4

RESULTS AND DISCUSSION

The results and discussion of the work entitled **"Developing Herbal Antimicrobial Finish Cotton Fabric for Wound Dressing"**are presented as follows;

4.1 Properties of Commercialy Available Wound Dressing Bandaids

4.1.1 Inteview Schedule

4.1.2 Properties Best Suitable for Wound Dressing Bandages Used for AcuteWound

4.2 The Yield % Obtained from Each Plant Extract

4.3 Determination of Minimum Inhibitory Concentration (MIC)

4.4 Antimicrobial Activity of the Herbal Extract

4.5 Antimicrobial Analysis for Poly Herbal Extract

4.6 Wound Scratch Cell Line Assay

4.7 Antimicrobial Assessment of Polyherbal Finished Fabric

4.8 SEM Analysis of Polyherbal Finished Fabric

4.9 Assessment of Finished Fabric Using Fourier Transform Infrared Spectroscopy

4.10 Physical Properties of Polyherbal Finished Fabric

4.10.1 Physical Properties of the Commercial Bandaids and Control Fabric

4.10.2 Fabric Weight of Polyherbal Finished Fabric

4.10.3 Tensile Strength of Polyherbal Finished Fabric

4.10.4 Sinking Test of Polyherbal finished fabrics

4.10.5 Water Holding Capacity of Polyherbal Finished Fabric

4.1 Properties of Commercialy Available Wound Dressing Bandaids

Self adhesive band aids require certain parameters in common which was collected through the market survey. In market survey it was found that the respondents expressed that the herbal antimicrobial bandaid for minor cut, burns and scratches should be made with plain woven cotton fabric of yarn count 30's in the warp yarn and 10's in the weft yarn. As per the study certain quality parameters such as absorbency, water holding capacity, air permeability, tensile strength needs to be taken care. The size varies from standard size has to 3/4 inch width and three inch length. Considering the length three inch length and two inch width had been adopted for the study. Other specification such as quality, good adhesion, perfect finishing, water proof, herbal finished, easy unwind of the bandaid and wound dressing materials for minor injuries and major injuries were also included in the question and this is presented in Appendix I

4.1.1 Inteview Schedule

The details of the parameter required for the wound dressing bandaids as mentioned by the physisans is mentioned in Table VII.

Table VII

Details of the Parameters Required Wound Dressing Bandaids

List of Bandages	Types of Wounds	No of Respondents%
Hydro colloid	Burns	28
	Wounds that emitting liquids	04
	Necroticwounds	28
	Pressure ulcers	44
	Varicose ulcers	28
Hydro gel	Leaking wounds	24
	Painful or necrotic wounds	44
Alginate dressing	High amounts of drainage	36
	Burns	24
	Venous ulcers	36
	Packing wounds	16
	Higher state pressure ulcers.	24
Collagen	Chronic wounds	32
	Pressure sores	20
	Transplant sites	36
	Surgical wounds	16
	Ulcers	24
	Burns or injuries with a large surface area	52
Foam	Injuriesexhibitodour	16
	Absorbs exudates for wound surface.	48
	Used on surgical incision sites	28
	Burns	16
	Ulcers	40
	IV sites	20
Cloth	Cover open wounds	52
	Grazes	12
	Cuts	12
	Areas of delicate skins	24

From the Table VII it is clear that Hydro colloide, Hydrogel, Alginate dressing,Collagen, Foam and Cloth dressings are best for pressure ulcers, painful or nercotic wounds, high amount of drainage and venous ulcers, transplant sites, burns or injuries with a large surface areas, absorbes exuades for wound surface and cover open wound respectively.

Hence it could be concluded that each wound dressing material was different and can be used for different kind of wounds.

4.1.2 Properties Best Suitable for Wound Dressing Bandages Used for AcuteWound

The properties best suitable for wound dressing use for acute wounds are given in Table VIII

Table VIII

Properties Best Suitable for Wound DressingBandages Used for Acute Wound

Best Suitable Properties for Wound Dressing	No of Respondents%
Non-breathable	nil
Breathable	92
Easy wearable	88
Comfortable	92
Self-adhesive	40
Suitable for sensitive skin type	80
Reduce pain	56
Remove dead tissue	68
Cooling effect on burning wounds	64
Absorb excess liquid	68
Containing sodium and seaweed fibres	16
Helping to bring the wound edges together	68
Aiding the growth of new blood vessels	72
Effectively speeding up healing	84
Allow water vapour to enter	20
Keeping the area moist	28
Promoting faster healing	72
Antimicrobial property	92
prevent infection	84
Used to dress all shapes and sizes	72
Biodegradable	60

The Table VIII contains clearly shows that breathable, comfortable and antimicrobial properties are most desirable factors for wound dressing as expressed by 92%of respondents respectively. This is followed by easy wearable, effectively speading up healing prevent infection and suitable for sensitive skin type as mentioned by 88,84 and 80% of the respondents respectively.

The hydrocolloid wound dressing are in relation to the results of (Pott et al,2014) in his paper "The Effectiveness of Hydrocolloid Dressing Versus Other Dressing in the Healing of Pressure Ulcers in Adult and Older Adults a Systematic Review and Meta Analysis".

4.2 The Yield % Obtained from Each Plant Extract

The results pertaining to the percentage yield of the plant parts of *Abutilon indicum, Cassia auriculata, Cassia fistula* and *Tridax procumbenz* upon various solvents obtained from the dry weight sample of the herbs are presented in the Table IX and Figure II.

Table IX

Yield % Obtain from Each Plant Extract

S. No	Plant Sample	Extract	Weight of sample (gram)	Dry weight of the concentrate (gram)	Yield %
1	*Abutilon indicum*	Hexane	100	1	1
		Ethyl acetate	100	1	1
		Methanol	100	2	2
2	*Cassia auriculata*	Hexane	100	1	1
		Ethyl acetate	100	1	1
		Methanol	100	2	2
3	*Cassia fistula*	Hexane	100	1	1
		Ethyl acetate	100	1	1
		Methanol	100	2	2
4	*Tridax procumbenz*	Hexane	100	1	1
		Ethyl acetate	100	1	1
		Methanol	100	2	2

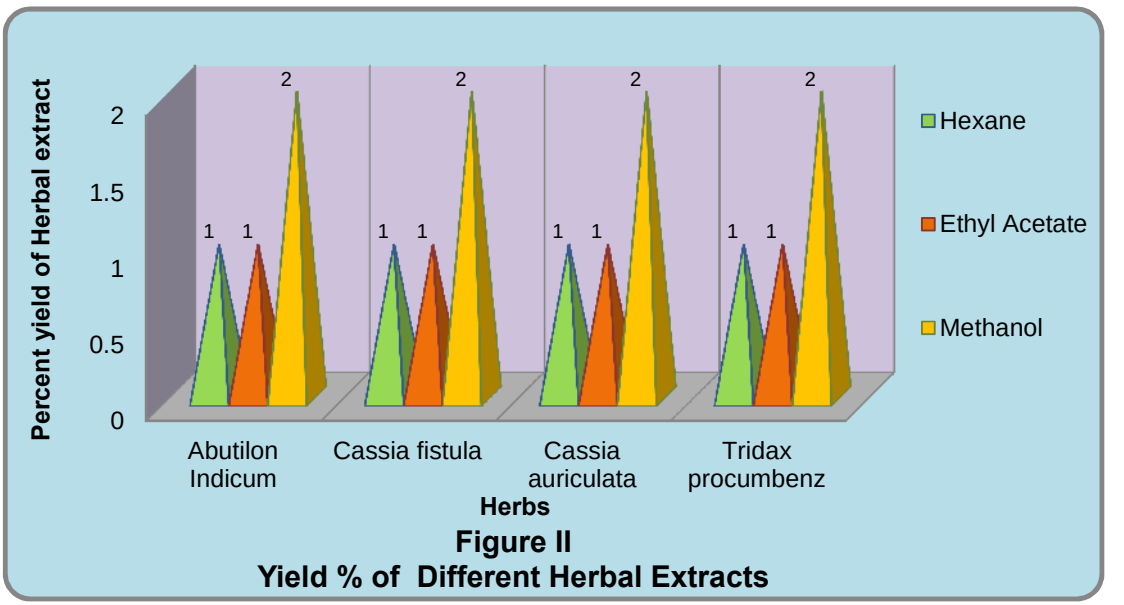


Figure II
Yield % of Different Herbal Extracts

From the Table IX and Figure II, it is evident that the percentage yield of herbal concentrate upon different solvents exhibit similar results except the herbal concentrate yield of Methanolic extract. Irrespective of the types of herbs, all the extracts done with methanol proved to have the maximum yield, as 2 gram. Hence, it was selected as the solvent for the study.

4.3 Determination of Minimum Inhibitory Concentration (MIC)

The outcome of the MIC value of *Abutilon indicum, Tridax procumbenz*, *Cassia fistula* and *Cassia auriculata* extracts are given in Table X and Figure III.

Table X
MIC Values of Herbal Extracts

S. No	Methanolic Extraction	MIC Values (µg /ml) of Herbal Extract				
		1	2	3	4	5
1	***Abutilon indicum***	250	125	250	250	1000
2	***Tridax procumbenz***	500	125	500	250	500
3	***Cassia fistula***	250	250	250	500	500
4	***Cassia auriculata***	62.5	125	250	250	62.5

1. *Candida albicans,* 2. *Pseudomonas aeruginosa* ,3. *Escherichia coli* ,
4. *Staphylococcus saprophyticus*,5. *Aeromonas hydrophila*

It is clear from the above Table X and Figure III that Methanolic extract was subjected to serial dilution method in which samples were diluted to the concentrations of 1000, 500, 250, 125, 62.5, 31.25 µg/ml and 100µl. The test culture of *Candida albicans, Pseudomonas aeroginosa, Staphylococcus saprophyticus, Escherichia coli* and *Aeromonas hydrophila* were inoculated with the equal amount of nutrient bath and herbal extract.It was then incubated at 37°C for 24hours and tested for Minimum Inhibitory Concentration. From the results obtained it was clear that *Tridax procumbenz* showed a breaking point at 500µg/ml where as remaining herbs *Cassia fistula, Cassia auriculata* and *Abutilon indicum* showed a breaking point at 250µg/ml.

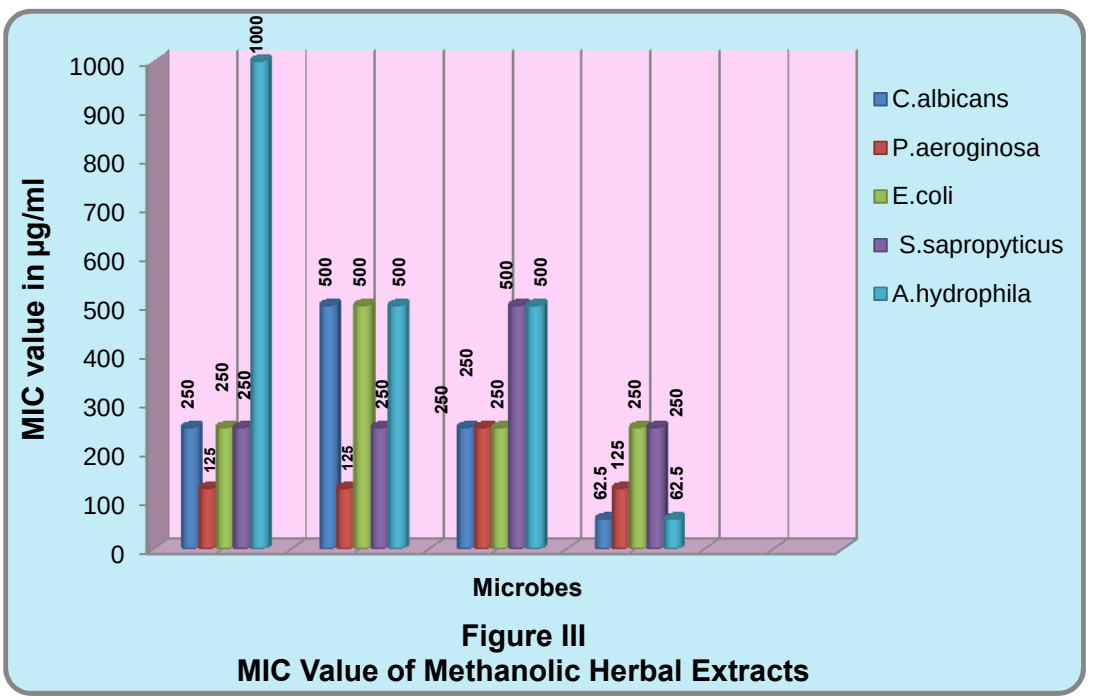


Figure III
MIC Value of Methanolic Herbal Extracts

4.4 Antimicrobial Activity of the Herbal Extract

The results for the zone of inhibition of Methanolic herbal extracts of *Abutilon indicum, Cassia fistula, Cassia auriculata* and *Tridax procumbenz* obtained are shown in the Table XI and Figure IV.

Table XI

Antimicrobial Activity of Herbal Extract by Well Diffusion Method

S. No	Sample	Zone of Inhibition (mm)									
		1		2		3		4		5	
1	Distilled water	-		-		-		-		-	
2	Levofloxacin	22	100	25	100	30	100	28	100	31	100
3	*Tridax procumbens* (500 µg/ml)	13	59%	14	56%	13	43.3%	12	42.8%	13	41.9%
4	*Abutilon indicum* (250µg/ml)	16	72.7%	15	60%	20	66.6%	23	82.1%	15	48.3%
5	*Cassia fistula* (250µg/ml)	15	68.1%	18	72%	16	53.3%	17	60.7%	19	61.2%
6	*Cassia auriculata* (250µg/ml)	19	86.3%	20	80%	22	73.3%	25	89.2%	26	83.8%

1.*Candida albicans*2.*Pseudomonas aeruginosa*3. *Escherichia coli*

4. *Staphylococcus Saprophyticus*5.*Aeromonas hydrophila*

From the Table XI and Figure IV it is proven that, the minimum Zone of Inhibition value obtained by the *Abutilon indicum, Cassia fistula,Cassia auriculata* and *Tridax procumbenz* extracts against the microbial pathogens such as, *Candida albicans*, *Pseudomonas aeruginosa*, *Escherichia coli*, *Staphylococcus Saprophyticus*, and *Aeromonas hydrophila* were evaluated.

Cassia auriculata(250µg/ml) proved to have better zone value such as 19, 20,22,25 and 26 mm respectively. *Abutilon indicum* (250µg/ml) also showed higher zone of inhibition as 20 and 23 for microbes.*Escherichia coli* and *Staphylococcus saprophyticus* respectively.On comparision with the negative control, it was clear that the fabrics were able to control the growth of microbes as far as the positive is concered.

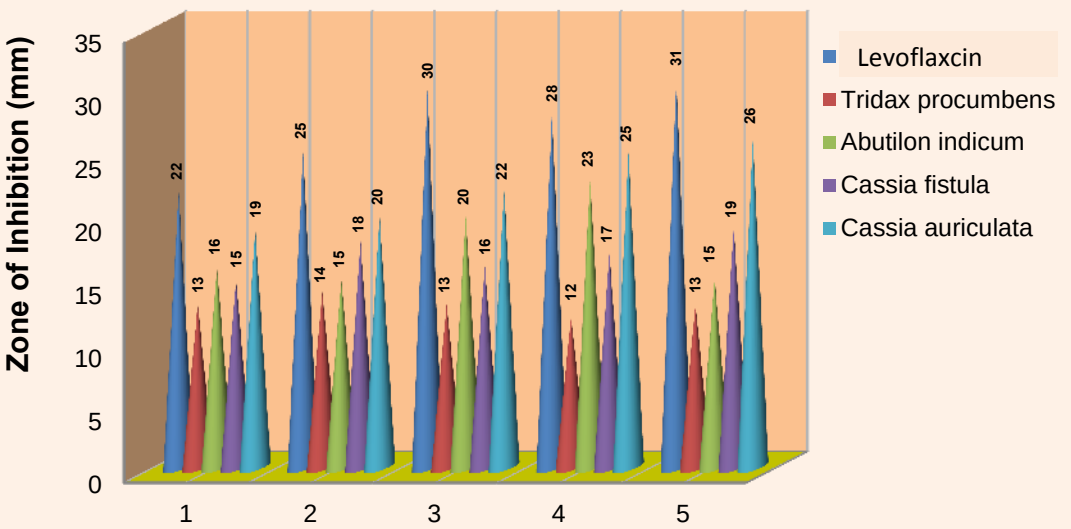


Figure IV
Antimicrobial Analysis of Herbal Extract by Well Diffussion Method

4.5 Antimicrobial Analysis for Poly Herbal Extract

The antimicrobial analysis of polyherbal extract obtained against *Candida albicans, Staphylococcus saprophsyticus, Pseudomonas aeroginosa, Escherichia coli* and *Aeromonas hydrophila* are discussed in Table XII and Figure V.

Table XII

Antimicrobial Activity of Polyherbal Extract by Well Diffusion Method

S. No	Sample		Zone of Inhibition (mm)									
			1		2		3		4		5	
1	Distilled water		-		-		-		-		-	
2	Levofloxacin		22	100	25	100	30	100	28	100	31	100
3	Polyherbal extract	50 µl	14	56%	12	38.7%	11	39.2%	15	75%	10	45.4%
		100 µl	18	72%	15	48.3%	17	60.7%	19	95%	15	68.1%
		150 µl	20	80%	17	54.8%	20	71.4%	21	105%	18	81.8%
		200 µl	22	88%	20	64.5%	22	78.5%	23	115%	20	90.9%

1. *Candida albicans* 2. *Pseudomonas aeruginosa* 3.*Escherichia coli*

4.*Staphylococcus saprophyticus*5.*Aeromonas hydrophila*

From the result it was identified that the polyherbal extract (50 µl,100µl,150µl,200µl) prepared at the ratio of 1:2:1:1 of 80 % concentration treated against the selected microbial pathogens such as *Candida albicans, Staphylococcus Saprophyticus, Pseudomonas aeroginosa, Escherichia coli* and *Aeromonas hydrophila* 200µl of poly herbal extract showed better zone of inhibition followed by 150µl, 100µl and 50µl and can be seen in Table XII and Figure V.

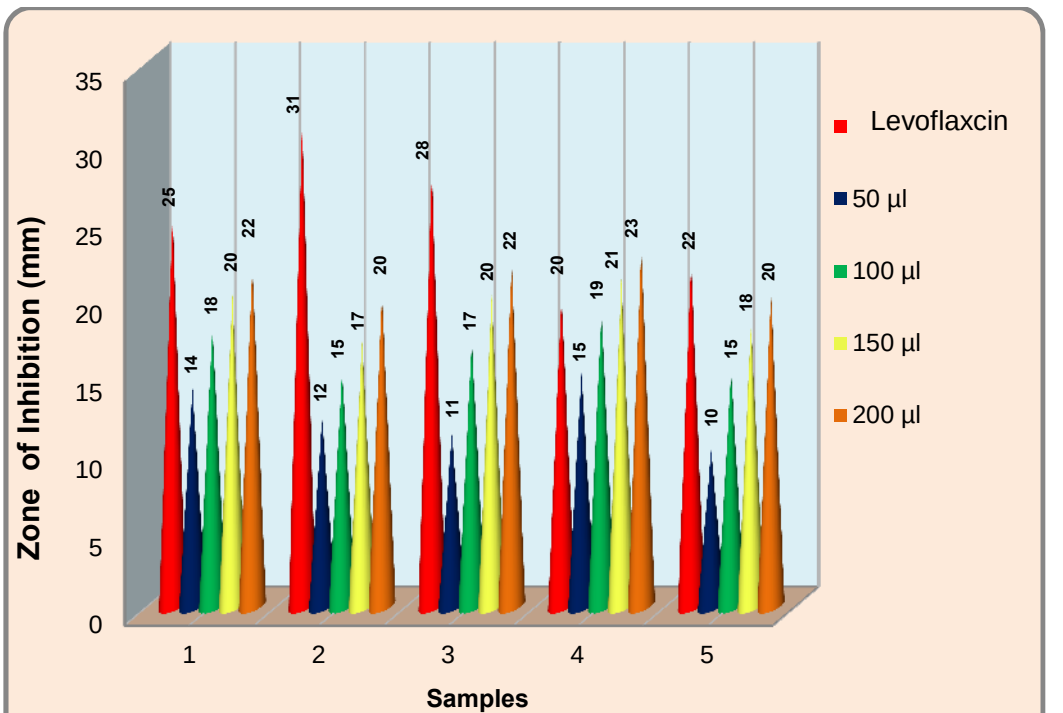


Figure V
Antimicrobial Analyis of Polyherbal Extract by Well Diffussion Method

4.6 Wound Scratch Cell Line Assay

The results pertaining to the wound scratch cell line assay conducted with polyherbal extract are shown in Plate XXXIX

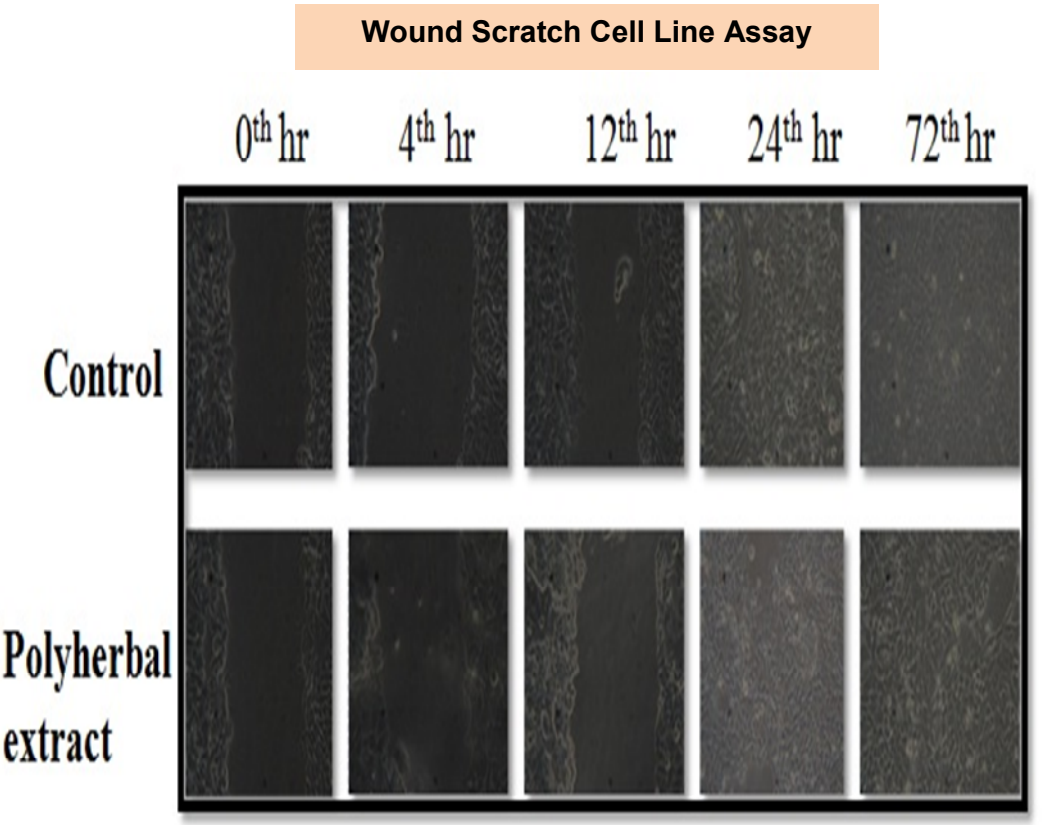


Plate XXXIX

For the study, cells were thoroughly rinsed with 1 X phosphate buffer salin (PBS) to remove cellular debris and treated with 80% concentration (25 µl) of Polyherbal extract. Cell proliferation was monitored at different time points such as 1, 4, 12, 24 and 72 hours and images of the migrated cells were taken at above mentioned time points using digital camera (Nikon, Tokyo, Japan) connected to the inverted phase contrast microscope (Radical instruments, India). Extent of wound healing was determined by the distance traversed by cells migrating into the denuded area, and the process result have been shown in the Plate XXXIX.

4.7Antimicrobial Assessment of the Polyherbal Finished Fabric

The antimicrobial assessment of the poly herbal finished fabrics are illustrated in the Table XIII and Figure VI.

Table XIII

Antimicrobial Activity of Various Types of Polyherbal Finished Fabrics

S. No	Type of polyherbal finished fabrics used	Diameter of Zone of Inhibition (mm)				
		S. saprophyticus	*P. aeruginosa*	*C. albicans*	*E. coli*	*A. hydrophila*
1	C	**13**	**16**	**11**	**19**	**10**
2	DDF	**21**	**25**	**20**	**23**	**20**
3	MEF	**32**	**29**	**31**	**32**	**25**
4	NEF	**34**	**33**	**32**	**35**	**29**

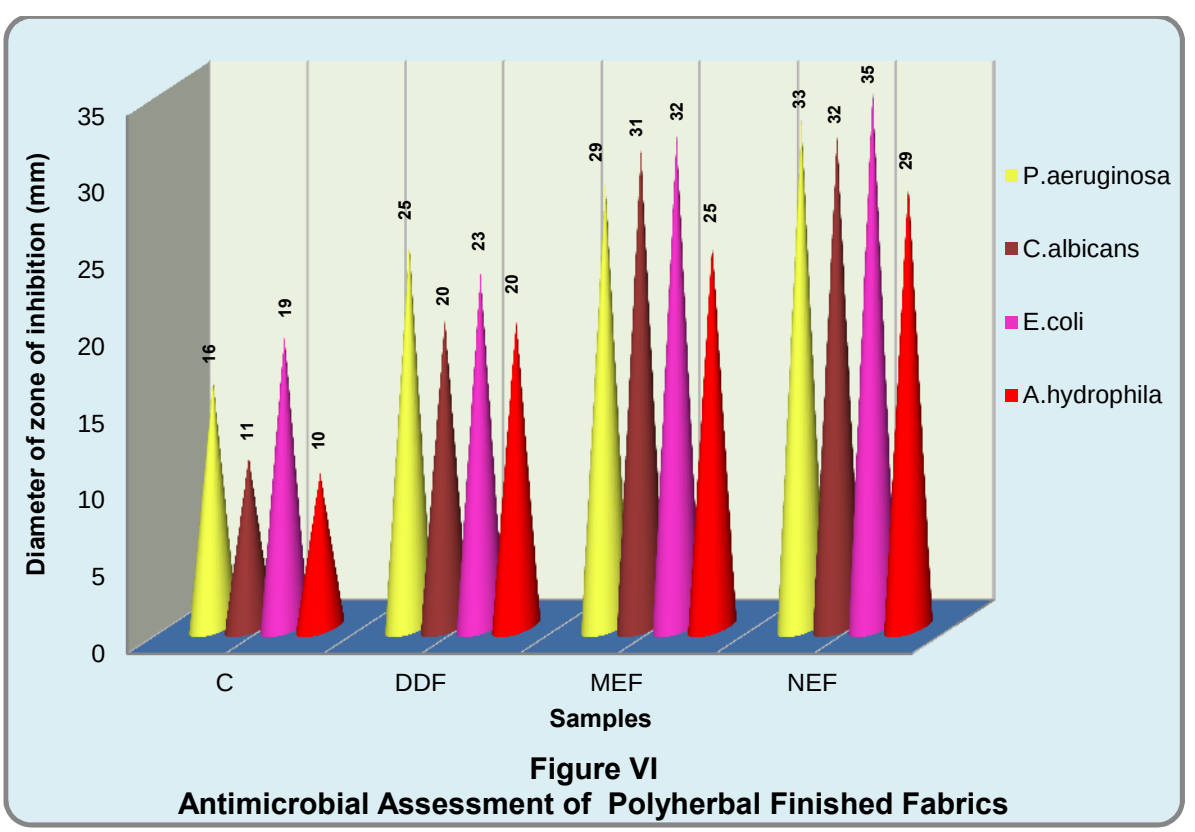


Figure VI
Antimicrobial Assessment of Polyherbal Finished Fabrics

The Antimicrobial assessment for polyherbal finished fabric such as Dip and Dry, Microencapsulation and Nanoencapsulation against microbial pathogens such as *Staphylococcus saprophyticus,Pseudomonas aeroginosa, Candida albicans, Escherichia coli* and *Aeromonas hydrophila we*re evaluated by AATCC 147 Agar well Diffusion method. Sample NEF showed the maximum zone of inhibition as 34,33,32,35 and 29 mm for the microbes *Staphylococcus Saprophyticus,Pseudomonas aeroginosa, Candida albicans, , Escherichia coli* and *Aeromonas hydrophila* respectively, followed by MEF and DDF. Hence it could be concluded that NEF polyherbal Finish had the maximum control over microbes.

4.8 SEM Analysis of Polyherbal Finished Fabrics

The SEM sample of MEF and NEF Figure VII (a,b) and Figure VIII (a,b) indicate the surface morphology of the polyherbal finished fabrics. The range of particle size of herbal extract was observed between 3.328μm of RSD 09 28 and similarly the particle size of nanocapsules had been identified between 171.43nm to 345.25nm. From the figure it is proved that the MEF and NEF particle deposition on the fabric had been embedded firmly on the fabric surfaces of MEF and NEF

SEM Analysis of MEF and NEF Finished Fabric

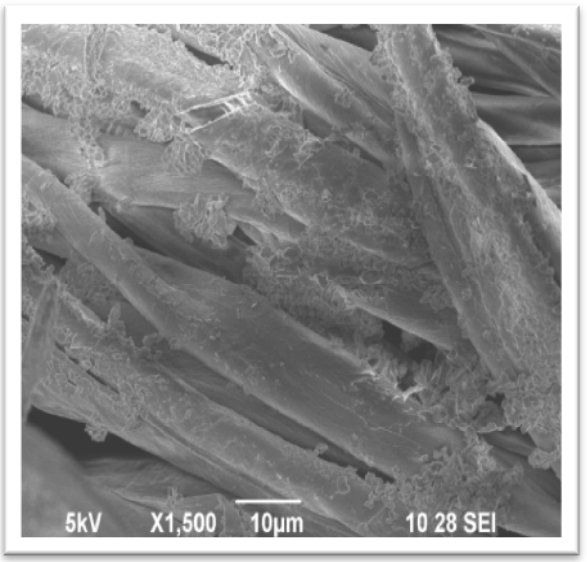


Figure VII (a)

SEM of Microencapsulated Fabric

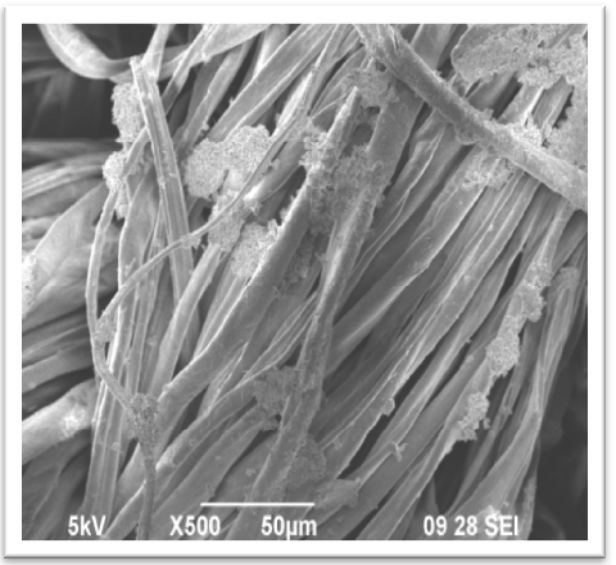


Figure VII (b)

SEM of MicroencapsulatedFabric

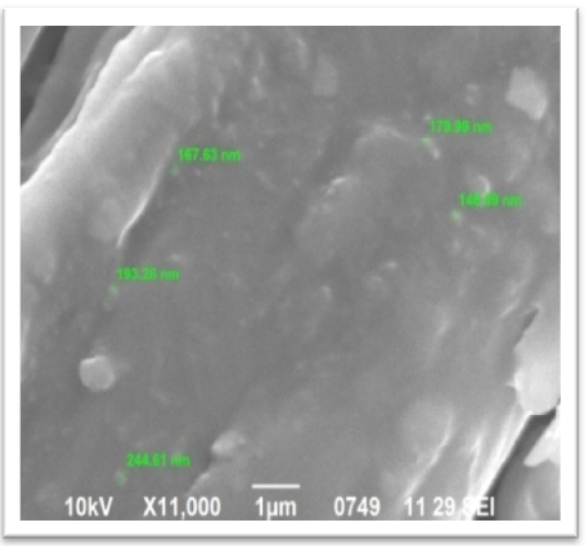


Figure VIII (a)

SEM of Nanoencapsule Fabric

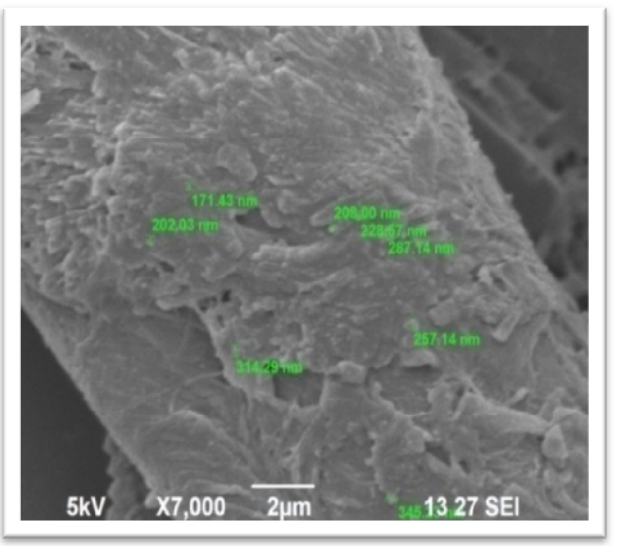


Figure VIII (b)

SEM of Nanoencapsule Fabric

4.9 Assessment of Finished Fabric Using Fourier Transform Infrared Spectroscopy

The results of FTIR images of the polyherbal finished samples with the 80% concentration of herbal extract are shown in the Figure IX, Figure Xand Figure XI.

FTIR Spectroscopy of Polyherbal Finished Fabric

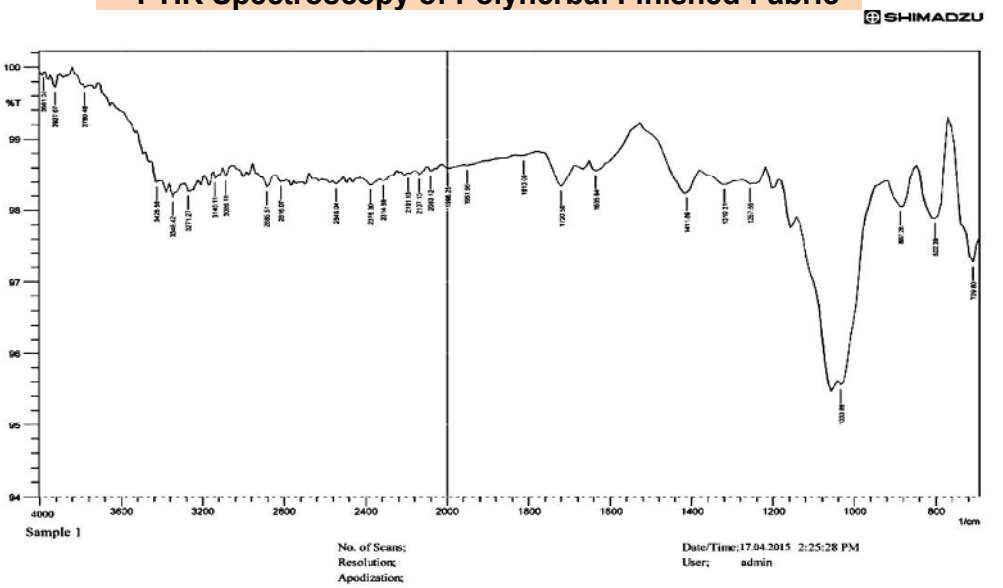


Figure IX
FTIR of Dip and Dry Fabric

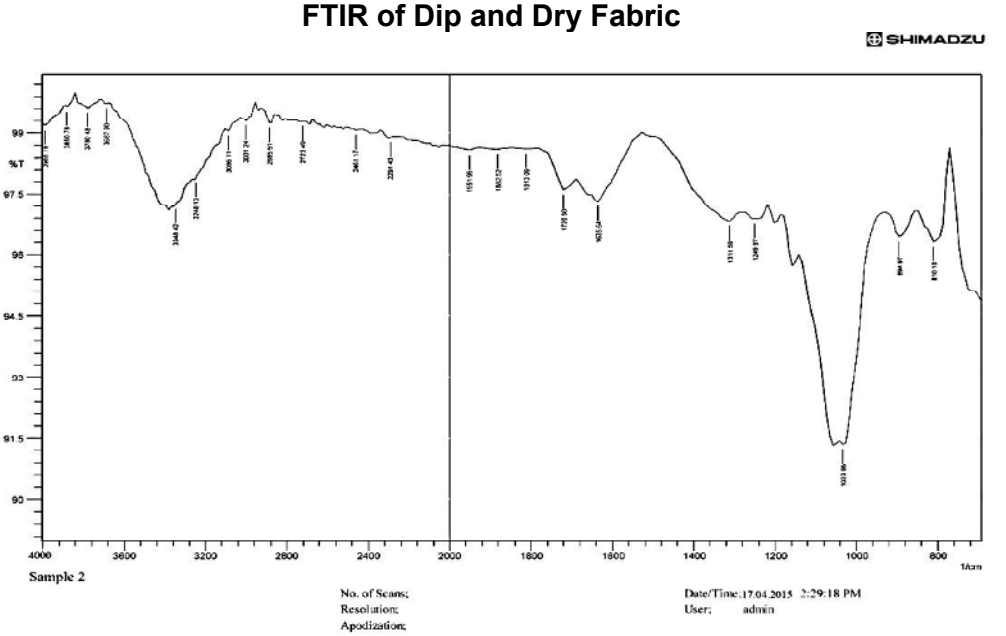


Figure X
FTIR of Microencapsulated Fabric

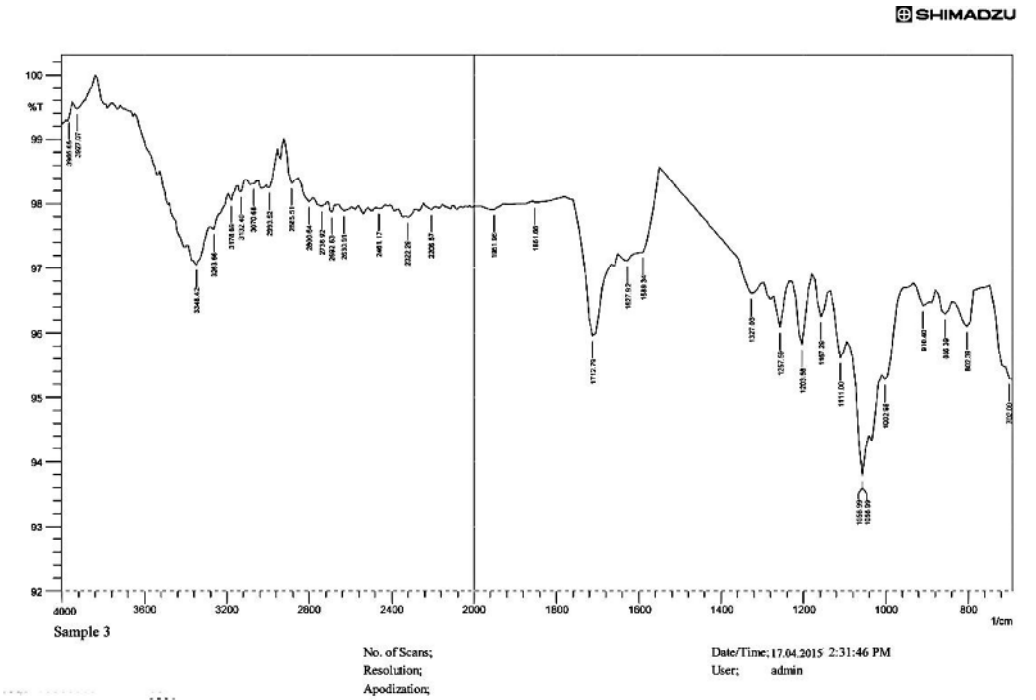


Figure XI

FTIR of Nanoencapsulated Fabric

Regarding the FTIR results from the Figures IX, X and XI the range between 1724cm^{-1} to 2915, 540.935 to 690 and 1242 showed the presence of carbohydrates, alkalides and phenolic compounds. In Figure IX, the presence of spectrum 1846.51 showed the presence of acid halides. In Figure IX the ranges between 1320-1000 proved the presence of carboxcylic, ester acid and ether. The bands of 1452.85 in Figure X showed the presence of alkenes. Similarly the presence of 3360-3549 cm^{-1} in the Figure IX, X and XI show the presence of alcohols. Hence from the FTIR, it was clear that the spectral band proved the presence of phytochemical compounds in herbal finishing fabrics. Hence it could be concluded that the finishing has enhanced the antimicrobial activity.

The Antimicrobial assessment for polyherbal finished fabric such as Dip and Dry, Microencapsulation and Nanoencapsulation against microbial pathogens such as *Staphylococcus saprophyticus,Pseudomonas aeroginosa, Candida albicans, Escherichia coli* and *Aeromonas hydrophila*were evaluated by AATCC

147 Agar well Diffusion method. The sample NEF showed the maximum zone of inhibition as 34,33,32,35 and 29 mm for the microbes *Staphylococcus saprophyticus,Pseudomonas aeroginosa, Candida albicans, , Escherichia coli* and *Aeromonas hydrophila* respectively followed by MEF and DDF. Hence it could be concluded that NEF polyherbal finish had the maximum control over microbes.

4.10 Physical Properties of Polyherbal Finished Fabrics

4.10.1 Physical Properties of the Commercial Bandaids and Control Fabric

The physical property of the commercial bandaid was assessed in need for comparision with that of the polyherbal finished fabric. The properties such as fabric weight, tensile strength, absorbency, air permeability and vertical wicking were tested analysed and presented in Table XIV.

Table XIV

Physical Properties of the Control Fabric

S.No	Fabric property	100 % cotton 30s Ne and 10s Ne
1	Tensile strength warp (kgf)	32.79
2	Tensile strength weft (kgf)	58.27
3	Yarn thickness warp (mm)	0.25
4	Yarn thickness weft(mm)	0.71
5	Air permeability(cm3/cm2/s)	79.3
6	Vertical wicking warp (cm)	0.412
7	Vertical wicking weft (cm)	0.410
8	Fabric GSM	174
9	Water absorbency(sec)	3

In the above Table XIV, the physical property of 30sN and 10sNe plain weave cotton fabric selected for the study is shown. The tensile strength of the

warp and weft is identified as 32.79 (Kgf) and 58.72(Kgf) respectively. The yarn thickness for the warp and the weft is 0.25mm and 0.71mm respectively. Similarly, the air permeability of the woven fabric is 79.3 $cm^3/cm^2/s$. The vertical wicking in the warp and weft direction is 0.412cm and 0.410 cm. The fabric GSM is 174 and the water absorbency is three seconds. These properties are suitable for wound dressing material.

On comparing these properties with the study "Comfort Properties and Dyeing Behavior of Cotton/Milkweed Blended Rotor Yarn Fabrics" carried out by Karthik et al , 2017 were in the tensile strength (21.3 Kgf), yarn thickness of warp and weft (0.42mm,0.59mm) and GSM (154) of the 20sNe and 19sNe fabric proves to be lesser than the present study. Hence, with the variation in counts the fabric prepared by the investigator could be a much better fabric for wound dressing bandaid. However, the air permeability (156.61$cm^3/cm^2/s$) of the woven fabric is lesser than the fabric quoted by Karthik et al, 2017. This may be due to the reason of using lesser yarn count.

In a nutshell it could be concluded that the fabric designed by the investigator for the present study is suitable for wound dressing bandaids.

4.10.2 Fabric Weight of Polyherbal Finished Fabric

The weight of the fabric before and after the fabric finishing had been presented in Table XV and Figure XII.

In the Table XV and Figure XII, the fabric weight of the C, DDF,MEF and NEF fabrics are given which confirms an increase in weight irrespective of the type of finish. The results confirmed that the MEF fabric showed increase in the fabric weight as 175.02 grams when compared to the C, DDF and NEF. Weight of the DDF fabric and NEF fabrics were similar to the weight of the controlled fabric. The increase in the fabric weight proves the adhesion of polyherbal extract to the fabric.

Table XV

Fabric Weight of Polyherbal Finished Fabric

S. No	Samples	Fabric GSM
1	C	174.182 ± 1.45
2	DDF	174.186 ± 1.57^{ns}
3	MEF	175.02 ± 1.73 ^{ns}
4	NEF	174.191 ± 1.96 ^{ns}
	'p' Value	0.523^{ns}

ns- not significance

The result of the analysis of variance of the fabric weight shows that there is no significant variance between the control sample and the herbal finished samples. The minimum increase in the weight of the treated fabric when compare to the control proves the presence of the polyherbal extract in the fabric.

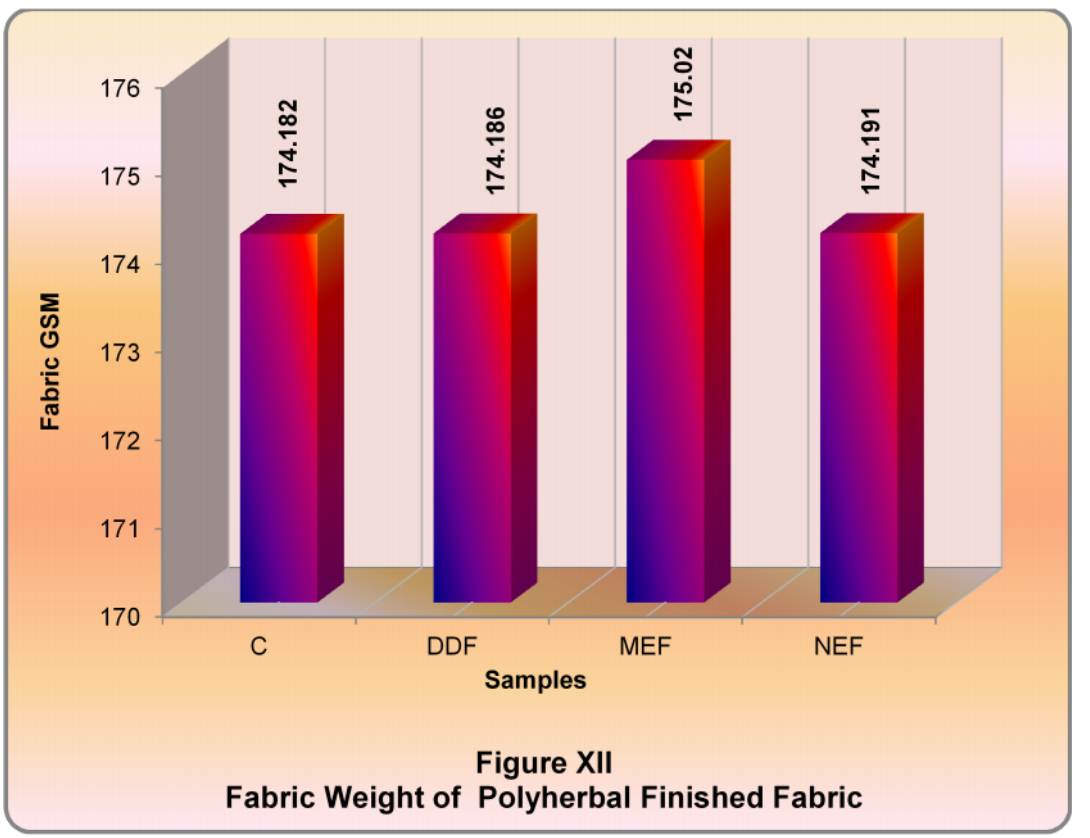


Figure XII
Fabric Weight of Polyherbal Finished Fabric

4.10.3 Tensile Strength of Polyherbal Finished Fabric

The assessment of tensile strength (Kgf) of C, DDF, MEF and NEF finished fabrics in warp and weft direction are presented inTable XVI and FigureXIII (a,b).

Table XVI

Tensile Strength of Polyherbal Finished Fabrics

S. No.	Samples	Warp strength	Warp elongation	Weft strength	Weft elongation
		(Kgf)	(%)	(Kgf)	(%)
1.	C	32.79 ± 1.33	19.22	58.27 ± 1.82**	12.77
2.	DDF	40.86 ± 1.50**	7.57	35.33 ± 1.08**	10.75
3.	MEF	45.52 ± 2.05**	9.73	39.47 ± 1.43**	20.69
4.	NEF	40.20 ± 1.86**	6.53	35.96 ± 1.28**	10.82
'p' value		0.012		0.003	

** - Significant at 1% level

From the analysis of results obtained by the warp direction, the MEF finished fabric with 45.52 Kgf showed maximum tensile strength followed by DDF finished, NEF with 40.86 and 40.20 Kgf respectively. When compared with the finished fabrics, the tensile strength for the original control fabric was lowest with a value of 32.79 Kgf. Hence it could be concluded that the strength of the fabric in warp direction increased on finished fabrics over the original samples.

As far as the analysis of result obtained by test the strength in the weft direction of the fabrics, the maximum strength was noted in original fabric with 58.27 Kgf, followed by MEF, NEF and DDF finished with 39.47 and 35.96 and 35.33 Kgfrespectively. When compared with the finished fabrics, the tensile strength for the original control fabric was highest. Hence it could be concluded that the strength of the fabric in weft direction decreased on finished fabrics over the original samples.

The elongation of the samples in the warp direction increased in NEF sample but decreased in the DDF and MEF samples when compared to the original as 6.53, 9.73 and 7.57% respectively. The increase in elongation in NEF sample may be due to the higher absorption of herbal extracts.

In case of weft elongation sample MEF showed an increase by 20.69% but samples DDF and NEF showed a decrease by 10.75 and 10.82% respectively when compared with control which was 12.77%.

The analysis of variance for the tensile strength of the sample C and polyherbal finished fabrics such as DDF, MEF and NEF are put forth in the Table XVI. The comparison of the tensile strength in both warp and weft directions between treated and the control fabrics showed significant difference at 1% level. The variance noted in the physical property of the treated fabric compare to that of the control fabric proves that finishing processes had significant effect on the tensile strength of the fabric.

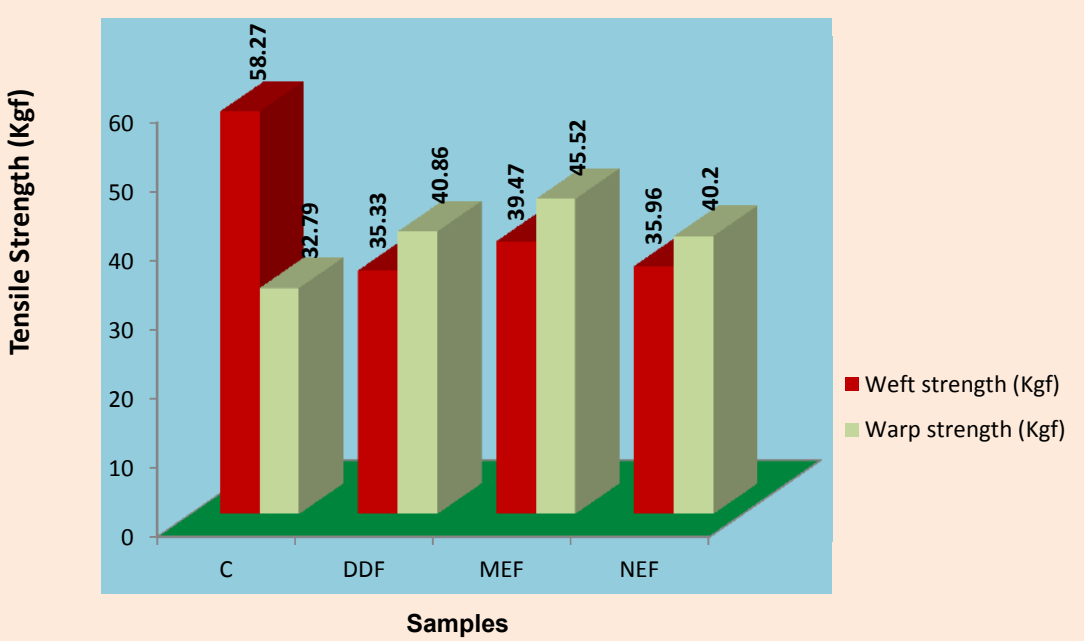


Figure XIII (a)
Tensile Strength of Polyherbal Finished Fabrics

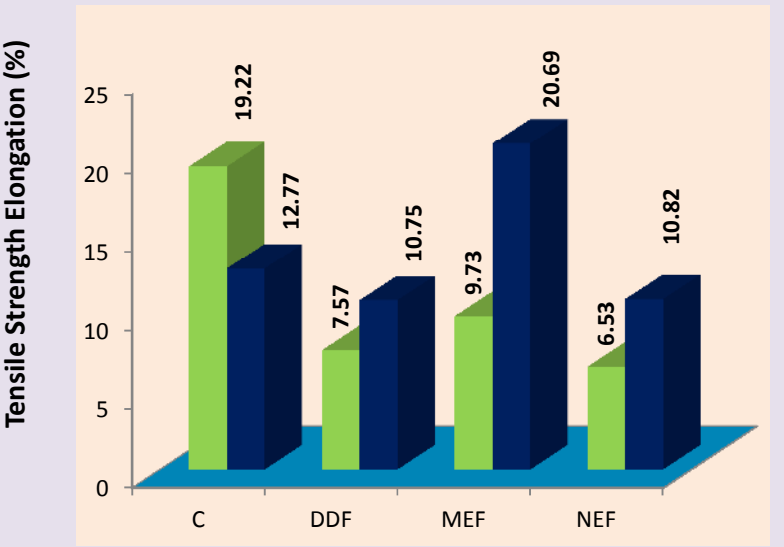


Figure XIII (b)
Tensile Strength of Polyherbal Finished Fabrics

4.10.4 Sinking test of polyherbal finished fabrics

The assessment of the sinking test is depicted in the Table XVII and Figure IX show the analysis of variance of sinking test of polyherbal finished fabrics.

Table XVII
Sinking Test of Polyherbal Finished Fabrics

S. No	Samples	Average sinking time (sec.)
1.	C	3 ± 0.45
2.	DDF	2 ± 0.29**
3.	MEF	1 ± 0.18**
4.	NEF	1 ± 0.18**
'p' value		0.015

** - Significant at 1% level

From the Table XVII and Figure XIV it is clear that the sinking time (seconds) for herbal finished samples reduced except for MFC sample. The

sinking time of the C was recorded to be 3 seconds. Where as the DDF, MEF and NEF samples had taken lesser time to sink as 2,1 and 1 second respectively. It can be inferred from the test the herbal extract finish has enhanced the wettability of the finished fabric DDF and NEF.

The results obtained by the analysis of variance for sinking test in second showed 1% significant variance between the control and polyherbal finished fabrics. The difference in the sinking time of the C,DDF,MEF and NEF finished fabrics emphasize that the processing and treatment given to the fabric affected the sinking property of the fabrics.

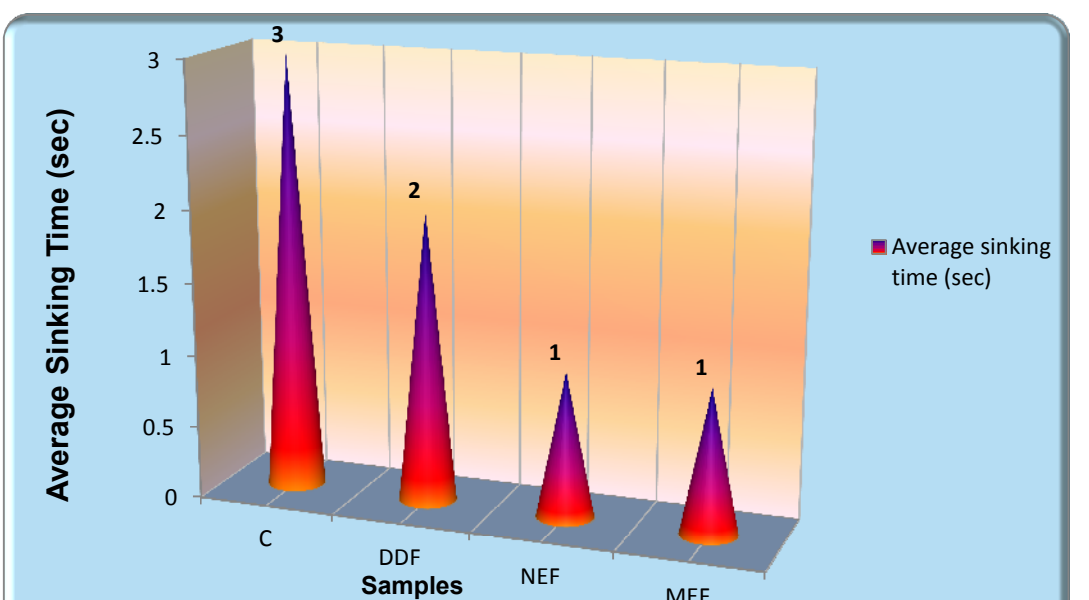


Figure XIV
Sinking Test of Polyherbal Finished Fabric

4.10.5 Water Holding Capacity of Polyherbal Finished Fabric

The following Table XVIII and Figure XVrevealthe analysis of variance of the polyherbal finished fabric.

Table XVIII

Water Holding Capacityof Polyherbal Finished Fabrics

S.No	Samples	Water holding capacity (%)
1.	C	51.25 ± 3.29
2.	DDE	70 ± 4.16**
3.	MEF	66 ± 3.78**
4.	NEF	53 ± 2.37^{ns}
'p' value		0.014

** - Significant at 1% level

From the Table XVIII and Figure XV it is evident that the water holding capacity of the finished fabrics has increased. With respect to water holding capacity, it was least in the sample cand had a capacity of 51.25%. The holding capacity increased for the herbal finished fabrics with the highest record for DDF finished fabric with a capacity of 70%. This was followed by MEF and NEF finished fabrics with a holding capacity of 66% and 53% respectively. Hence it could be concluded that the water holding property of the fabric samples on finishing, improved to a great extent. Increasing in the water holding capacity might be due to the herbal components present in the fabric and also due to the compact arrangement of yarns during the finishing processes, which permits the water to enter into the fabric easily.

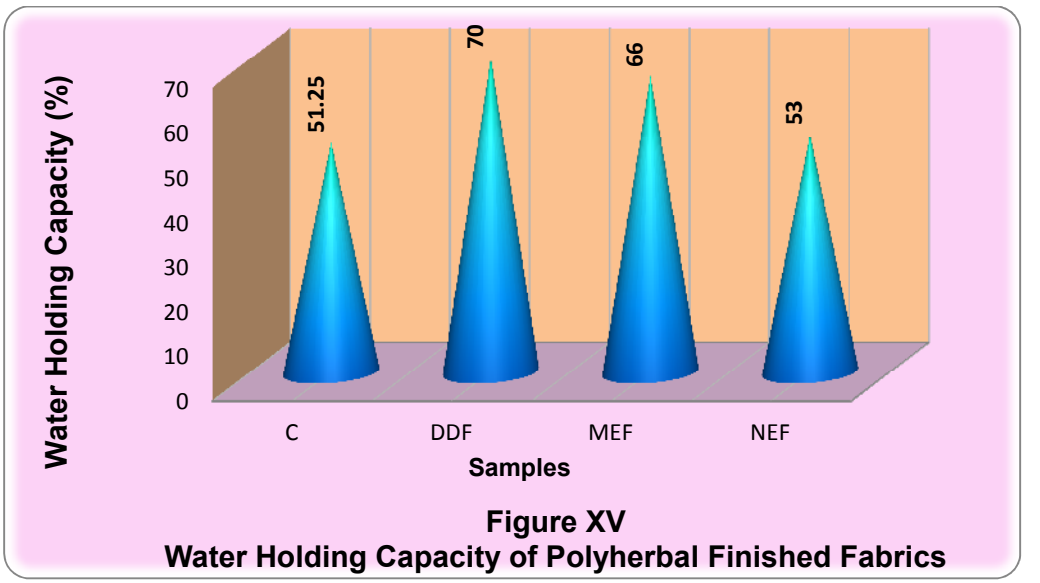


Figure XV
Water Holding Capacity of Polyherbal Finished Fabrics

From the results obtained from the analysis of variance, it was observed that there was no significant variance in the water holding capacity of the C.The finished fabrics such as DDF,MEF shows 1% variancewhereas NEF fabric shows minimum varinance in water holding capacity compare to other samples. The result showedthat the fabric treatment exhibited some significant variance in the water holding capacity of the polyherbal finished fabric.

4.10.6 Air permeability of Polyherbal Finished Fabric

The results of air permeability of the control and finished fabric of DDF, MEF and NEF are presented in the Table XIX and Figure XVI.

Table XIX

Air Permeability of Polyherbal Finished Fabrics

S. No	Samples	Air Permeability($cm^3/cm^2/s$)
1.	C	79.3 ± 3.67
2.	DDF	76.4 ± 2.98*
3.	MEF	79.1 ± 3.46^{ns}
4.	NEF	74.2 ± 3.79**
'p' value		0.004

** - Significant at 1% level; ns - Not significant

From the Table XIX and Figure XVI it is found that the air permeability of the finished fabrics was comparable. Sample C and MEF showed an air permeability of values 79.3 and 79.1cm^3/cm^2/srespectively. However, the air permeability of the DDF and NEF has reduced to 76.4and 74.2cm^3/cm^2/s respectively. The reduction in air permeability proved the finish to enhance movement of air, which in turn will help in the wound/cut/burn healing. Hence it could be concluded that fabris are suitable for bandaid preparation.

The analysis of variance for air permeability shown in Table XIX shows 1%variancelevel had been shown between the control and finished fabrics which identified that the fnishing processes showed notable change in the physical properties of the finished fabric.

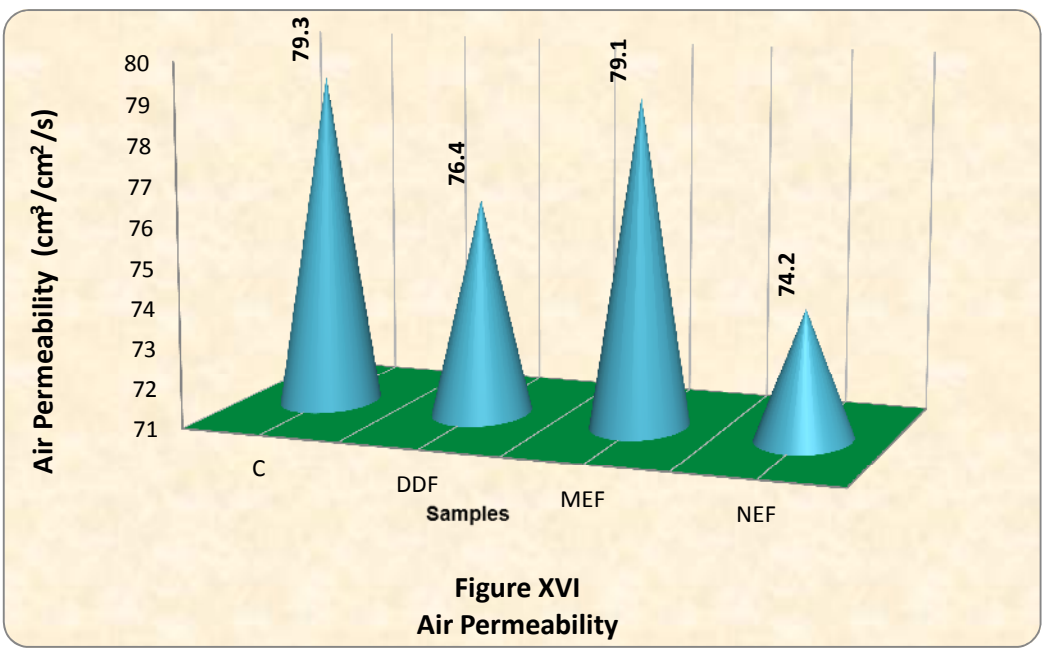


Figure XVI
Air Permeability

4.10.7 Absorbency of Polyherbal Finished Fabric

The results of the water absorbency capacity of the controlled samples DDF, MEF and NEF finished fabrics are given in the Table XX, Figure XVII show the analysis of variance of the absorbency rate of polyherbal finished fabric.

Table XX

Water Absorbency of Polyherbal Finished Fabrics

S. No	Samples	Absorbency(sec.)
1.	C	3 ± 0.29
2.	DDF	2 ± 0.19**
3.	MEF	1 ± 0.15*
4.	NEF	1 ± 0.15*
	'p' value	0.032

** - Significant at 1% level

From the Table XX and Figure XVII, it is found that the sample C took 3 seconds to absorb a droplet of water. Where as, DDF, MEF and NEF samples had taken 2,1 and 1 seconds respectively to absorb a water droplet which have got reduced when compared with controlled fabric. This result revealed that the herbal extract finished fabrics DDF and NEF have better absorbency when compared to controlled sample. Hence it could be conducted that Nano finishing has enhanced the property of water absorbency.

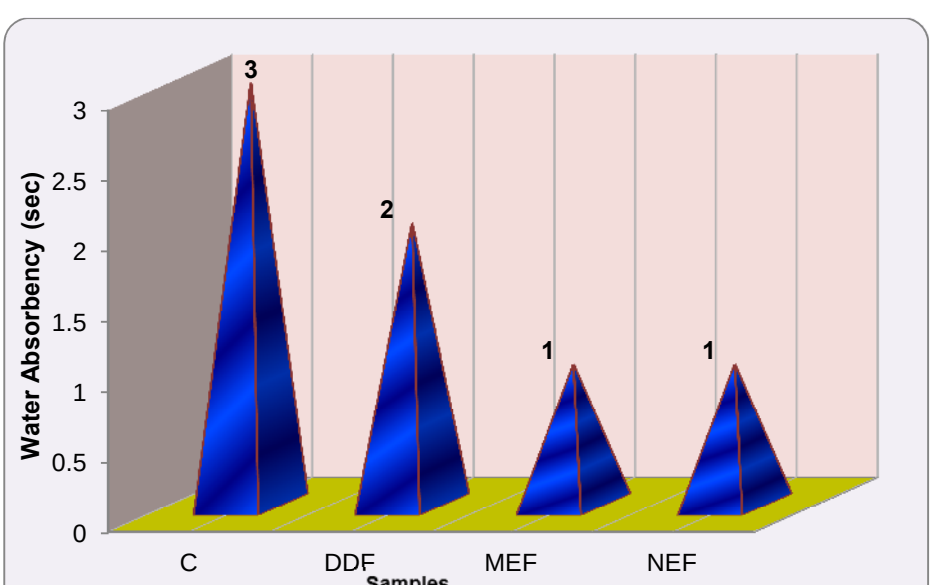


Figure XVII
Water Absorbency of Polyherbal Finished Fabrics

The statistical analysis of variance on the water absorbency of the control and the treated fabric shows 1% level of variance which provides the result that the fabric processing andfinishing processes showed a identifiable effect on the time duration taken in water absorbency .

4.10.8 Vertical Wicking of Polyherbal Finished Fabric

The results of vertical wicking of the sample C and DDF, MEF and NEF for the warp and weft direction are given in the Table XXI and Figure XVIII show the analytical variance of vertical Wicking of herbal finished fabric.

TableXXI

Vertical Wicking of Polyherbal Finished Fabrics

S. No	Samples	Time exponent k (warp)	Time exponent k (Weft)
1	C	0.412 ± 0.07	0.410 ± 0.05
2	DDF	0.396 ± 0.05*	0.395 ± 0.03*
3	MEF	0.415 ± 0.03^{ns}	0.440 ± 0.02^{ns}
4	NEF	0.459 ± 0.06*	0.430 ± 0.04
	'p' value	0.039	0.042

* - Significant at 5% level; ns - Not significant

The Table XXI and Figure XVIII epict an increase in vertical wicking of DDF, MEF and NEF method of finishing on sample.further it is seen that in the warp direction, the wickabilty of DDF sample was noted for 0.39 minutes. As for the weft direction, the wickabilty of DDF sample was noted as 0.39 minutes, which increased gradually to 0.410, 0.430 and 0.440 minutes in C, NNF and MEF samples respectively. Hence it could be concluded that the rate of water absorbency proved to be increased in the MEF and NEF finished samples compared to the DDF samples.

Analysis of variance for vertical wicking of the control and herbal finished fabrics show significance at 5% level, which prove that the pretreated and finishing processes shows a remarkable effect in the physical property of the finished fabric when compared to that of controlled samples.

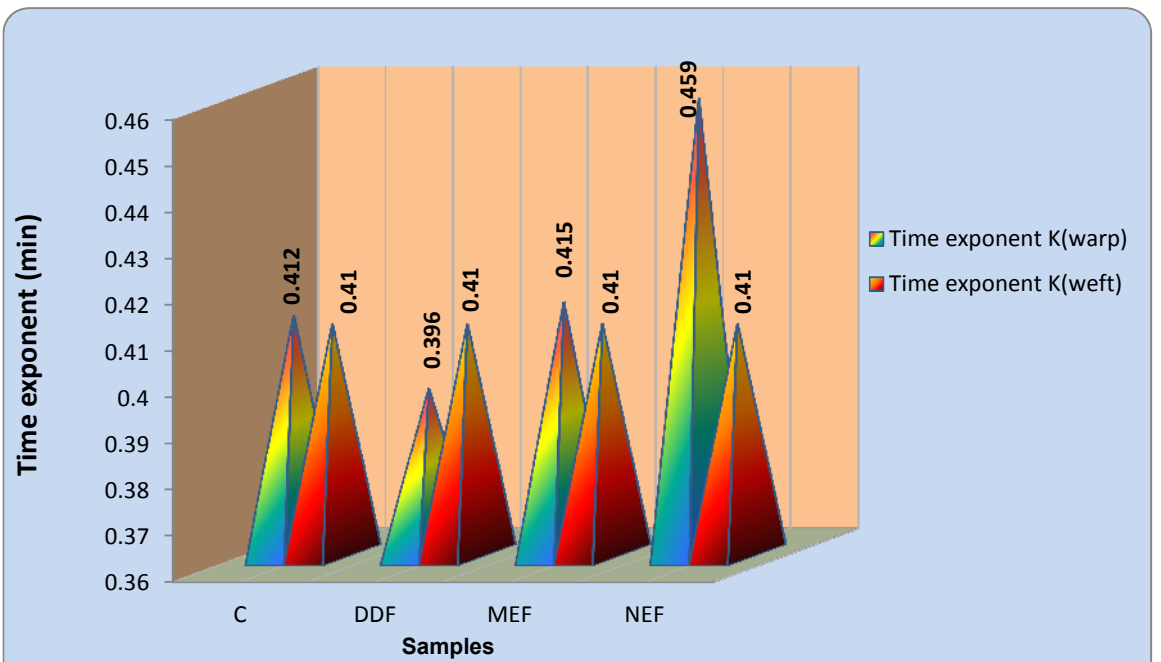


Figure XVIII
Vertical Wicking of Polyherbal Finished Fabrics

4.11 Microbial Filteration Test

4.11.1 Bacterial Filteration Test

From the Table XXII and Plates XL,XLI,XLII and XLIII results it confirms that the samples tested with *Escherichia coli* ATCC 25922, *Staphylococcus sapropyticus* ATCC 6538, *Aeromonas hydrophila* ATCC 100-2004 and *Pseudomonas aeroginosa* ATCC 100-2004 for bacterial filteration shows better filteration when compare to the control untreated sample. The Dip and Dry finished fabric show 80% to 85% of bacterial reduction. Were as, Microfinished and Nanofinished samples shows more or less same bacterial reduction properties as 90% to 95% and 93% to 96%

Table XXII

Bacterial Filteration Test for Control and Treated Bandaids

S. No.	Samples	Bacterial Filter (Reduction - %)			
		***Escherichia coli* ATCC 25922**	***Staphylococcus sapropyticus* ATCC 6538**	***Pseudomonas aeroginosa* ATCC 100-2004**	***Aeromonas hydrophilla* ATCC 100-2004**
1	Control	Nil	Nil	Nil	Nil
2	Dip-dry finished	80	84	85	80
3	Micro finished	94	95	95	90
4	Nano finished	95	93	96	95

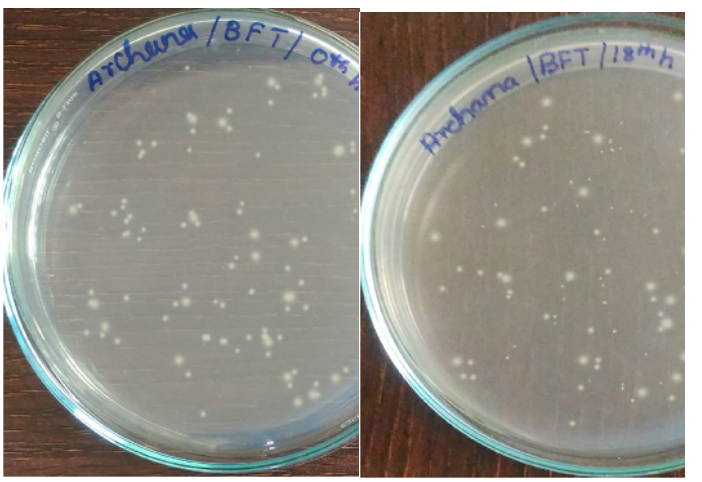
From the Table XXII, it is evident that the three finished test samples, Dip-dry, Microcapsules and Nanocapsules finished medical textile materials exhibited excellent antibacterial properties. As per the test, the bacterial numbers were quantitatively filtered by the test materials during the analysis. The incubation period of 18 hours had greatly influenced in reducing or filtering the number of test bacteria by the samples. This was significantly evident from Table XXII. Microcapsules finished samples exhibited 94% and 95% of bacterial reduction when tested against the respective test bacteria *Escherichia coli* ATCC 25922,*Staphylococcus sapropyticus*ATCC 6538, *Aeromonas hydrophila* ATCC 100-2004 and *Pseudomonas aeroginosa* ATCC 100-2004. The Microencapsulated finished samples showed 94,95,95 and 90 per cent reduction in bacteria colonies respectively. Whereas, Nanofinished samples showed 95, 93, 96 and 95 per cent reduction in bacterial colonies respectively. Dip-Dry finished showed comparatively less reduction percentage than the other finished samples. This may be due to the difference in the durability properties of the antibacterial agents finished onto the sample materials. Hence from the Table XXII it is clear that all the finished fabric showed reduction in bacterial colonies irrespective of the method of treatment for all the different type of bacteria.

Bacterial Filteration Test for ControlSamples

The test result is show in in Plate XL which indicated no variation in the number of colonies (Colony Forming Unit -CFU) of the test organisms. This proves that the control fabric had not been finished with the polyherbal extract.

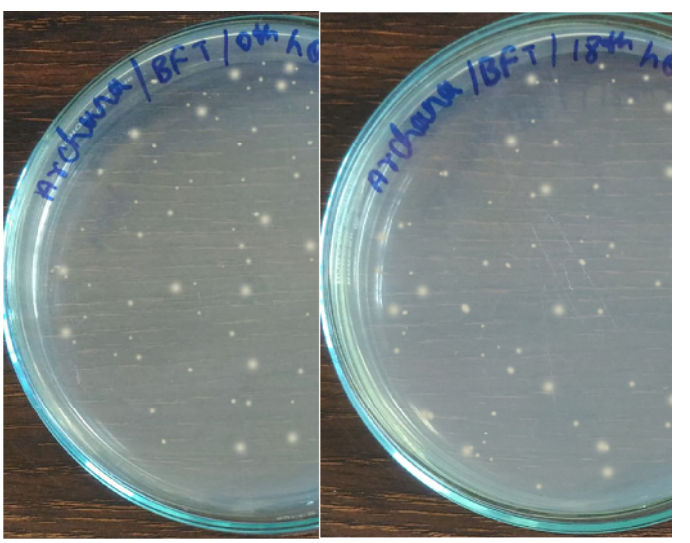
Bacterial Filteration Test for Control Samples

***Escherichia coli* ATCC 25922**



0th hour plate 18th hour plate

***Staphylococcus Saprophyticus* ATCC 6538**

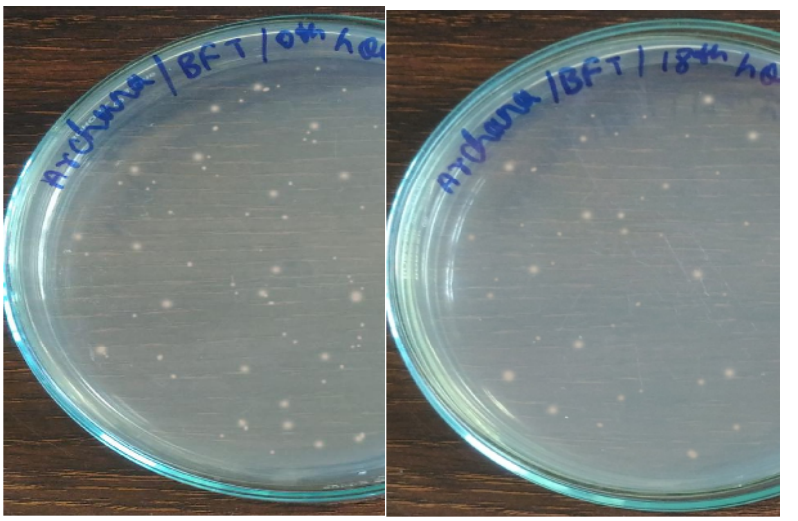


0th hour plate 18th hour plate

Plate XL

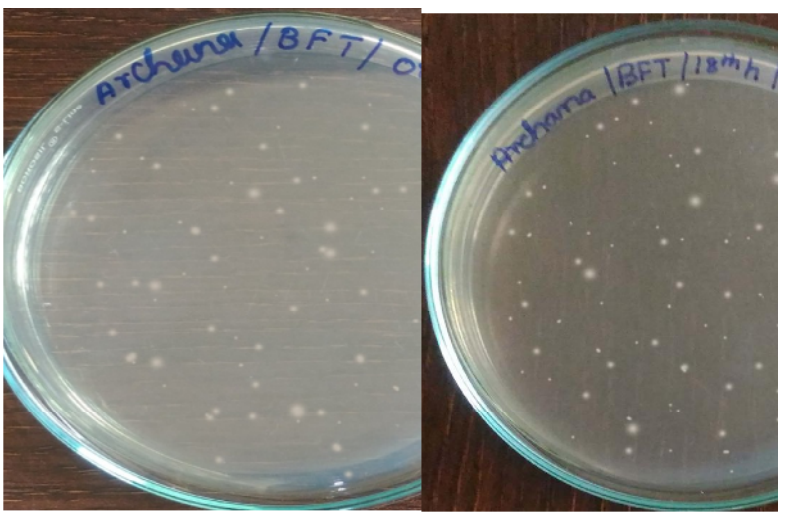
Bacterial Filteration Test for Control Samples

Pseudomonas aeruginosa



0^{th} hour plate 18^{th} hour plate

Aeromonas hydrophila



0^{th} hour plate 18^{th} hour plate

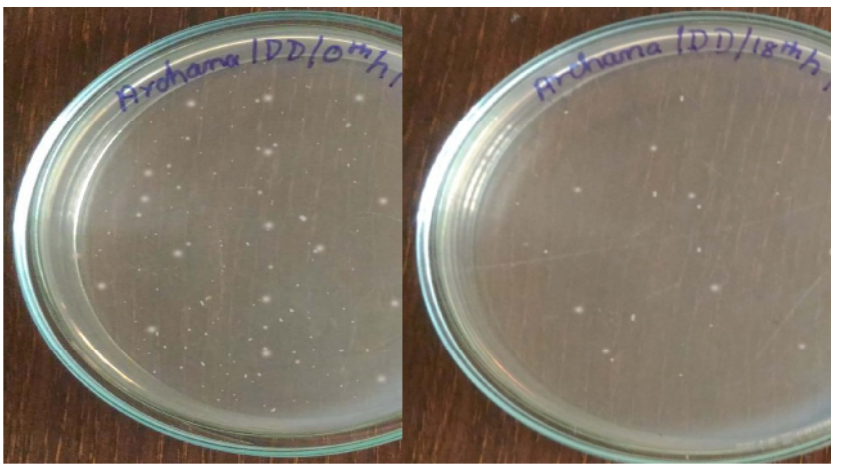
Plate XL

Bacterial Filteration Test for Dip-Dry Finished Samples

The test results in Plate XLI shows the variation in the number of colonies (CFU) of test organisms such as *Escheritia coli, Staphylococcus sapropyticus, Aromonashydrophila* and *Pseudomonas aerognosa* and is evident from the image. 0th hour plate showing more CFU than 18thhour plate. The variation was due to the presence of polyherbal finishing on the bandaid.

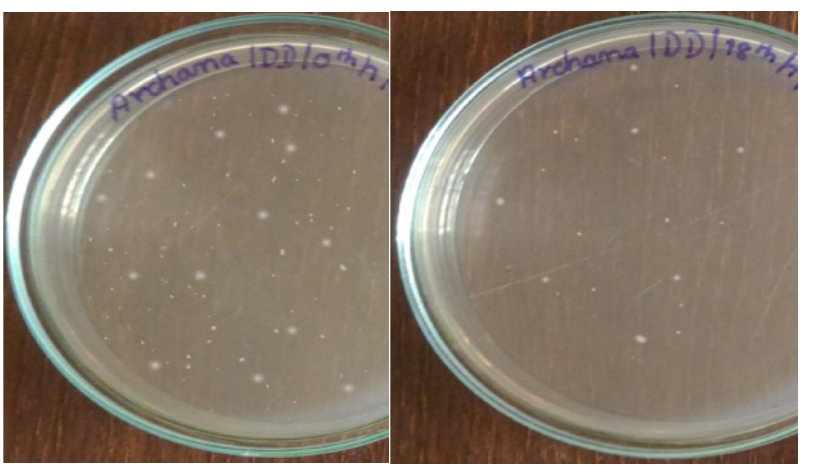
Bacterial Filteration Test for Dip-Dry Finished Samples

***Escherichia coli* ATCC 25922**



0th hour plate 18th hour plate

***Staphylococcus Saprophyticus* ATCC 6538**

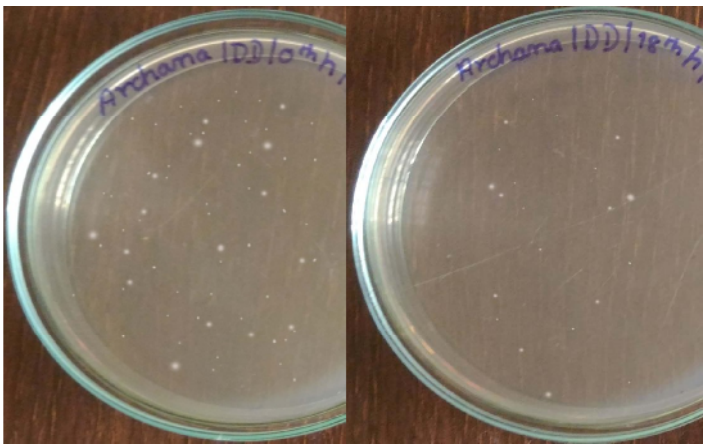


0th hour plate 18th hour plate

Plate XLI

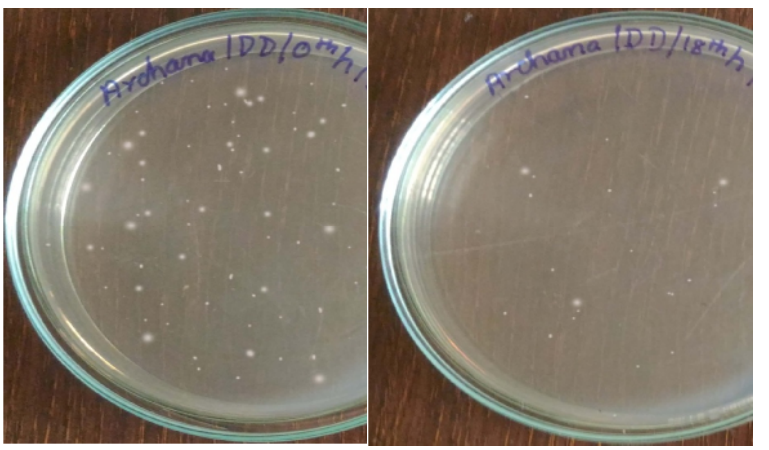
Bacterial Filteration Test for Dip-Dry Finished Samples

Pseudomonas aeruginosa



0th hour plate 18th hour plate

Aeromonas hydrophila



0th hour plate 18th hour plate

Plate XLI

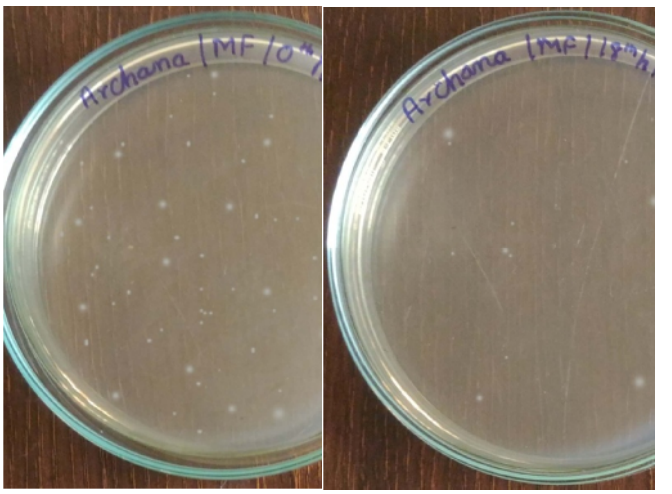
Bacterial Filteration Test for Microcapsule Finished Samples

The result shown in Plate XLIII indicates the number of colonies (CFU) of test organisms such as *Escheritia coli, Staphylococcus sapropyticus, Aromonashydrophila* and *Pseudomonas aerognosa*. 0th hour plate showing more CFU than 18th hour plate. The difference was due to exposure of organisms to the

polyherbal finish on the bandaid for 18hours, whereas fabrics exposed to 0 hours did not have any antibacterial effect on the test organisms.

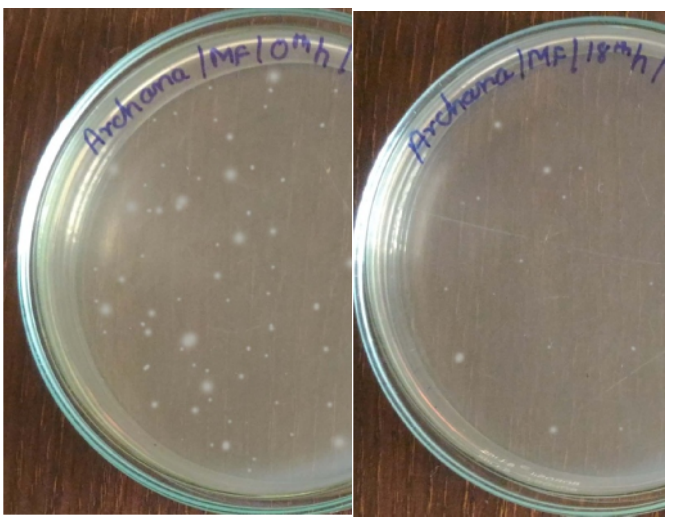
Bacterial Filteration Test for Microcapsule Finished Samples

Escherichia coli ATCC 25922



0^{th} hour plate 18^{th} hour plate

Staphylococcus Saprophyticus ATCC 6538

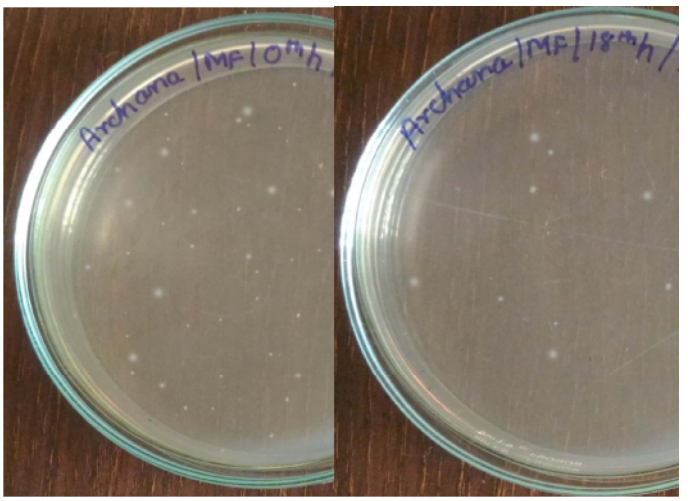


0^{th} hour plate 18^{th} hour plate

Plate XLII

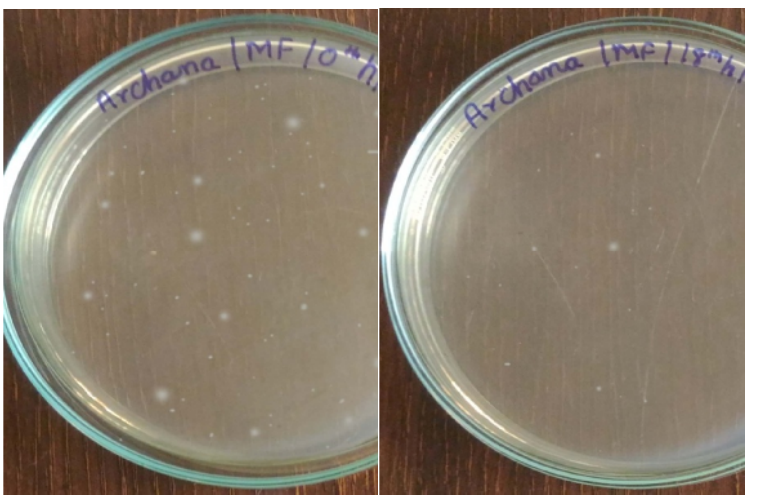
Bacterial Filteration Test for Microcapsule Finished Samples

Pseudomonas aeruginosa



0^{th} hour plate 18^{th} hour plate

Aeromonas hydrophila



0^{th} hour plate 18^{th} hour plate

Plate XLII

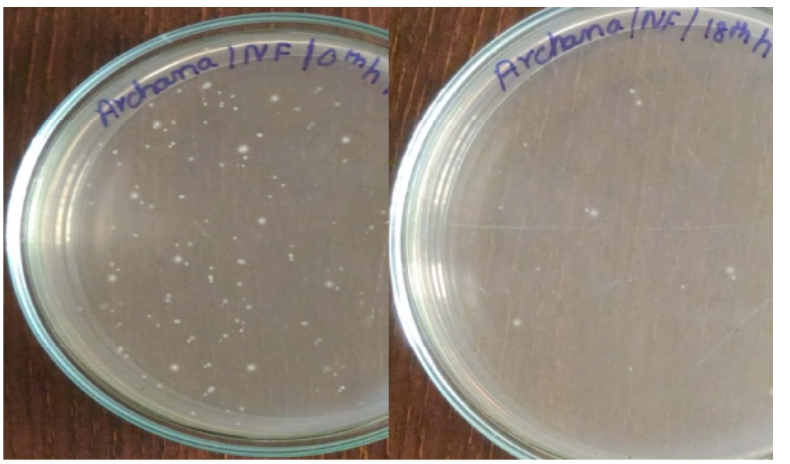
Bacterial Filteration Test for Nanocapsule Finished Test Samples

The result shown in Plate XLIIII indicates the number of colonies (CFU) of test organisms such as *Escheritia coli, Staphylococcus sapropyticus, Aromonashydrophila* and *Pseudomonas aerognosa*. 0^{th} hour plate showing more

CFU than 18th hour plate. The difference was due to exposure of organisms to the polyherbal finish on the bandaid for 18hours, whereas fabrics exposed to 0 hours did not have any antibacterial effect on the test organisms

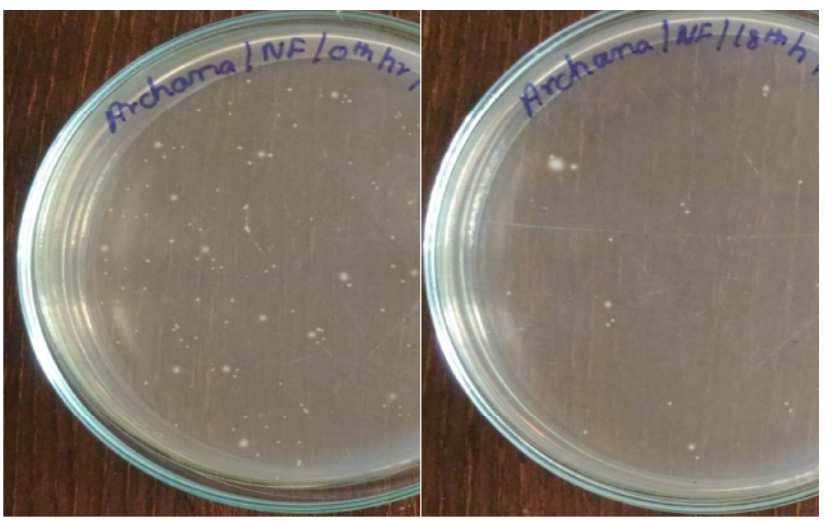
Bacterial Filteration Test for Nanocapsule Finished Test Samples

***Escherichia coli* ATCC 25922**



0th hour plate 18th hour plate

***Staphylococcus Saprophyticus* ATCC 6538**

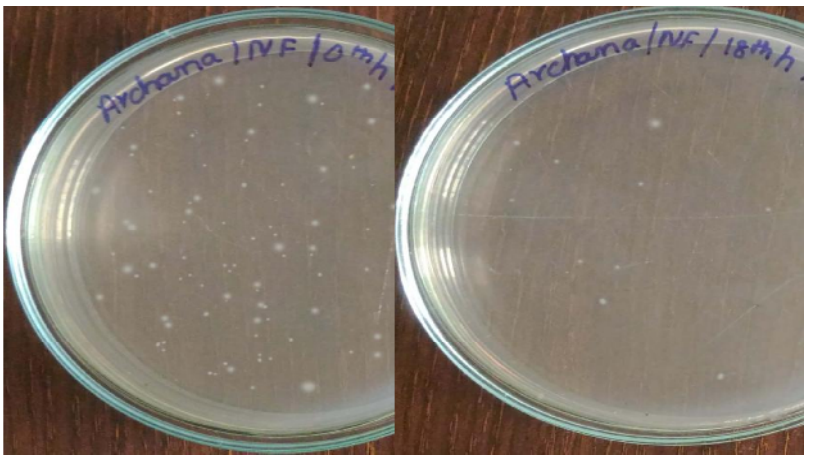


0th hour plate 18th hour plate

Plate XLIII

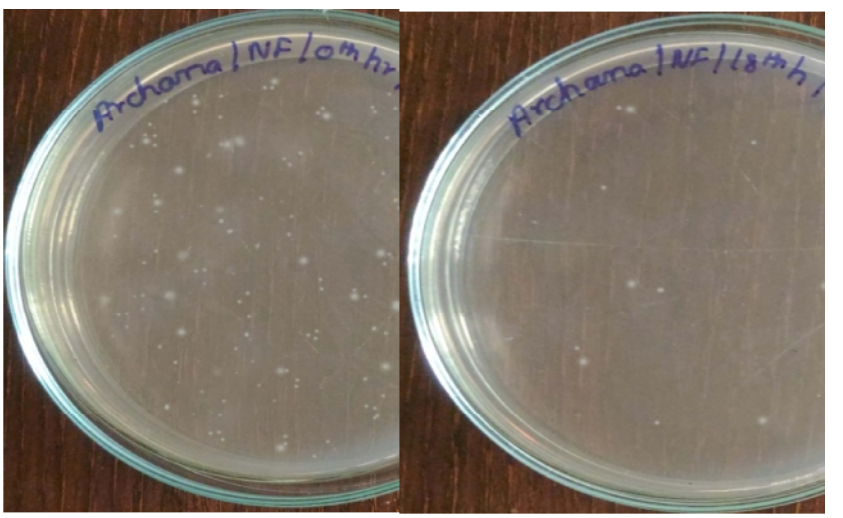
Bacterial Filteration Test for Nanocapsule Finished Test Samples

Pseudomonas aeruginosa



0th hour plate 18th hour plate

Aeromonas hydrophila



0th hour plate 18th hour plate

Plate XLIII

4.11.2 Fungal Filteration Test for Control and Treated Samples

From the Table XXIII and Plate XLIV, it is confirmed that the samples tested with *Candida albicans* for fungal filteration shows better filteration when compared to the control untreated sample. The Dip and Dry finished fabric

showed 85% of fungal reduction where as, Microfinished and Nanofinished samples showed more or less similar fungal reduction properties as 90% and 96%.

Table XXIII

Fungal Filteration Test for Control and Treated Bandaids

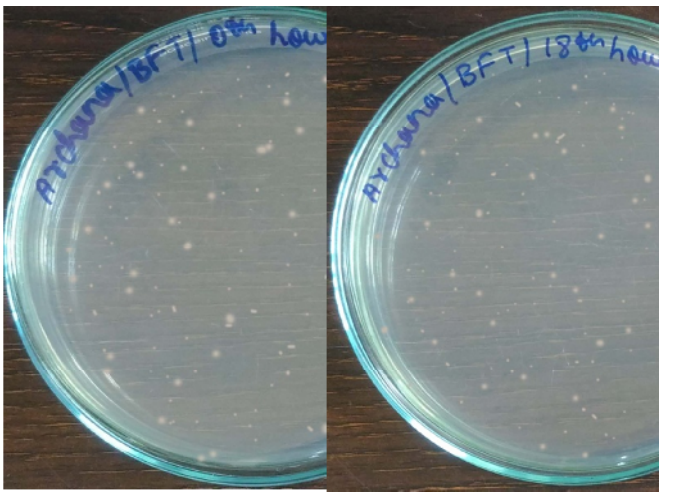
S. No.	Test Samples	Fungal Filter (Reduction - %)
		Candida albicans
1	Control	Nil
2	Dip-dry finished	85
3	Microcapsule finished	90
4	Nano finished	96

Among the three finished test samples, microcapsules and nanocapsules finished bandaids materials exhibited excellent anti-fungal properties. As per this test, the fungal numbers were quantitatively filtered by the test materials during the analysis. The incubation period of 18hours had greatly influenced in reducing or filtering the number of test fungi by the bandaids. This was significantly evident from Table XXIII. Dip and dry bandaid exhibited 85 per cent of fungal reduction when tested against the respective test fungi *Candida albicans*. Whereas, microencapsules and nanoencapsules finished bandaid showed a reduction of 90 and 95 per cent of bacterial reduction respectively. From the Table XXIII it is identified that Dip and dry shows less reduction percentage compared to that of Micro and Nano finished bandaids. This may be due to the difference in the durability properties of the anti-fungal agents finished onto the bandaid materials. This result also proved that the finished samples had antifungal property against the selected fungi.

Fungal Filteration Test for Control and Finished Samples

Fungal Filteration Test for Control Samples

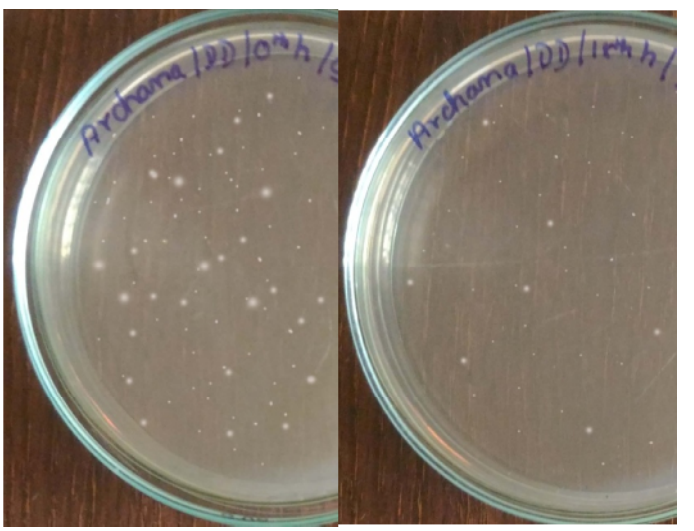
Candida albicans



0th hour plate 18th hour plate

Fungal Filteration Test for Dip-Dry Finished Samples

Candida albicans



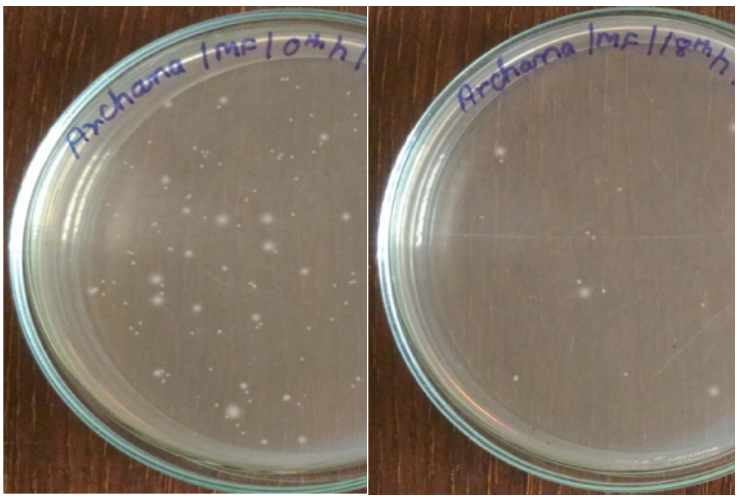
0th hour plate 18th hour plate

Plate XLIV

Fungal Filteration Test for Control and Finished Samples

Fungal Filteration Test for Microcapsule Finished Samples

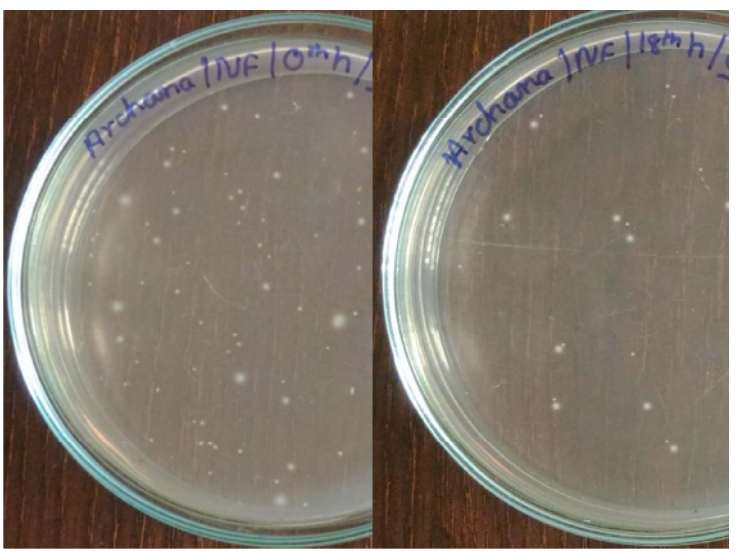
Candida albicans



0th hour plate 18th hour plate

Fungal Filteration Test for Nanocapsule Finished Test Samples

Candida albicans



0th hour plate 18th hour plate

Plate XLIV

From the results, difference in the number of colonies (CFU) of test organisms was evident from the image. 0^{th} hour plate showing more CFU than 18^{th} hour plate. The difference was due to exposure of organisms to the antibacterial nanoparticles for 18hours, whereas fabrics exposed to 0hours does not have any antibacterial effect on the test organisms.

4.12 Bandaid Toxicity Test

The results shown in Table XXIV reveals the concentration, % of cell inhibition and % of viable cell for Dip and dry, Micro and Nano encapsulated finished Bandaids.

Table XXIV

Bandaid Toxicity Test for Control and Treated Banaids

S. No.	Samples	Concentrations (µg/ml)	% cell inhibition (L_{929})	% viable cells (L_{929})
1	Control	10	12.6	87.3
2	Microcapsule samples	55	14.5	85.3
3	Dip-Dry samples	55	12.4	87.1
4	Nano particle samples	60	11.3	88.2

All the four bandaids used in the study were subjected for toxicity test after exposing the required concentrations on the mouse fibroblast cell lines (L_{929}). From the Table XXIV it is clear that during the analysis, the antibacterial agents finished onto the sample swatches (extracts from microcapsule finished swatches, dip-dry swatches and nanoparticle finished swatches) did not exhibit any toxicity for the mouse fibroblast cell lines (L_{929}). This was evident from the percentage of viable cells. All the four samples showed more than 80 per cent of viable cells; and the percentage of cell inhibition was recorded less than 15 per cent for the same type of samples. Thus the samples were proved to be highly biocompatible and nontoxic to the users irrespective of the type of finishing method.