Imparting Eco-friendly Antibacterial and Anti-inflammatory Finishing by Microencapsulation Technique for Cotton Fabric

Marwa M. M. Khodary Corresponding author: mar.khodary@gmail.com
Home Economics Department, Women's College, AinShams University, Cairo, Egypt.
Hanaa M. El-Rafie,
Pharmacognosy Department, National Research Centre, Dokki, Giza, Egypt.
Heba M. Abdel Salam
Home Economics Department, Women's College, Ain Shams University, Cairo, Egypt.
Mohamed H. El-Rafie
Department of Pre-Treatments and Finishing, National Research Centre, Dokki, Giza, Egypt.

Abstract:

Studies on eco-friendly antibacterial agents based on bioactive ingredients extracted from natural products for textile application is gaining worldwide interest. In the current paper, an ethanolic extract of Pelargonium hortorum (Geranium) leaves was used to impart antibacterial finishing to cotton fabric. The bioactive compounds of the extract were identified. The extract was microencapsulated using eco-friendly wall shell material such as sodium alginate ormypro gum. The microcapsules forms were examined by light and TEM microscopes whereas the shape of microcapsules on the fabric surface was identified by SEM microscope. Cotton fabrics were treated with the microencapsulated extract by the pad-dry-cure method. Cotton samples treated with microencapsulated extract were post treated with citric acid or binder to fix the microcapsules on the fabric.

The microencapsulated extract treated cotton showed antibacterial efficacy against both Escherichia coli(gram negative bacteria) (-ve) and Staphylococcus aureus (gram positive bacteria)(+ve). The treated fabric also showed anti-inflammatory efficacy. Effectiveness of finishing was accessed by determined numbers of washing cycles and the treated fabric retained an effective antibacterial property after 10 washing cycles. The effect of the treatments on the physio-mechanical properties of the treated fabrics was measured.

Keywords:

Microencapsulation
Antibacterial
Anti-inflammatory
Pelargonium
cotton fabric.

Paper received 28th February 2017, Accepted 20th March 2017, Published 15st of April 2017

1. Introduction

Textile goods especially those made from natural fibers provide an excellent environment for microorganisms to grow because of their large surface area and ability to retain moisture. Most textile materials currently used in hospitals, hotels and crowded public areas are conductive to cross infection or transmission of disease caused by microorganisms[20]. Cotton is widely used for apparel and bedding due to its comfort property. Human sweat provide a suitable shelter for bacterial growth, containing 1.4 million bacteria per gram which increases to 9000 million at 50% moisture level[9]. The presence of carbohydrates in cotton fibers acts as nutrients and energy source for microorganisms. These microorganisms are sources of pathogens and may also cause staining, strength loss and damage to the fabric[6]. Antimicrobial finishing of cotton fabrics can protect the wearers against the spread of microbes, bacteria and diseases rather than protect the quality and durability of the textile material.

The abundance of plants on the earth surface has led to an increasing interest in the investigation of different extracts obtained from the traditional medicinal plants as potential sources of new antimicrobial agents[16]. The antimicrobial activity of extracts of Pelargoniums and their constituents is reported against bacterial, fungal and pathogens as well as opportunistic yeasts. The Pelargonium extracts can potentially be used as novel antioxidant, antimicrobial, anticancer agents in the food, cosmetic and pharmaceutical industries[19].

Antimicrobial finishes can be applied on textile substrates by exhaust, pad-dry-cure, coating, and spray methods or in spinning dope. Antimicrobial agents control the growth of microbes by various mechanisms ranging from preventing cell reproduction, blocking of enzymes, and reaction with the cell membrane to the destruction of the cell walls and poisoning the cell from within[10].

Microencapsulation of natural materials is one of the methods used to increase the durability of the antimicrobial finishing on textile materials[23]. Microencapsulation is the process of surrounding or enveloping one substance within another substance on a very small scale, yielding capsules

ranging from less than one micron to several hundred microns in size [13].

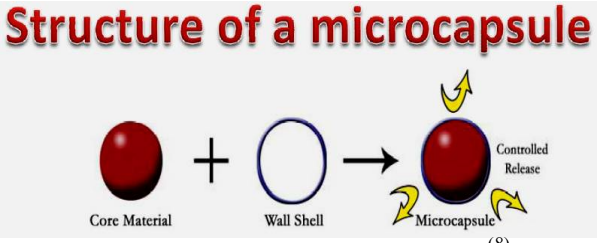


Fig. (1): structure of microcapsule[8]

Many special and functional properties can be imparted to the fabrics by microencapsulating the core material. This core material can be any substance having a special function to perform for the fabric[14].The wall shell may be natural, semi-synthetic or syntheticpolymer[8].The microcapsules can introduce important new qualities to garments and fabrics, such as enhanced stability and the controlled release of active compounds[14].It offers many advantages as compared to conventional process in terms of economy, energy saving, and eco-friendliness.

The present investigation is a trial to produce eco-friendly antibacterial and anti-inflammatory finished cotton to be used in the medical field and personal care industries.

This research assumes finishing of cotton fabric with active compounds extracted from a natural-based material (pelargonium hortorum) to avoid the environmental risks of using synthetic finishes and applying the finishing agent to the cotton fabric through a microencapsulation technique to facilitate a controlled release of the active compounds and enhance the durability of the finishing process.

2. Materials and methodology:

2.1. Materials:

2.1.1. Fabric:

Mill scoured 100% plain weave cotton fabric (125 g/cm^2) was kindly supplied by Misr Company for Spinning and Weaving, El Mehalla El Kobra, Egypt and cotton wound dressing fabric (125 g/cm^2).

2.1.2. Extraction source:

Pelargonium hortorum (geranium) was collected from Giza zoo during the months of March – April.

2.1.3. Chemicals:

Sodium alginate supplied by research-lab fine chem. industries, Mypro-gum, binder (Printofix Binder MTB EG liq.), Egyptol PLM, maconcy agar, mannitol agar, methanol, citric acid. All the chemicals were of laboratory grade chemicals.

2.2. Methods:

2.2.1. Preparation of Pelargonium hortorum extract:

The Pelargonium hortorum (Geranium) leaves and basts were dried at 40^{0}C and grounded to powder. 50 g of pelargonium was soaked in 500 ml ethanol (70%) for 24 hours, and then filtered.

2.2.2. Finishing of cotton fabric with the ethanolic extract:

Cotton samples were immersed in the ethanolic extract of Pelargonium hortorum for 30 min, air-dried and then used for bioactivities's evaluation.

2.2.3. Microencapsulation:-

10 g of wall material (mypro gum or sodium alginate) was allowed to swell for 30 minutes by mixing with 100 ml of water. To this mixture 50 ml of hot water was added and stirred for 15 min with maintaining the temperature between 40^{0}C and 50^{0}C in water bath, after that core material (15 ml of Pelargonium hortorum ethanolic extract) was added and stirred at 400 rpm for 15 minutes maintaining the same temperature [23].

2.2.4. Treatment of cotton fabric with microencapsulation:-

The cotton fabric was treated by pad-dry-cure method. The cotton samples were padded in 10 % microencapsulated solution to attain a wet pick –upabout 100%, then the samples were dried at 80^{0}C for 10 minutes, and finally cured at 120^{0}C for 2 minutes.

2.2.5. Post treatment for treated cotton fabric:

In order to fix microcapsules on the fabric it was post treated into two ways:

1 The treated fabric was padded in 2% citric acid to attain a wet pick –up about 100%, then dried at 80^{0}Cfor 5 minutes and cured at 120^{0}C for 2 min.

2 2- The treated fabric was padded in 1% binder (Printofix Binder MTB EG liq.)to attain a wet pick –up about 100%, then dried at 80°Cfor 5 minutes and cured at 120°C for 2 min.

2.3. Test and analysis methods:-

2.3.1. Chemical analysis of the extract:

2.3.1.1. Phytochemical screening of the extraction:

Phytochemical screening refers to the extraction, screening and identification of the medicinally active substances found in plants. In this study, phytochemical screening of the ethanolic extract of Pelargonium hortorum was carried out according to the standard methods [11&24].

2.3.1.2. GC-MS analysis

Quantitative determination of the ethanolic extract of Pelargonium hortorum was achieved by GC/MS Capillary column of fused silica (5% phenyl methyl polysiloxane), 30m length, 0.25mm I.D. and 0.25 µm thickness, DB-5, carrier gas helium at

13 psi; oven temperature 50-280°C, chart speed 0.5 cm/min; ion source temperature 220°C; ionization voltage 70 ev; accelerated voltage 2000 v; volume injected 1 µl. The identification of the compounds was accomplished by comparing their retention times and mass spectral data with those of the NIST (Nat. Inst. St. Technol., USA), library (Wiley Int. USA), and/or published data [1].

2.3.2. Analysis of microcapsules surface morphology:

2.3.2.1. Detecting microcapsules shape:

Light microscope (Confocal laser scanning microscope-LSM 710 Germany) at a magnification of 400 and transmission electronic microscope (TEM) used to detect the shape of microcapsules.

2.3.2.2. Detecting microcapsules shape on fabric surface:

The scanning electron microscope (SEM) Joel 1 (JXA-840A) electron probe microanalyzer was used to confirm the binding and alignment of microcapsules on the fabric sample.

2.3.3. The anti-bacterial properties of the treated fabric:

The antibacterial properties of treated cotton as well as untreated cotton fabrics were evaluated quantitatively (Bacterial Count) according to the AATCC test method 100–1999 by using two types of bacteria, namely Escherichia coli AATCC 2666 (gram negative bacteria) (-ve) and Staphylococcus aureus AATCC 6538 (gram positive bacteria) (+ve) [2].

All fabric samples were kept at controlled temperature 35°C. After incubation the fabrics were then transferred into 100 mL of nutrient broth (1:500) and shaken vigorously for 1 minute. A 10-fold dilution with 0.9% (w/v) normal saline solution was prepared, spread at varying dilutions onto Mannitol salt agar plates for E. coli and Maconky salt agar plates for S. aureus. Incubation to all plates was done at 37°C for 24 hours. All experiments were performed in triplicate.

The antibacterial activity is expressed in % reduction of the organisms after contact with the test specimen compared to the number of the organism cells surviving after contact with the control.

Bacteria reduction was calculated as follows:

$$\text{Reduction rate \%} = \frac{B - A}{B} \times 100$$

Where **B** is the number of bacterial colonies of the untreated cotton and **A** is the number of colonies after 24 hours contact with treated cotton.

2.3.4. Wash durability of the anti-bacterial finishing:

The antibacterial properties were quantitatively evaluated after 5 and 10 washing cycles in solution containing 2g/l Egyptol PLM, the washing was conducted at 40^0C for 20 min per each washing cycle [3].

2.3.5. Anti-inflammatory activity test:

The anti-inflammatory properties were determined according to the method described by Winter Etal 1962[27]. Carrageenan induced oedema in hind paw of the rat as an assay for anti-inflammatory drugs. Forty eight male albino rats were divided into eight groups, each of six animals. Animals were anaesthetized by open mask method with anaesthetic ether and their backs were shaved with electric clippers.

First group: - blank clothes film was applied to the skin of the back and tied firmly.

Second, third, fourth, fifth, sixth, seventh groups: treated clothes film applied respectively to the skin of the back and tied firmly.

Eighth group: - the reference Indomethacin cream was applied to the blank tissue on film and tied firmly.

One hour later all the animals has a sub-plantar injection of 0.1 of 1% carrageenan solution in saline, in the right hind paw and 0.1 ml saline in the left hind paw. Four hours after application of films the rat were sacrificed. Both hind paws were excised and weighted separately, the percentage oedema was calculated according to the following equation:-

$$\frac{\text{Wt. of right paw - Wt. of left paw}}{\text{Wt. of left paw}} \times 100$$

2.3.6. Antibacterial activity on wound dressing:

Two samples of cotton wound dressing were treated with microencapsulated extract of the pelargonium hortorum using sodium alginate as a wall shell, then one of the samples is post treated with citric acid. Each sample was independently examined towards antibacterial activity (evaluated quantitatively according to the AATCC test method 100–1999) using two types of bacteria (Escherichia coli AATCC 2666 and Staphylococcus aureus AATCC 6538)[2]. The result was taken after 4 hours, 8 hours and after 24 hours incubation time.

2.3.7.Whitenessmeasurement:

The changes in fabric whiteness index (WI) before and after treatment was assessed using Hunter lab spectrophotometer, Miniscan Diffuse SAV, Stdz Mode: RSIN.

2.3.8. Physio-mechanical measurements:

2.3.8.1. Tensile strength and elongation:

The tensile strength and elongation of treated fabrics were measured according to ASTM procedure D/3822 [(5)].

2.3.8.2. Stiffness test:

The stiffness of the treated fabrics was measured according to ASTM procedure D/1388[(4)].

2.3.8.3. Roughness test method:

Surface roughness of treated fabrics was measured at N.R.C. labs using surface roughness measuring instruments (Surfcoder SE 1700) manufactured by Kosaka laboratory Ltd. Japan[(15)].

3. Results and discussion:

3.1. Phytochemical and GC/MS analysis of the ethanolic extract of pelargonium hortorum:

3.1.1. Phytochemical analysis:

The phytochemical analysis of pelargonium ethanolic extract is recorded in table (1). It shows the presence of different groups of secondary metabolites such as carbohydrates, fats/oils, saponins, terpenoids, steroids, flavonoids, phenolics, tannins, proteins and alkaloids which have medicinally active properties.

Table (1): Phytochemical constituents detected in ethanol extract of pelargonium hortorum

Phytochemical	P.hortorum
Carbohydrates	+
Fats/Oils	+
Saponins	+
Terpenoids	+
Steroids	+
Flavenoids	+
Phenolics/Tannins	+
Proteins/Amino acids	+
Alkaloids	+
Cardiac glycosids	-
Anthraquinones	-

+ = Present ; - = Absent

3.1.2. GC/MS analysis:

Table (2) shows the chemical classes of the compounds identified in GC/MS analysis of ethanolic extract of pelargonium hortorum. Methyl and ethyl esters of fatty acids represents the greatest ratio by 73.9% followed by 23.6% fatty acids, then unsaponifiable matter represents 1.5% from the total identified peak area.

Table (2): chemical classes of the compounds identified in GC/MS analysis of pelargonium hortorumethanolic extract

Chemical classes	percentages	No.of compounds	Major compound
Fatty acids	23.6	6	Heptadecanoic acid
Methyl & ethyl esters of fatty acids	73.9	18	Ethyl hexadecanoate
Unsaponifiable matter	1.5	1	Butylated-hydroxytoluene

Table (3) shows the identified compounds in ethanolic extract of pelargonium hortorum and their retention time, molecular weight, molecular formula and concentration (%). Twenty seven compounds are representing 83.57% of the total peak area were identified. **Ethyl hexadecanoate** (Ethyl palmitate) is the major compound (24.94%), it is one of Palmitic acid ethyl esters, it is a neutral, lipid-soluble form of the free acid and it has a several bioactivities such as antimicrobial,antioxidant, hypocholesterolemic, nematicide, pesticide, antiandrogenic flavor, hemolytic, alphareductase inhibitor effect[(22)].

Heptadecanoic acid or Margaric acid (12.19%) is a Long chain saturated fatty acid; it has antibacterial and antifungal effects [(7& 12)].

Butylated-hydroxytoluene is an unsaponifiable matter represent (1.26%) used as anti-oxidant in cosmetics, pharmaceuticals, food additives [(17, 21, 25& 26)] and recently it has been reported that this compound has an anticancer (cytotoxicity and apoptosis-inducing) activity[(18)].

Table (3): GC/MS analysis of the aqueous ethanolic extract of the Pelargonium hortorum.

No	R.T	M.W	M.F	Area%	B.P	Compound name
1	21.50	122	$C_7H_6O_2$	0.40	121	Benzaldehyde4-hydroxy

2	22.94	194	$C_{10}H_{10}O_4$	0.31	163	Dimethyl tetraphthalate
3	23.99	166	$C_9H_{10}O_3$	0.23	151	Ethyl paraben
4	24.17	200	$C_{11}H_{20}O_3$	0.94	88	Ethyl-9-oxo-nonanoate
5	24.35	220	$C_{15}H_{24}O$	1.26	205	Butylated hydroxytoluene
6	25.76	200	$C_{12}H_{24}O_2$	0.29	73	Dodecanoic acid
7	26.42	196	$C_{10}H_{12}O_4$	0.37	151	4-hydroxy-3-methoxy-benzoic acid
8	28.16	200	$C_{12}H_{24}O_2$	2.52	88	Ethyl decanoate
9	30.41	228	$C_{14}H_{28}O_2$	1.31	73	Tetradecanoic acid
10	30.97	256	$C_{16}H_{32}O_2$	0.53	88	Ethyl tetradecanoate
11	32.08	268	C18H36O	2.33	43	Trimethyl-2-pentadecanone
12	33.56	268	$C_{19}H_{40}$	0.43	57	Nonadecane
13	34.24	268	$C_{17}H_{32}O_2$	0.42	55	Heptadecenoic acid
14	34.79	270	$C_{17}H_{34}O_2$	12.19	73	Heptadecanoic acid
15	35.25	284	$C_{18}H_{36}O_2$	24.94	88	Ethyl hexadecanoate
16	37.14	298	$C_{19}H_{38}O_2$	0.71	88	Ethyl heptadecanoate
17	38.12	296	$C_{19}H_{36}O_2$	2.66	55	9-nonadecenoic acid
18	38.46	308	$C_{20}H_{36}O_2$	2.59	67	Ethyl -9.12-octadecadienoate
19	38.57	310	$C_20H_{38}O_2$	4.60	55	Ethyl -9-octadecadecenoate
20	39.03	312	$C_{20}H_{40}O_2$	3.21	88	Ethyl octadecanoate
21	40.25	326	$C_{21}H_{42}O_2$	3.21	88	Ethyl nonadecanoate
22	41.94	326	$C_{21}H_{42}O_2$	4.43	74	Methyl eicosanoate
23	42.56	340	$C_{22}H_{44}O_2$	1.35	88	Ethyl eicosanoate
24	43.07	354	$C_{23}H_{46}O_2$	1.16	74	Methyl docosanoate
25	44.17	354	$C_{23}H_{46}O_2$	2.87	73	Tricosanoic acid
26	45.17	390	$C_{24}H_{48}O_2$	7.39	149	Diisooctyl phethalate
27	45.82	368	$C_{24}H_{48}O_2$	0.92	88	Ethyl tricosanoate
Total identified area				83.57		

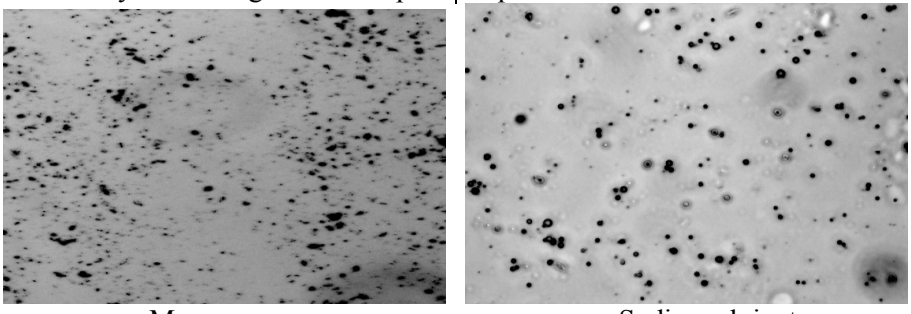
R.T= Retention time, M.W= Molecular weight, M.F= Molecular formula, B.P= Base beak

3.2. Morphological characteristics of microcapsules:

Microcapsules were prepared using ethanolic extract of pelargonium as a core material and sodium alginateor mypro gum as a shell material. This method was very rapid and can be easily adapted to the industrial scale. To identify the formed microcapsules and determine their morphology, light microscopy was firstly used, then the microcapsules were examined under TEM microscope and finally scanning microscope examined the microcapsules on the surface of the fibers.

3.2.1. Light microscope examination:

Photographs of the microencapsules by Confacal laser scanning microscope LSM 710 at a magnification of 400 are shown in figure (2). It is observed that microcapsules were successfully prepared using an ethanolic extract of pelargonium as a core material and sodium alginate or mypro gum as a coating agent. The microcapsules are spherical and have a smooth surface structure.

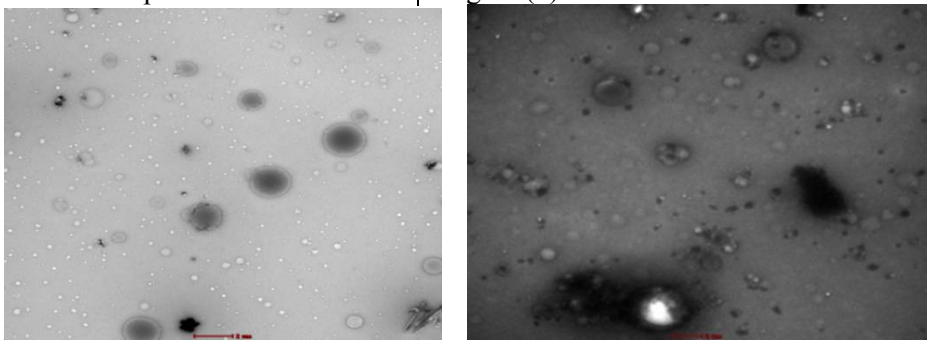


Mypro gum Sodium alginate

Fig. (2): images of pelargonium microcapsules by laser scanning microscope at a magnification of 400

3.2.2. TEM microscope examination:

The morphology of the microcapsules also determined by TEM microscope. The examination showed that the microcapsule consists of a shell with a smooth surface and a core as shown in figure (3).

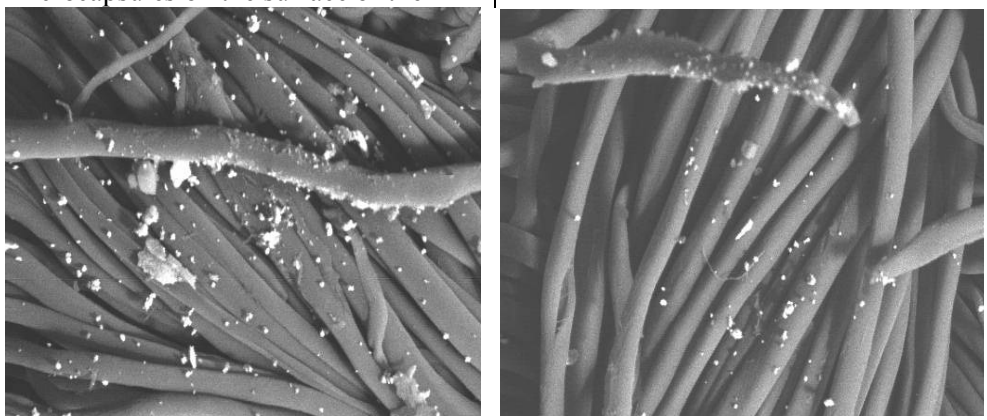


Mypro gum Sodium alginate

Fig. (3): Images of pelargonium microcapsules by TEM microscope

3.2.3. Scanning microscope examination:

A scanning microscope examination image was taken to the microcapsules on the surface of the fibers. Figure (4) shows that the microcapsules were deposited on the treated cotton samples.



Mypro gum Sodium alginate

Fig. (4): Images of scanning microscope examination (SEM) of the fiber surface treated with pelargonium microcapsules

3.3. Antibacterial activity:-

The bacterial reduction percentage of two types of microorganisms (E. coli, G -ve bacteria and S. aureus, G +ve bacteria) imparted by cotton fabrics finished under a variety of treating conditions. The different treating conditions includes **(a)** fabrics treated withethanolic extract only **(b)** fabrics treated with microencapsulated extracts **(c)** fabrics treated with microencapsulated extracts and post treated by citric acid **(d)** fabrics treated with microencapsulated extracts and post treated by binder. The antibacterial activity examined before and after different washing cycles (5 and 10 cycles).

3.3.1. Antibacterial activity of fabric treated with ethanolic extract only:-

Table (4) shows the antibacterial activity of fabric treated with ethanolic extract before and after washing cycles. The samples show a sufficient bacterial reduction %, this ratio can be explained due to the effective antibacterial constituents which confirmed by phytochemical screening and GC/MS analysis.

Table (4): Antibacterial activity of fabric treated with ethanolic extract only

Reduction %					
Escherichia coli			Staphylococcus aureus		
0 washes	5 washes	10 washes	0 washes	5 washes	10 washes
89.5	51.9	14.7	90.2	65.2	17.2

Blank sample with E.coli = 580 colonies

Blank sample with S. aureus = 540 colonies

3.3.2. Antibacterial activity of fabric treated with microencapsulated extract:-

Table (5) shows the antibacterial activity of fabric treated with the microencapsulated

extract before and after washing cycles. The bacterial reduction % increases when compared with the reduction % of the samples that treated with extract only. The microcapsules enhance the antibacterial activity and increase the durability to the washing cycles. We can logically explain that due to increasing the adherence of the extract constituents on the surface of the fabric. Also the microcapsules may be increase the surface area of the extract to which the bacteria exposed.

Table (5): Antibacterial activity of fabric treated with microencapsulated pelargonium extract:-

Reduction %											
Escherichia coli						Staphylococcus aureus					
0 wash		5 washes		10 washes		0 wash		5 washes		10 washes	
Alg	Mypro	Alg	Mypro	Alg	Mypro	Alg	Mypro	Alg	Mypro	Alg	Mypro
97.2	97.9	79.3	88.6	70.9	76.6	94.4	92.5	84	83.7	69.1	68.7

Alg = sodium Alginate, Mypro = mypro gum

Blank sample with E.coli = 580 colonies, Blank sample with S. aureus = 540 colonies

3.3.3. Antibacterial activity of fabrics treated with microencapsulated extract and post treated by citric acid or binder:-

Table (6) shows the antibacterial activity of fabrics treated with microencapsulated extracts and post treated by citric acid or with binder before and after washing cycles. The reduction % increases and shows more durability to washing cycles. This result can be explained by: (a) citric acid and binder in the post treatment of the samples may considerably fix the extract constituents on and within the fabric surface; (b) citric acid and binder also have an antibacterial effect. The samples post treated with citric acid show the highest antibacterial activity and the highest durability to washing cycle.

Table (6): Antibacterial activity of fabrics treated with microencapsulated extract and post treated by citric acid or binder

Encapsulated samples post treated with citric	Reduction %											
	Escherichia coli						Staphylococcus aureus					
	0 wash		5 washes		10 washes		0 wash		5 washes		10 washes	
	Alg	Mypro	Alg	Mypro	Alg	Mypro	Alg	Mypro	Alg	Mypro	Alg	Mypro
	100	100	99.3	100	89.8	90.9	100	100	99	99.8	88.7	90.6
Encapsulated post treated with binder	**Reduction %**											
	Escherichia coli						Staphylococcus aureus					
	0 wash		5 washes		10 washes		0 wash		5 washes		10 washes	
	Alg	Mypro	Alg	Mypro	Alg	Mypro	Alg	Mypro	Alg	Mypro	Alg	Mypro
	100	100	98.7	100	89.1	92.2	97.5	100	99.3	99.3	89.4	89

Table (7): Acute anti- inflammatory activity of some treated samples

Name of sample	% Oedema Mean ± S.E	% of Change	% of Potency
Blank	61.4 ± 1.8	--	
Indomethacin	21.9 ± 0.4	64.3	--
Samples treated with pelargonium extract only	37.9 ± 1.6	38.3	59.6
Samples treated with microencapsulated extract			
Alg	35.5 ± 1.3	42.2	65.6
Mypro	34.4 ± 1.2	44	68.4
Post treated microencapsulated samples with citric acid			
Alg	25.7 ± 0.4	58.1	90.4
Mypro	27.4 ± 0.6	55.4	86.2

Note: - Alg = sodium Alginate, Mypro = mypro gum

Alg = sodium Alginate, Mypro = mypro gum

Samples which post treated with citric acid were assigned to a blank sample treated with 2% citric acid, pick-up 100%, dried at 80°Cfor 5 min., cured at 120°C for 2 min.(Blank sample with E.coli = 30 colonies, Blank sample with S. aureus = 35 colonies)

Samples which post treated with binder were

assigned to a blank sample treated with 1% binder, pick-up 100%, dried at 80°C for 5 min., cured at 120°C for 2 min.(Blank sample with E.coli = 78 colonies, Blank sample with S. aureus = 80 colonies)

3.4. Acute anti- inflammatory activity of some treated samples and Endomethacin drug on male albino rats:-

The anti-inflammatory activity examined on the male albino rats for each treatment condition. The result obtained was tabulated in table (7). Obviously the anti-inflammatory potency of samples is affected by the post treatment condition and follows the order:

Samples treated with crud extracts only <samples treated with microencapsulated extracts <samples post treated with citric acid.

The superiority of the anti-inflammatory potency of the samples due to the active constituents of the ethanolic extract as mentioned earlier. The samples which post treated with citric acid reportedly had the highest anti-inflammatory effect. This result may be explained as mentioned before due to the different rules of citric acid for retaining a large number of extract microcapsules all-over the fabric surface.

3.5. Antibacterial activity of the microencapsulated pelargonium extract with sodium alginate applied on wound dressing with and without post treatment with citric acid.

Two cotton wound dressing samples were treated with microencapsulated extract of the pelargonium hortorum with sodium alginate, then one of them was post treated with citric acid.The antibacterial activity of each sample was evaluated.

Table (8) shows the result obtained, after 4 hours both samples maintain no bacterial growth which represented in 100% reduction, after 8 hours the reduction % decreased to 98.2% with E.coli and 96.9% with S. aureus according to the result of sample treated with microencapsulated extract only but the sample post treated with citric acid remained with no bacterial growth. After 24 hours the sample treated with microencapsulated extract only recorded lower reduction % when compared with that post treated with citric acid which reported a bacterial reduction of 98.6% with E.coli and 98.2% with S. aureus.

The Ratio of the bacteria reduction % of the wound dressing sample which treated with microencapsulated extract only is lower than that obtained from the woven sample which treated with the same conditions as was reported in table (6) which showed 100% reduction percantage, the possible explanation of that may be due to the weaving structure of the fabric that have more numbers of yarns per cm and subsequently more number of microcapsules retaining on.

Table (8): activity of the microencapsulated pelargonium extract with sodium alginate applied on wound dressing

Sample No	Sample name	No. of Hours	Reduction %	
			E.coli	S. aureus
1	Microencapsulated Extract only	4 hours	100	100
		8 hours	98.2	96.9
		24 hours	92.9	93.2
2	Microencapsulated and post treated with citric acid	4 hours	100	100
		8 hours	100	100
		24 hours	98.6	98.2

Blank sample with E.coli= 792 colonies, and with S. aureus=912colonies – i.e. 100% bacterial growth

3.6. Changes in fabric whiteness:

The Changes in fabric whiteness (WI) for both the untreated and treated fabric was measured. The results are illustrated in table (10). It is noticed that this treatment led to a slight decrease in WI, it may be due to the turbid color of the extract itself, in addition to exposing the finished fabric to high temperatures to fix the treatment.

Table (10): Changes in fabric whiteness of untreated and treated fabric

WI of untreated fabric	68.74
WI of fabric treated with pelargonium extract microencapsulated with mypro gum & post treated with citric acid	52.99
WI of fabric treated with pelargonium extract microencapsulated with sod. alginate & post treated with citric acid	51.53

3.7. Physico-mechanical properties of treated fabric:

Table (9) shows the physical properties of the fabric microencapsulated with alginate as a wall material. The treatment generally led to an increase in the tensile strength and a decrease in the elongation of the cotton fabric in both warp and weft directions. Sample (MC) recorded the highest tensile strength (Max STR) and sample (M) recorded the lowest elongation (Max STN).

Roughness of the samples was enhanced by the treatment as it was observed in the results, the sample (MC) also shows the lowest roughness compared with others.

Fabric face and back stiffness were measured in both directions warp and weft. Asobserved, the stiffness of the fabric slightly increased and sample (MC) recorded the lowest stiffness, then (MB), then (M) by order.

Table (9): physical properties of the fabric before and after different treatment conditions

Sample name	Tensile strength and elongation				roughness	Stiffness			
	Warp		Weft			Warp		Weft	
	Max.STR ($kgf.mm^2$)	Max.STN (%)	Max.STR ($Kgf.mm^2$)	Max.STN (%)		face	back	face	back
B	1.158	16.50	1.16	16.75	16.13	4.3	4.4	4.6	4.7
M	1.29	10.25	1.34	10.42	15.21	6.3	5	5.7	4.4
M.C	2.67	12.25	3.13	12.4	13.82	5.3	4.6	5.4	4.5
M.B	2.32	11.75	2.89	11.92	14.7	5.8	4.7	5.6	4.7

***Note:- B-** blank, **M-** sample treated with microcapsules, **MC-** sample treated with microcapsules and post treated with citric, **MB-** sample treated with microcapsules and post treated with binder.

4. Conclusion:

Pelargonium hortorum (geranium) leaves is a source of natural product that can be used to impart antibacterial and anti-inflammatory properties to the textile substrate. Cotton treated fabrics with pelargonium extract showed antibacterial efficacy against both Escherichia coli, gram negative bacteria (-ve) and Staphylococcus aureus, gram positive bacteria (+ve). The durability of the treatment was increased by the microencapsulation technique. Post treatment either with citric acid or binder inhibits the bacterial by 88.7-90.6% after 10 washing cycles. The treated fabric also showed anti-inflammatory efficacy.The potency% reached to 90.4% for the fabric microencapsulated using sodium alginate as a wall material and post treated with citric acid.Because of the nature, non-toxic and medical properties of Pelargonium hortorum, it is a promising candidate for niche applications such as medical and healthcare textile.

References:

1 Adams R. P., "Identification of Essential Oil Components by Gas Chromatography/ Quadrupole Mass Spectroscopy", Allured Pub. Corp., Carol Stream, USA, 1995.

2 American Association of Textile Chemists Colorists, AATCC Test Method100-1999, Antibacterial Finishes on Textile Materials: Assessment, of AATCC Technical Manual (Vol. 75) NC: 2000 Technical Manual of the American Association of Textile Chemists and Colorists, AATCC, Research Triangle Park, NC (1999).

3 American Association of Textile Chemists Colorists. AATCC Test Method 61-1989, Colorfastness to Laundering, Home and Commercial: Accelerated, ATCC Technical Manual (1989) 68, p. 94, 1993.

4 ASTM procedure D/1388/96, Determination of fabric stiffness.

5 ASTM procedure D/3822, Determination of Tensile Strength and Elongation.

6 BORYO, D.E.A., "The Effect of Microbes on Textile Material: A Review on the Way-Out So Far", The International Journal of Engineering And Science, 2 (8), 9-13, 2013.

7 Carolina H. Pohl, Johan L.F. Kock & Vuyisile S. Thibane, "Antifungal free fatty acids: A Review", Science Against Microbial Pathogens: Communicating Current Research and Technological Advances 1, FORMATEX,p 61 -71, 2011.

8 Cheng S.Y., Yuen C.W.M., Kan C.W. & Cheuk K.K.L., "Development of Cosmetic Textiles Using Microencapsulation Technology", RJTA, 12 (4), p. 41, 2008.

9 Chinta S K & Pooja P. Wane, "Imparting antimicrobial finish by microencapsulation

technique", IJIRSET, 2 (6), P 2326-2336, 2013.
10 Dhiman, G. & Chakraborty, "Antimicrobial performance of cotton finished with triclosan, silver and chitosan", Fashion and Textiles, p. 2-13, December 2015.
11 Harbone J B, "Phytochemical Methods: A Guide to modern Techniques of plant Analysis", 3rd edition, p. 117, Chapman and Hall Ltd, London, 1998.
12 Jubie S. & Dhanabal S.P., "Gas Chromatography, Mass Spectrometry Analysis and Antibacterial Activity of Fatty Acid Mixture of Spirulina platensis", journal of pharmaceutical sciences and research, 4 (6), p 1836, June 2012.
13 Jyothi Sri. S, A.Seethadevi, K.Suria Prabha, P.Muthuprasanna & P.Pavitra, "Microencapsulation: A review", International Journal of Farma and Bio Sciences, 3 (1), p 509-531, 2012.
14 Khushboo Shrimali & ElaManoj Dedhia, "Microencapsulation for Textile Finishing", IOSR Journal of Polymer and Textile Engineering, 2 (2), p. 1-4, 2015.
15 N. R. C. Lab,Using Surface Roughness Measuring Instruments (Surfcoder SE 1700) Manufactured by Kosaka Laboratory Ltd. Japan.
16 Nwachukwu Ifeanyi, Aliga, Chinanu, Upabi Chibueze F.&Ukogo Ifeoma, "In-Vitro Antibacterial Effect of Crude Extract of Chromolaena Odorata Leaves on Wound Isolates", IOSR Journal of Pharmacy and Biological Sciences, 11 (6), p. 49-52, 2016.
17 OlgaGortzi, StavrosLalas, Ioanna Chinou & John Tsaknis , "Evaluation ofthe Antimicrobial and Antioxidant Activities of Origanum dictamnus Extracts before and after Encapsulation in Liposomes", Molecules,12 (5), p 932-945, 2007.
18 Saito M, Sakagami H&Fujisawa S, "Cytotoxicity and apoptosis induction by butylated hydroxyl anisole (BHA) and butylated hydroxyl toluene (BHT) ", Anticancer Res. 23(6C), Nov. 2003.
19 Saraswathi J, Venkatesh K, Nirmala Babura, Majid Hameed Hilal1 and A. Roja Rani1, "Phytopharmacological importance of Pelargonium species", Journal of Medicinal Plants Research, 5 (13), p. 2587-2598, 2011.
20 Sheila Shahidi & Jakub Wiener. "Antibacterial Agents in Textile Industry, Antimicrobial Agents", Dr. Varaprasad Bobbarala (Ed.), InTech, 2012, DOI: 10.5772/46246. Available.from:http://www.intechopen.com/books/antimicrobial-agents/antibacterial-agents-in-textile-industry.
21 Siu-Po Ip, Kam-Ming Ko, "The crucial antioxidant action of schisandrin B in protecting against carbon tetrachloride hepatotoxicity in mice: A comparative study with butylated hydroxytoluene", Biochemical pharmacology, 52 (11), 1687-1693, 1999.
22 Sudha T, Chidambarampillai S & Mohan V.R, "GC-MS Analysis of Bioactive Components of Aerial parts of Fluggea leucopyrus Willd. (Euphorbiaceae) ", Journal of Applied Pharmaceutical Science, 3 (5), p 126 – 130, May 2013.
23 Thilagavathi G & Kannaian T, "Combined antimicrobial and aroma finishing treatment for cotton, using encapsulated geranium (pelargonium graveolens L' Herit ex Ait.) leaves extract", Indian journal of natural products and resources, 1 (3), p 348-352, 2010.
24 Vinod D. R., "Pharmacognosy and Phytochemistry, part 1", p. 132, Carrier publication, Nasik, 2002.
25 Wageeh A. Yehye, Noorsaadah Abdul Rahman, Abeer A. Alhadi, Hamid Khaledi, Seik Weng Ng, & Azhar Ariffin, "Butylated Hydroxytoluene Analogs: Synthesis and Evaluation of Their Multipotent Antioxidant Activities", Molecules,17, p 7645 -7665, 2012.
26 Wayne R. Bidlack, Stanly T.Omaye, Mark S.Meskin, & Debra K.W.Topham, "Phytochemical as bioactive agents", CRC press, New York, 2000.
27 Winter CA, Risley EA, Nuss GW, "Carrageenin-induced edema in hind paw of the rat as an assay for antiinflammatory drugs" Proc. Soc. Exp. Biol. Med, 111, 1962.