown that the knitted fabrics treated with M or P can offer an advanced comfort at the direct contact with the skin, due to the capacity of liquid transport from the skin level to the environment. For the variants (1–3), the humidity is easily adsorbed, and the drying process is slow. This behaviour also favours the humidity transfer from the skin and implicitly the skin comfort.

3.6. Physiological effect of the presence of anti-allergic materials on epidermis

The coetaneous physiology in terms of the allergic pathology is complex. The tests made in the L.A.T.T. Laboratory from Citta degli Studi in Biella (Italy), namely water trans-dermal loss, water loss through the total skin surface, hydration level, irritation level, skin pH and blood circulation, were carried out on the knitted fabric with and without active principles. From the analysis of the physiological data obtained on volunteers on the forearm zone, it has been concluded that the treatments realized on knitted fabric have not established a deterioration of skin physiology. The clinical tests necessary after the communication of these results for the DC and DA patients should confirm that the utilized materials are bio-compatible with allergy-affected skin.

3.7. Resistance to microbiological deterioration of cotton materials treated with anti-allergic natural active compounds

The determination of the morphological structures of fungi was carried out on fungal material mounted in lactophenol by slide culture technique (Fig. 3).

Using the simulation of allergic conditions with natural sources of infection, we isolated and identified from the surfaces of non-treated (blank sample) and treated cotton materials six fungal genera. *Chaetomium* and *Aspergillus* were the most prevalent fungal

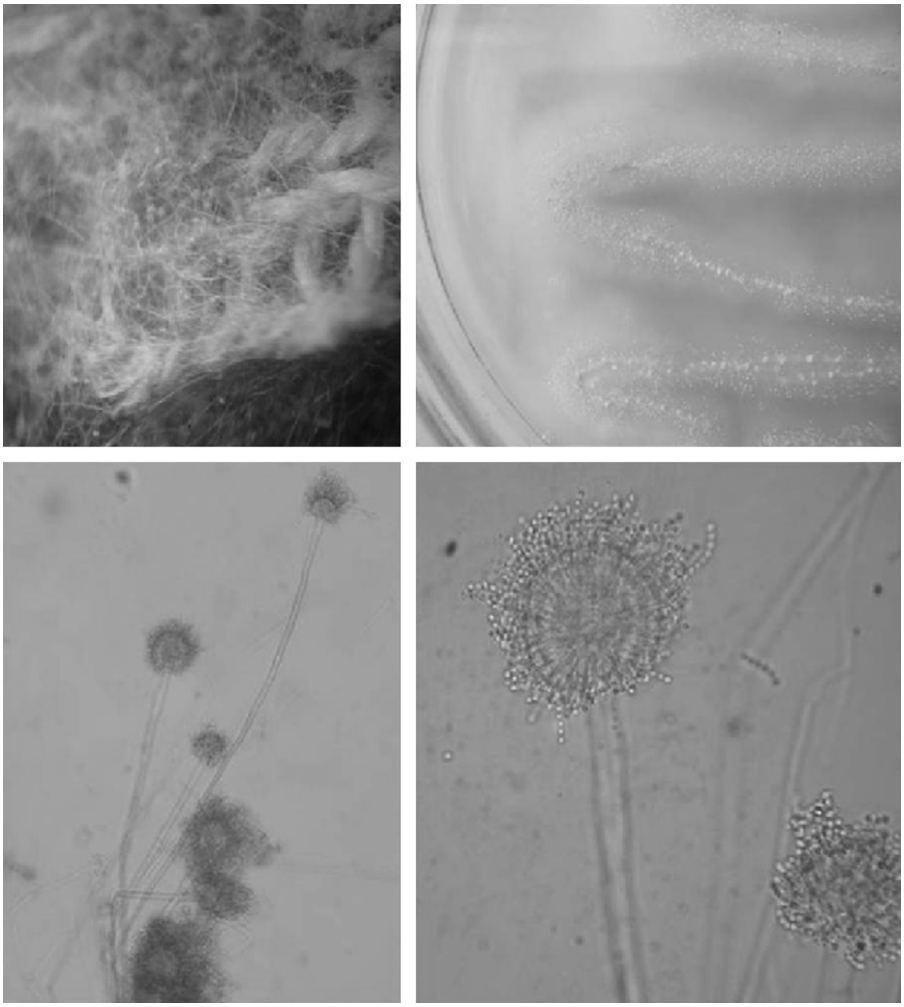


Fig. 3. Macro- (x 6) and microscopic (x 40) images from isolation until identification of *Aspergillus wentii Wehmer*, present on all cotton materials treated with antiallergic natural active compounds.

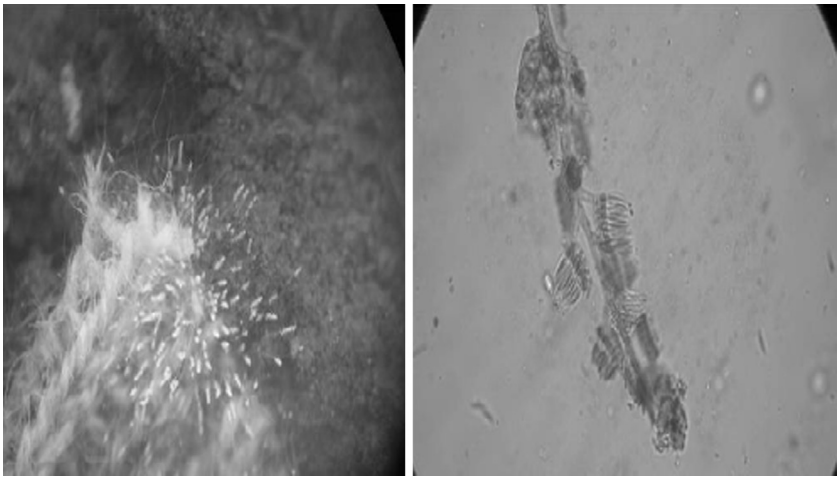


Fig. 4. Macro- (x 6) and microscopic (x 20) images of *Coemansia pectinata* (Coem.).

genera. *Aspergillus* spores are the most frequent and predominant aeroallergens in the world and may induce the following diseases: allergic bronchopulmonary aspergillosis, aspergilloma and chronic pulmonary aspergillosis, aspergillus sinusitis (Fischer & Dott, 2003; Pastuszka, Paw, Lis, Wlazlo, & Ulfig, 2000) reported also that *Aspergillus*, *Alternaria* and *Cladosporium* are fungal genera often associated with allergic symptoms in the respiratory system.

Based on the experimental tests we have concluded that, by contrast with treated sample material, the highest number of fungal species, i.e. *Stachybotrys alternans*, *Chaetomium spirale*, *Chaetomium globosum*, *Aspergillus wentii* and *Aspergillus niger* were developed on non-treated cotton. Therefore, from cotton material treated with active compounds extracted from *VtH, there* were isolated four fungal species: *Coemansia pectinata*, *Stachybotrys alternans*, *A. wentii* and *A. niger*. From the surface of material treated with propolis also were isolated four species: *Chaetomium spirale*, *Myrotecium verrucaria*, *A. wentii* and *A. niger*. The treated material most resistant to fungal deterioration was that which included menthol as natural active compound, the isolated from this cotton sample comprising three fungal species: *Chaetomium spirale*, *A. wentii* and *A. niger*.

The present microbiological isolation and identification provided for our mycological collection a new fungal genus and species for Romania: *Coemansia pectinata* (Coem.) Bainier (Fig. 4). The cotton materials treated with anti-allergic natural active compounds display an antimicrobial effect, appropriate for medical usage. This final statement is based on the lower number of isolated fungal genera compared to the blank sample, and also on the lack of bacterial activity upon cotton materials during the experiment.

3.8. Aspects concerning the manufacturing of anti-allergic pajamas

A pajamas consisting of a blouse and trousers is manufactured from interlock knitted fabric which was previously alkaline boiled and bleached with hydrogen peroxide and then dried. Inside of these pajamas, were inserted pieces of knitted fabric treated with MCT-β-CD and with VtH or M or P. The zone covered with anti-allergy treated knitted fabric is indicated by the doctor, depending on the type of allergy, patient anthropometric dimensions and pathological specific character.

Generally, a pajamas set for atopic patients with DA is designed tightly on the waist and with slight pressing effect at the level of wrist band, waist, maleolli and collar. For a DC-affected patient, the lingerie must be quite easy. For the both pathologies, but especially for DC, it is absolutely necessary to avoid creases or assembling elements that affect the comfort of allergic skin through: seams, buttons, links, creases or zips.

3.9. Other reasoning

The controlled release of the active principles under the action of the coetaneous perspiration in terms of diffusion rate needs to follows doctor's prescriptions and to provide a controlled release for a certain time period, depending on the knitted fabric capacity to get loaded with active principles. Ensuring the therapeutic dose represents a deciding factor in the improvement of the allergic patient. Details related to these processes are known after clinical tests under conditions given by the peculiarities of each patient and the allergic manifestation.

4. Conclusions

The processing operations for all-cotton interlock knitted fabric through the stages of alkaline boiling and bleaching with hydrogen peroxide permits to obtain a textile support bio-compatible with the sensitized skin of the allergic patient.

The utilization of MCT-β-CD as a support for the formation of an inclusion compound with the active principles used in this work is favourable to the realization of a controlled-release system, but it affects the textile support softness.

Besides its therapeutic effect, the introduction of VtH, M or P extract inside the cyclo-dextrin cavity has a significant softening effect. The textile materials with reservoirs of active principles showed no physiological coetaneous modifications which affect their bio-compatibility with epidermal interface.

In the case of P, its administration to the allergic patients needs thorough investigations, in order to avoid the initiation of an allergic episode.

The above presented processing stages of the textile material can be also extended to the application of some pharmacological anti-allergic products in terms of: – *in-vivo* established performances; – product sensitivity to temperature; – molecular dimensions of the medicine which needs to be able to penetrate inside the cyclodextrin cavities. Utilization of the pharmacological products necessitates the additional utilization of a softener.

Utilization of the active principles and of the processing stages of the textile support determines an inhibition of the microbial development, thus avoiding the encouragement of allergic reaction.

Manufacturing of anti-allergic pajamas for allergic patients is customized, depending on the clinician prescriptions.

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References

Aalberse, R. C. (2011). Is 99.9% purity good enough for allergens? *Allergy*, *66*(9), 1131–1132.

Aalberse, R. C., & Crameri, R. (2011). IgE-binding epitopes: A reappraisal. *Allergy*, *66*(10), 1261–1274.

Akdis, C. A., Akdis, M., Bieber, T., Bindslev-Jensen, C., Boguniewicz, M., et al. (2006). Diagnosis and treatment of atopic dermatitis in children and adults. *Journal of Allergy and Clinical Immunology*, *118*, 152–169.

Andritoiu, V. C., & Andritoiu, V. (2010). In Andritoiu & Andritoiu (Ed.), *Theses and hypotheses in therapy and diet with hive byproducts* (pp. 107–114). Iasi: Denus.

Barnett, H. L., & Hunter, B. B. (1999). *Illustrated genera of imperfect fungi* (4th ed.). St. Paul: APS, Press, The American Phytopathological Society.

Burdock, G. A. (1988). Review of the biological properties and toxicity of bee propolis. *Food and Chemical Toxicology*, *36*, 356–358.

Buschmann, H. J., Knittel, D., & Schollmeyer, E. (2001). New textile applications of cyclodextrins. *Journal of Inclusion Phenomena and Macrocyclic Chemistry*, *40*, 169–172.

De Hoog, G. S., Guarro, J., Gené, J., & Figueras, M. J. (2000). *Atlas of clinical fungi* (2nd ed.). Utrecht: Centraal bureau voor Schimmel cultures.

Ellis, M. B. (1971). *Dematiaceous Hyphomycetes*. London: Commonwealth Mycological Institute/Kew, The Eastern Press.

Ellis, M. B., & Ellis, J. P. (1997). *Microfungi on land plants: An identification handbook, enlarged ed.* Co. Ltd. Slough, England: Richmond Publishing.

Ferri, A., Dotti, F., Salariu, M., Radu, C. D., & Grigoriu, A. (2011). *Evaluation of skin physiology after the contact fabrics grafted with cyclodextrin and loaded with active principles intended for allergic diseases* Second European Conference, Asti (Italy), (pp. 17–24).

Fischer, G., & Dott, W. (2003). Relevance of airborne fungi and their secondary metabolites for environmental, occupational and indoor hygiene. *Archives of Microbiology*, *179*, 75–82.

Gun, A. D. (2012). Dimensional physical and thermal comfort properties of plain knitted fabrics made from modal viscose yarns having microfibers and conventional fibers. *Fiber Polymer Journal*, *12*(2), 258–267.

Moldovan, D. (2000). In D. Moldovan (Ed.), *Allergy – diagnosis and treatment* (1st ed., pp. 17–51). Tirgu-Mures, Romania: Prisma.

Oglakcioglu, N., & Marmarali, A. (2007). Thermal comfort properties of some knitted structures. *Fibres and Textiles in Eastern Europe*, *15*(5), 94–96.

Pastuszka, J. S., Paw, U. K. T., Lis, D., Wlazlo, A., & Ulfig, K. (2000). Bacterial and fungal aerosol in indoor environment in Upper Silesia. *Atmospheric Environment*, *34*, 3833–3842.

Petrescu, Z., Branisteanu, D. E., & Statescu, L. (2008). Manifestations of cutaneous hypersensitivity. In Z. Petrescu (Ed.), *Dermatology and infections sexually transmitted* (pp. 137–193). Iasi, Romania: Junimea, chapter V.

Popescu, I. Gr. (Ed.). (1998). *Allergy, pathophysiology, diagnosis and treatment*. (pp. 35–71). Bucharest: BIC ALL.

Radu, C. D., & Salariu, M. (2012). In A. Grigoriu, & C. Racu (Eds.), *Antiallergy properties – the study for a textile fabric* (pp. 87–106). Iasi: Performantica.

Radu, C. D., Salariu, M., Oproiu, L. C., Lupusoru, C., Foia, L., & Ghiciuc, C. (2011). *Sustainable development for the medical textiles with anti-allergic properties II. In vivo tests* International Conference on Management of Technological Changes, Democritus University of Thrace (Greece), Alexandroupolis, (pp. 113–116).

Radu, C. D., Salariu, M., & Oproiu, L. C. (2009). Antiallergy textiles in contact dermatitis. In C. D Radu (Ed.), *Textile materials with medical end uses* (pp. 135–149). Iasi: Performantica, chapter X.

Rengasamy, R. S. (2011). Improving moisture management in apparel. In G. Song (Ed.), *Improving comfort in clothing* (pp. 182–212). University of Alberta, Canada.: Woodhead Publishing Limited.

Rippke, F. (2004). Stratum corneum pH in atopic dermatitis: Impact on skin barrier function and colonization with staphylococcus aureus. *Journal of Allergy and Clinical Immunology*, *5*, 217–223.

Salariu, M., (2012). Researches on obtaining some antiallergic textile materials. Ph. D. Thesis. Technical University Iasi.

Salariu, M., Ferri, A., Peila, R., Radu, C. D., Grigoriu, A., & Oproiu, L. C. (2011). Wettability, a prominent comfort factor in the development of fabrics with anti-allergic properties. *Buletinul Institutului Politehnic*, *57*, 27–37.