Results and Discussion

4. RESULTS AND DISCUSSION

The results of the study are discussed under the following heads :

4.1 Preliminary Phytochemical, Solvent, Herbal, Concentrations and Antimicrobial Activity against Antibiotic Screening Tests

4.2 Identification of Selected Herbal Antibacterial Activity against Commercial Antibiotics

4.3 Fourier Transform – Infra Red Spectra (FT-IR) Study of Selected Pad Dry and Micro Encapsulation Herbal Finished Samples

4.4 Optimization of Finish Process Parameters for the Application of Herbal Extracts on Fabrics

4.5 SEM Study of Selected Pad Dry and Micro Encapsulation Herbal Finished Samples

4.6 Antimicrobial Assessment Tests

4.7 Subjective Evaluation

4.8 Objective Evaluation

4.9 Finish Wash Durability Test

4.10 Test for Functional Properties of Recommended Products

4.11 Performance Evaluation

4.12 Costing of Herbal Medicated Products

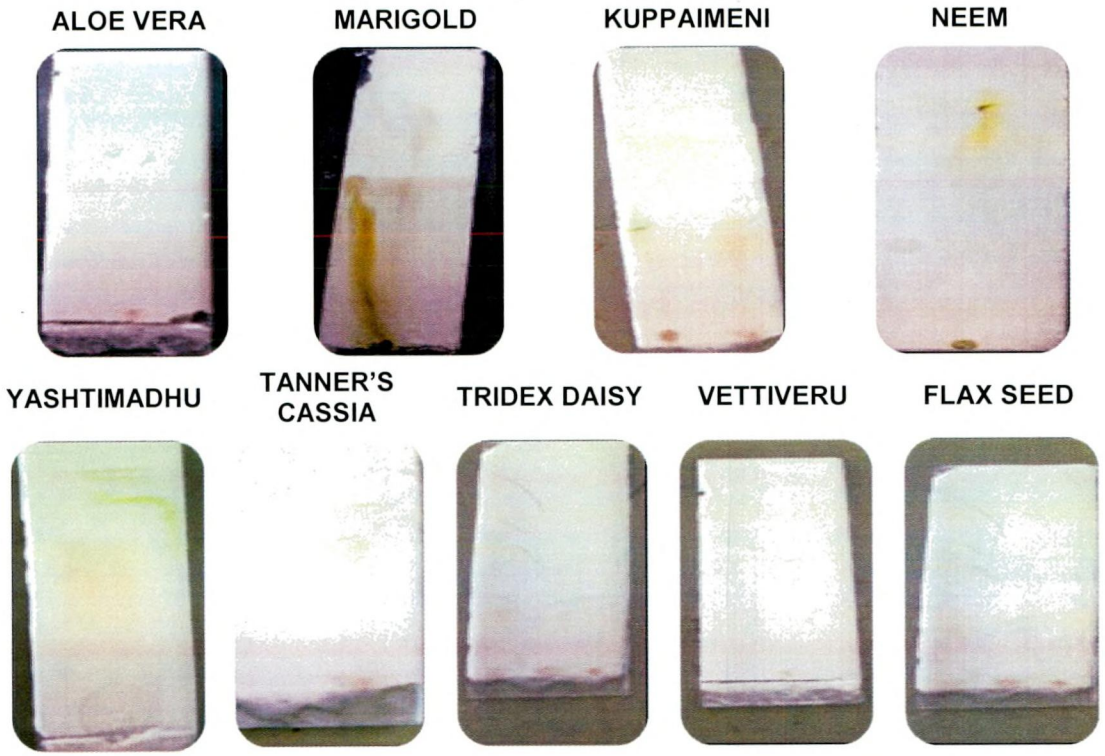
4.1 PRELIMINARY PHYTOCHEMICAL, SOLVENT, HERBAL, CONCENTRATIONS AND ANTIMICROBIAL ACTIVITY AGAINST ANTIBIOTIC SCREENING TESTS

The phytochemical compounds namely terpenoids, tannins, flavonoids, saponin, glycosides, steroids, alkaloids and phenols present in the selected medicinal plants Aloe vera (*Aloe barbadensis*), Marigold (*Calendula officinalis*), Kuppaimeni (*Acalypha indica*), Neem (*Azadirachta indica*), Yashtimadhu (*Glycyrrhiza glabra*), Tanner's cassia (*Cassia auriculata*), Tridex daisy (*Tridax procumbens*), Vettiveru (*Vetiveria zizanioides*) and Flax seed (*Linum usitatissimum*) and their antimicrobial effects were determined by Thin Layer Chromatography (TLC) and Agar Well Diffusion test methods.

4.1.1 Thin Layer Chromatography (TLC)

The chromatographic analysis lays a strong foundation to identify the specific components present in natural colourants extracted in different media and methods have been tested for all the selected nine herbal extracts and illustrated in Plate – 13.

VISIBLE LIGHT



FAR UV LIGHT

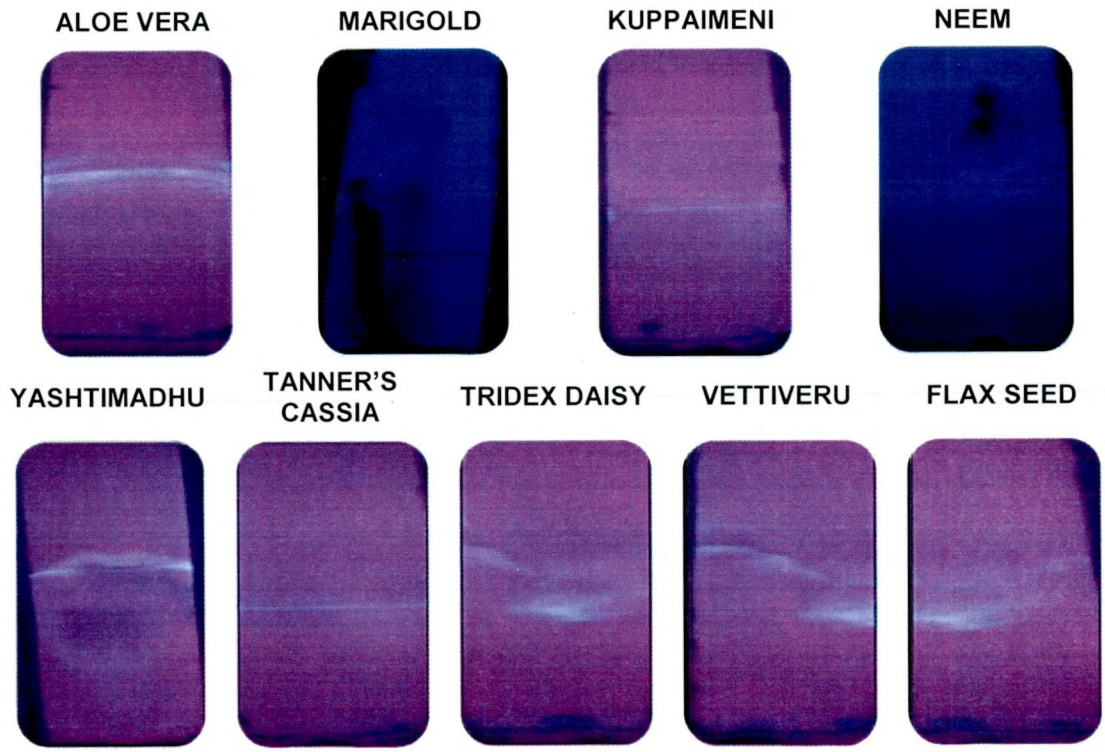


PLATE – 13

IDENTIFICATION OF PHENOLIC COMPOUNDS AND FLAVONOIDS UNDER VISIBLE AND FAR UV LIGHT BY TLC ANALYSIS

The results of TLC test in visible light reveals the presence of rutin related compounds of flavonoids and phenolic acid compounds in all the selected nine herbal extracts by the presence of dark brown and yellow band respectively. In far UV light, the same compounds were viewed as orange brown and blue shades as reported by Males et al. (2006) and Adam et al. (2002). According to Guinot et al. (2006), Dixon et al. (1998), Hodnick et al. (1988) the presence of the above mentioned compounds indicate antimicrobial property.

Hence it could be concluded that the nine extracted herbal solution namely aloe vera, marigold, kuppaimeni, neem, yashtimadhu, tanner's cassia, tridex daisy, vettiveru and flax seed had phytochemical compounds which exhibits antimicrobial property.

4.1.2 Agar Well Diffusion Test

The zone of inhibition results of both 50 µl and 100 µl concentrations with different medium of solvents against the positive and negative bacteria are documented in the Table – 13.

TABLE – 13

SCREENING OF ANTIMICROBIAL ACTIVITY, SOLVENT AND HERBAL CONCENTRATIONS USING AGAR WELL DIFFUSION TEST FOR SELECTED MEDICINAL PLANTS

S.No.	Medicinal herbs	Micro organisms	Concentration of Herbal Solutions					
			Zone of inhibition (mm)					
			50 µl/µg			100 µl/µg		
			Water	Methanol	Ethanol	Water	Methanol	Ethanol
1.	Aloe vera	*Staphylococcus aureus*	19 ± 0.5	18 ± 0.3	19 ± 0.7	28 ± 0.5	20 ± 0.7	22 ± 0.6
		Escherichia coli	23 ± 0.3	18 ± 0.8	19 ± 0.2	27 ± 0.7	21 ± 0.5	23 ± 0.7
2.	Marigold	*Staphylococcus aureus*	16 ± 0.6	16 ± 0.3	17 ± 0.5	22 ± 0.7	21 ± 0.3	23 ± 0.5
		Escherichia coli	15 ± 0.9	16 ± 0.7	19 ± 0.6	19 ± 0.8	20 ± 0.4	24 ± 0.3
3.	Kuppaimeni	*Staphylococcus aureus*	16 ± 0.7	18 ± 0.6	18 ± 0.4	19 ± 0.4	20 ± 0.3	22 ± 0.5
		Escherichia coli	16 ± 1.1	18 ± 0.3	19 ± 0.2	19 ± 0.8	20 ± 0.1	27 ± 0.3
4.	Neem	*Staphylococcus aureus*	20 ± 0.5	19 ± 0.3	20 ± 0.1	27 ± 0.4	23 ± 0.6	24 ± 0.3
		Escherichia coli	19 ± 0.5	17 ± 0.8	19 ± 0.2	24 ± 0.1	19 ± 0.7	22 ± 0.4
5.	Yashtimadhu	*Staphylococcus aureus*	22 ± 0.7	20 ± 0.1	20 ± 0.5	27 ± 0.6	21 ± 0.3	22 ± 0.4
		Escherichia coli	22 ± 0.1	18 ± 0.4	19 ± 0.6	25 ± 1.0	22 ± 0.3	23 ± 0.5
6.	Tanner's cassia	*Staphylococcus aureus*	14 ± 0.7	16 ± 0.3	15 ± 0.4	18 ± 0.9	18 ± 0.4	17 ± 0.7
		Escherichia coli	17 ± 0.4	18 ± 0.6	16 ± 0.7	19 ± 0.1	20 ± 0.9	17 ± 0.6
7.	Tridex daisy	*Staphylococcus aureus*	16 ± 0.7	15 ± 0.8	16 ± 0.5	19 ± 0.2	17 ± 0.5	19 ± 0.6
		Escherichia coli	15 ± 0.6	14 ± 0.9	16 ± 0.7	18 ± 0.7	17 ± 0.1	18 ± 0.3
8.	Vettiveru	*Staphylococcus aureus*	16 ± 0.7	14 ± 0.5	13 ± 0.9	17 ± 0.1	17 ± 0.3	18 ± 0.3
		Escherichia coli	15 ± 0.6	14 ± 0.4	14 ± 0.3	17 ± 0.2	15 ± 0.1	18 ± 0.6
9.	Flax seed	*Staphylococcus aureus*	17 ± 0.4	16 ± 0.2	18 ± 0.4	20 ± 1.0	17 ± 0.3	19 ± 0.1
		Escherichia coli	15 ± 0.1	14 ± 0.2	15 ± 0.3	18 ± 0.7	16 ± 0.3	17 ± 0.8

TABLE – 13(a)

ANALYSIS OF VARIANCE OF SCREENING OF ANTIMICROBIAL ACTIVITY, SOLVENT AND HERBAL CONCENTRATIONS USING AGAR WELL DIFFUSION TEST FOR SELECTED MEDICINAL PLANTS

Variables	Aloe vera		Marigold		Kuppaimeni		Neem		Yashtimadhu		Tanner's cassia		Tridex daisy		Vettiveru		Flax seed	
	'F' ratio	Significance	'F' ratio	Significance	'F' ratio	Significance	'F' ratio	Significance	'F' ratio	Significance	'F' ratio	Significance	'F' ratio	Significance	'F' ratio	Significance	'F' ratio	Significance
Within groups	24.1739		27.0816		24.1467		32.8243		18.5497		10.8662		13.2520		58.0821		31.2836	
Between groups	74.7248	0.000**	84.0188	0.000**	74.5337	0.000**	100.5431	0.000**	56.0847	0.000**	31.6867	0.000**	38.3468	0.000**	174.9556	0000**	94.3280	0000**
Between solvents	156.5204	0.000**	83.6533	0.000**	158.5525	0.000**	99.5821	0.000**	120.2469	0.000**	34.9196	0.000**	37.8437	0.000**	90.2304	0.000**	109.1101	0.000**
Between herbal concentrations	368.9643	0.000**	679.4446	0.000**	404.6473	0.000**	662.1627	0.000**	286.5048	0.000**	157.6980	0.000**	314.7286	0.000**	1255.5358	0.000**	374.6340	0.000**
Between bacteria	62.7371	0.000**	3.4206	0.078^{NS}	7.2396	0.013**	157.9741	0.000**	0.9480	0.341^{NS}	76.8773	0.000**	19.3413	0.000**	22.9280	0.000**	3676.4231	0.000**
Between solvent and concentration	6.0846	0.000**	2.1855	0.136^{NS}	35.9221	0.000**	19.9507	0.000**	3.5437	0.046*	6.4686	0.006**	1.1724	0.328^{NS}	156.1653	0.000**	23.8054	0.000**
Between concentration and bacteria	0.0093	0.924^{ns}	12.4297	0.002**	0.9234	0.347^{NS}	14.9561	0.001**	61.8434	0.000**	8.1706	0.009**	0.0000	1.000^{NS}	20.1929	0.000**	10.5792	0.004**
Between solvent and bacteria	23.9158	0.000**	27.8349	0.000**	8.0368	0.002**	12.8156	0.000**	9.0045	0.001**	8.6368	0.002**	1.3391	0.283^{NS}	31.1658	0.000**	7.4234	0.003**
Between solvent, concentration and bacteria	8.6102	0.002**	0.7825	0.470^{NS}	1.0188	0.377^{NS}	3.0919	0.066^{NS}	1.0223	0.376^{NS}	2.8789	0.078^{NS}	3.5171	0.047*	35.3661	0.000**	2.6469	0.093^{NS}

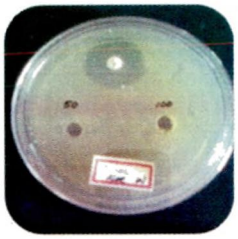
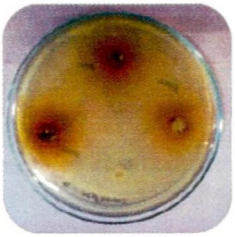
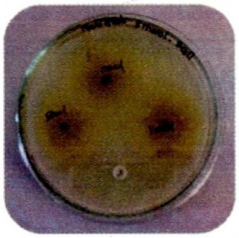
* Significant at five per cent level
** Significant at one per cent level.
NS – Not Significant

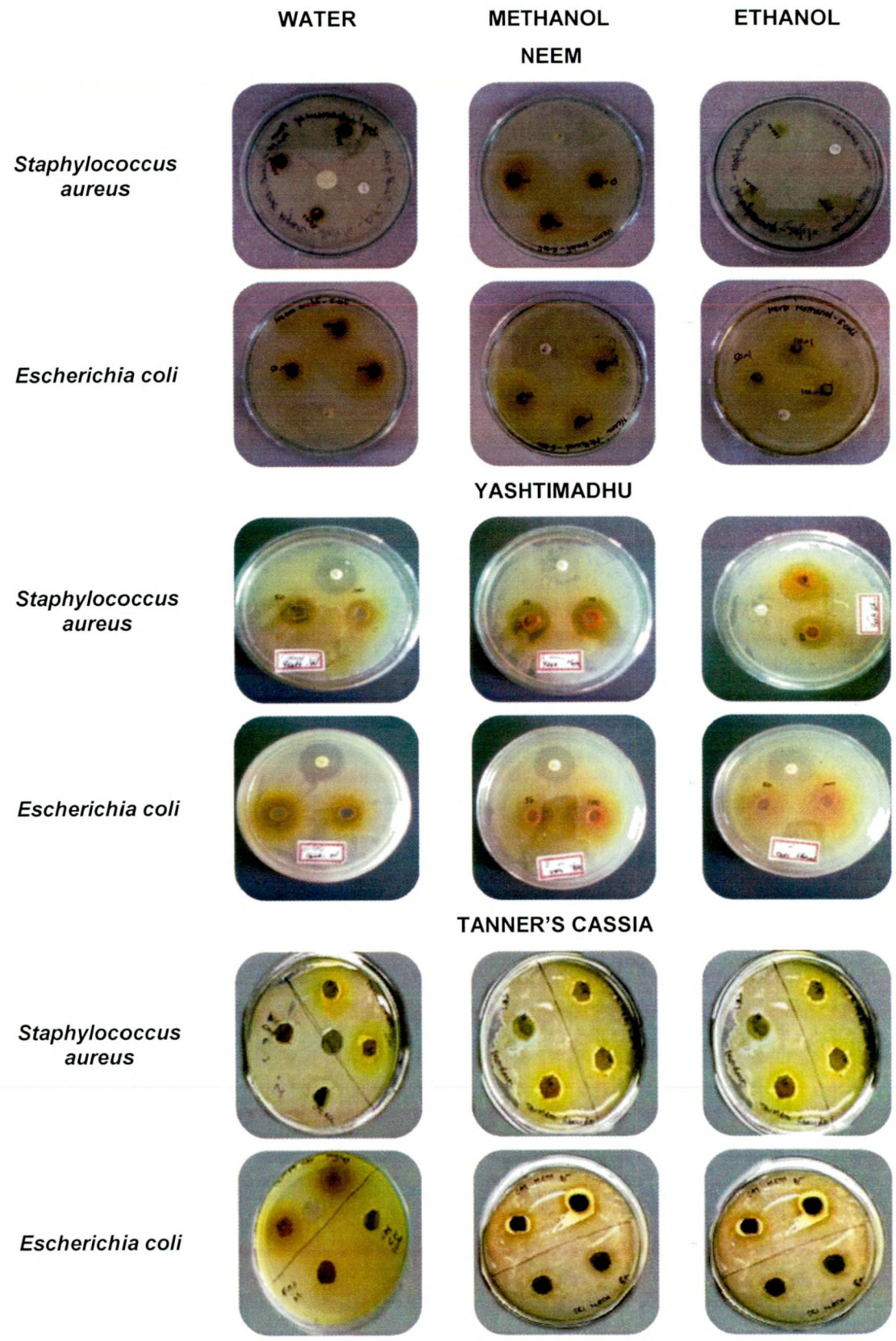
In Table – 13, the maximum diameter of zone was identified and compared with different medium of solvents and herbal concentrations. The 100 µl concentration of herbal extracts showed the maximum zone of inhibition when compared to 50 µl. The antibacterial activity was assessed based on the amount of zone exhibits in the extracted herbal solutions as denoted by Narayanan et al. (2007).

The maximum zone of inhibition in mm was found in the medicinal plants like aloe vera, marigold, neem, yashtimadhu, tridex daisy and flax seed against the *Staphylococcus aureus* bacteria. The herb kuppaimeni and tanner's cassia showed better zones of inhibition against *Escherichia coli* negative bacteria. These herbs have the highest degree of potent inhibitory effects against negative bacteria than positive bacteria as revealed by Prakash (2006). The higher zone of inhibition was measured in the selected solvents and the best suitable solvent and herbal concentrations were identified and selected namely distilled water for aloe vera (28 mm x 27 mm), neem (27 mm x 24 mm), yashtimadhu (27 mm x 25 mm), flax seed (20 mm x 18 mm), ethanol solvent for marigold (23 mm x 24 mm), kuppaimeni (22 mm x 27 mm), tridex daisy (19 mm x 18 mm), vettiveru (18 mm x 18 mm) and methanol for tanner's cassia (18 mm x 20 mm) in 100 µl concentrations. Hence, based on the yield of plants and the maximum zone of antimicrobial activity, the five herbs namely aloe vera, marigold, kuppaimeni, neem and yashtimadhu were selected among the nine herbs for the final research work (Plate – 14).

From the statistical analysis, it is noted that the variance of all the herbal solutions between groups, between solvents, between herbal concentrations is significant at one per cent level. The marigold, yashtimadhu samples are not significant when compared between the bacteria, solvent and concentrations. The samples of aloe vera, kuppaimeni and tridex daisy revealed insignificant level in concentration and bacteria combination. All the medicinal plant solutions showed insignificant in between the solvent, concentration and bacteria except aloe vera and vettiveru. The 'F' ratio of all the medicinal plant solutions shows the maximum antibacterial activity between the herbal concentrations.

Hence it can be concluded that all the selected nine medicinal plants showed good antibacterial activity against *Staphylococcus aureus* and *Escherichia coli* bacteria.

	WATER	METHANOL	ETHANOL
		ALOE VERA	
Staphylococcus aureus			
Escherichia coli			
		MARIGOLD	
Staphylococcus aureus			
Escherichia coli			
		KUPPAIMENI	
Staphylococcus aureus			
Escherichia coli			


WATER
METHANOL
ETHANOL
NEEM
Staphylococcus aureus
Escherichia coli
YASHTIMADHU
Staphylococcus aureus
Escherichia coli
TANNER'S CASSIA
Staphylococcus aureus
Escherichia coli

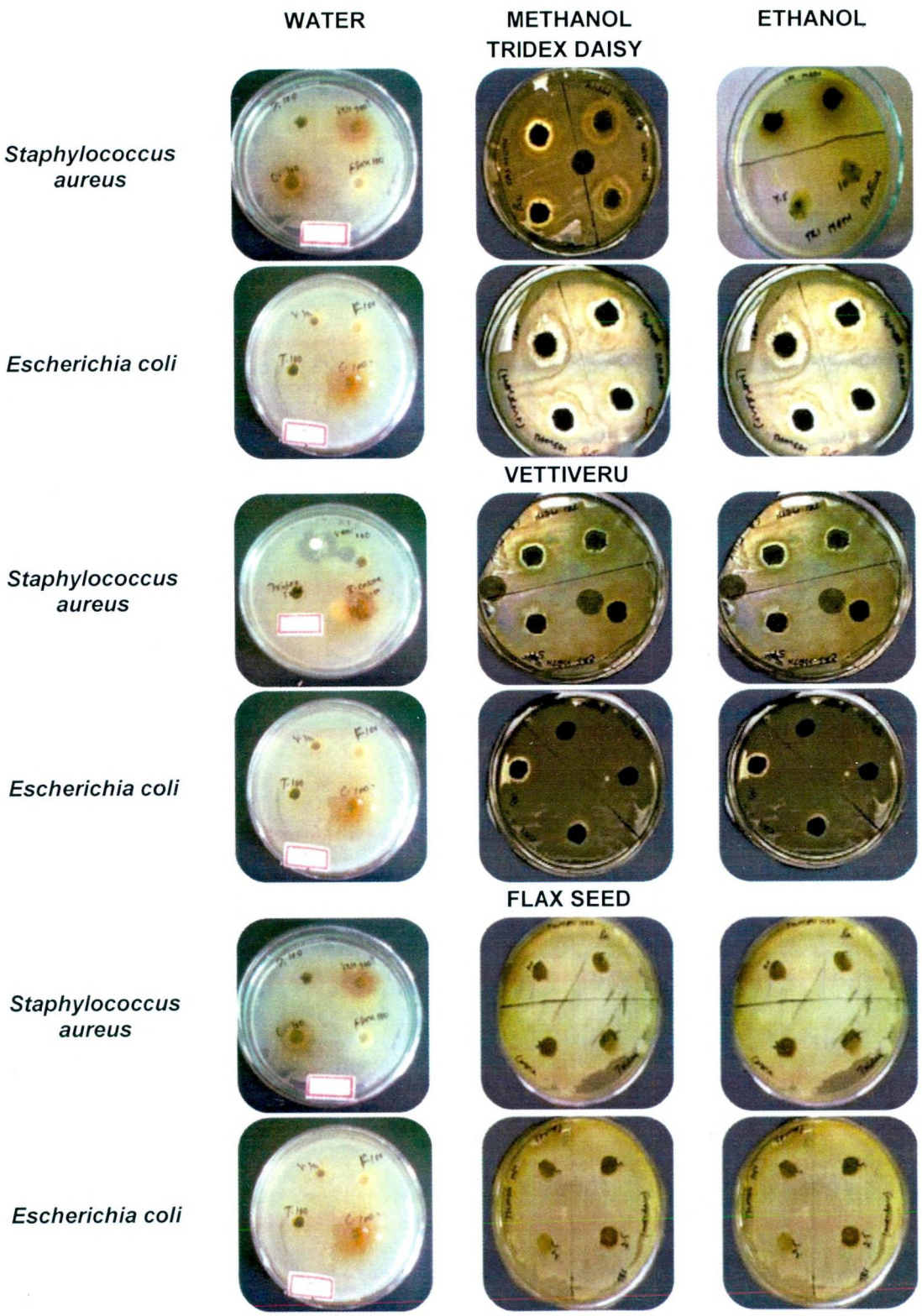


PLATE – 14

ZONE OF INHIBITION FOR HERBAL EXTRACTIONS AND ANTIBIOTICS USING AGAR WELL DIFFUSION TEST FOR SELECTED MEDICINAL PLANTS

4.2 IDENTIFICATION OF SELECTED HERBAL ANTIBACTERIAL ACTIVITY AGAINST COMMERCIAL ANTIBIOTICS

The antibacterial activity of the selected five herbal extracts against *Staphylococcus aureus* bacteria and *Escherichia coli* were compared with the standard antibiotics of penicillin and chloramphenicol. These results are presented in the Tables – 14 and 15.

TABLE – 14

ANTIBACTERIAL ACTIVITY OF SELECTED HERBAL EXTRACTS FOR *Staphylococcus aureus* BACTERIA AGAINST PENICILLIN

S.No.	Selected medicinal herbs	Antibiotic Penicillin (10 µg)	Concentration of Herbal Solutions					
			Zone of inhibition (mm)					
			50 µl/µg			100 µl/µg		
			Water	Methanol	Ethanol	Water	Methanol	Ethanol
1.	Aloe Vera	29	19 ± 0.5	18 ± 0.3	19 ± 0.7	28 ± 0.5	20 ± 0.7	22 ± 0.6
2	Marigold	27	16 ± 0.6	16 ± 0.3	17 ± 0.5	22 ± 0.7	21 ± 0.3	23 ± 0.5
3.	Kuppaimeni	25	16 ± 0.7	18 ± 0.6	18 ± 0.4	19 ± 0.4	20 ± 0.3	22 ± 0.5
4.	Neem	28	20 ± 0.5	19 ± 0.3	20 ± 0.1	27 ± 0.4	23 ± 0.6	24 ± 0.3
5.	Yashtimadhu	28	22 ± 0.7	20 ± 0.1	20 ± 0.5	27 ± 0.6	21 ± 0.3	22 ± 0.4

From Table – 14, it is clear that the selected herbal extracts show better antibacterial activity in 100 µl concentration when compared to 50 µl. The zone of inhibition for aloe vera, neem, yashtimadhu in the aqueous media is 28, 27 and 27 mm respectively against antibiotic penicillin. The herbal extracts from marigold and kuppaimeni show better antibacterial activity in ethanol extract as 23 mm and 22 mm, when compared to antibiotic penicillin. In a nutshell, all the five herbs show an activity between 16 to 28 mm in all the solvents namely distilled water, methanol and ethanol of 50 µl and 100 µl concentrations against gram positive bacteria as described by Benson (2002). Hence it can be concluded that the selected herbal extracts have antibacterial activity against positive bacteria.

TABLE – 15

ANTIBACTERIAL ACTIVITY OF SELECTED HERBAL EXTRACTS FOR *Escherichia coli* BACTERIA AGAINST CHLORAMPHENICOL

S.No.	Selected medicinal herbs	Antibiotic Chloram-phenicol (30 µg)	Concentration of Herbal Solutions					
			Zone of inhibition (mm)					
			50 µl/µg			100 µl/µg		
			Water	Methanol	Ethanol	Water	Methanol	Ethanol
1.	Aloe Vera	35	23 ± 0.3	18 ± 0.8	19 ± 0.2	27 ± 0.7	21 ± 0.5	23 ± 0.7
2	Marigold	39	15 ± 0.9	16 ± 0.7	19 ± 0.6	19 ± 0.8	20 ± 0.4	24 ± 0.3
3.	Kuppaimeni	28	16 ± 1.1	18 ± 0.3	19 ± 0.2	19 ± 0.8	20 ± 0.1	27 ± 0.3
4.	Neem	38	19 ± 0.5	17 ± 0.8	19 ± 0.2	24 ± 0.1	19 ± 0.7	22 ± 0.4
5.	Yashtimadhu	29	22 ± 0.1	18 ± 0.4	19 ± 0.6	25 ± 1.0	22 ± 0.3	23 ± 0.5

It is evident from Table – 15, that all the selected herbal extracts indicated good antibacterial activity in 100 µl concentration when compared to 50 µl. The zone of inhibition against negative bacteria in aqueous media was 27 mm, 24 mm and 25 mm in aloe vera, neem and yashtimadhu herbal extracts respectively when compared to chloramphenicol antibiotic. The marigold and kuppaimeni herbal extracts exhibited better activity in alkaline media picturing 24 mm and 27 mm of zone of inhibition.

In a nutshell, all the selected five herbs showed a zone of inhibition from 15 to 27 mm in all the solvents of both concentrations. Hence it can be concluded that the selected herbs had antibacterial activity against *Escherichia coli* bacteria.

4.3 FOURIER TRANSFORM – INFRA RED SPECTRA (FT-IR) STUDY OF SELECTED PAD DRY AND MICRO ENCAPSULATION HERBAL FINISHED SAMPLES

The FT-IR analysis of the unfinished, pad dry and micro encapsulation finished samples are presented in the Figures – 1 to 6. The phytochemicals responsible for the antimicrobial property was identified, quantified and the frequencies were documented.

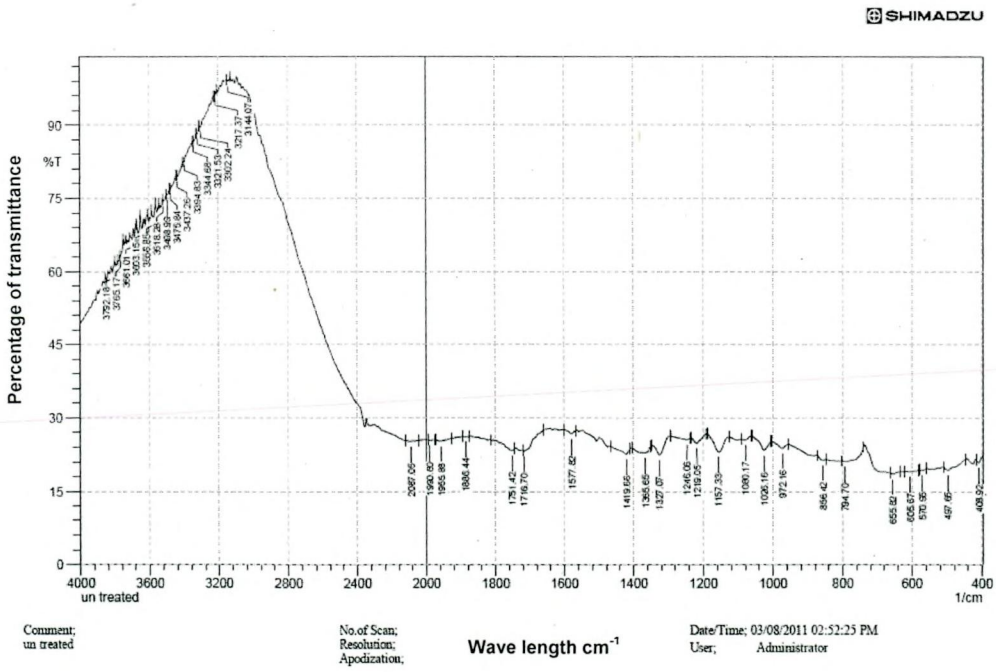
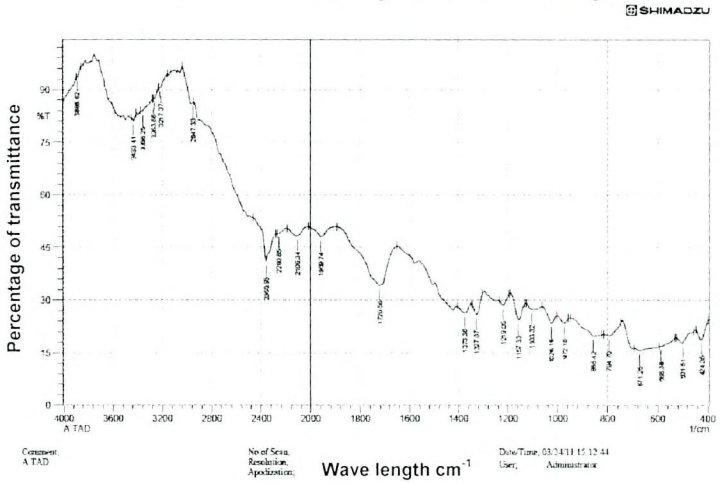


FIGURE – 1

FOURIER TRANSFORM – INFRA RED SPECTRA (FT-IR) STUDY OF UNFINISHED SAMPLE

From the FT-IR results, it is clear that the absorption of the unfinished sample was in the region of 3200 – 3600 cm^{-1} and 1000 – 1500 cm^{-1}, confirming the presence of the –OH functional group. The absorption range of 1600 – 1900 cm^{-1} confirmed the absence of carbonyl (–C=O) groups in the unfinished sample as reported by Chen and Chang (2007) (Figure – 1). The FT-IR spectrum of the aloe vera pad dry finished sample showed absorption in the region of 1720.36 and 3433.41 cm^{-1} confirming the presence of ketone and normal polymeric OH stretch are shown in the Figure – 2a.

2a. Aloe Vera Pad Dry Finished Sample



2b. Aloe Vera Micro Encapsulation Finished Sample

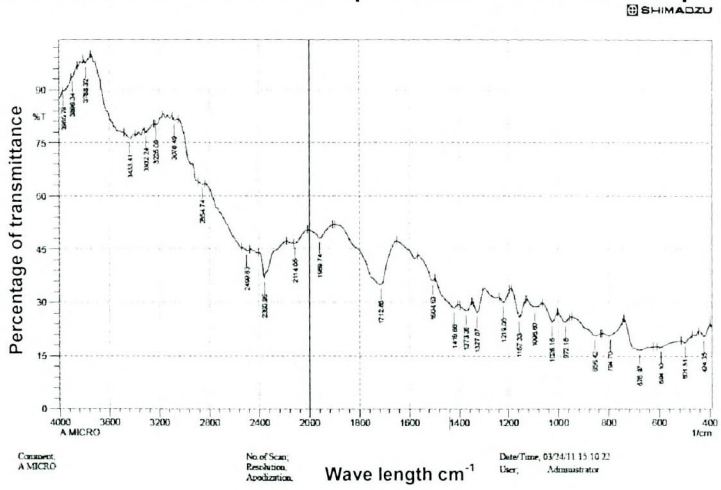
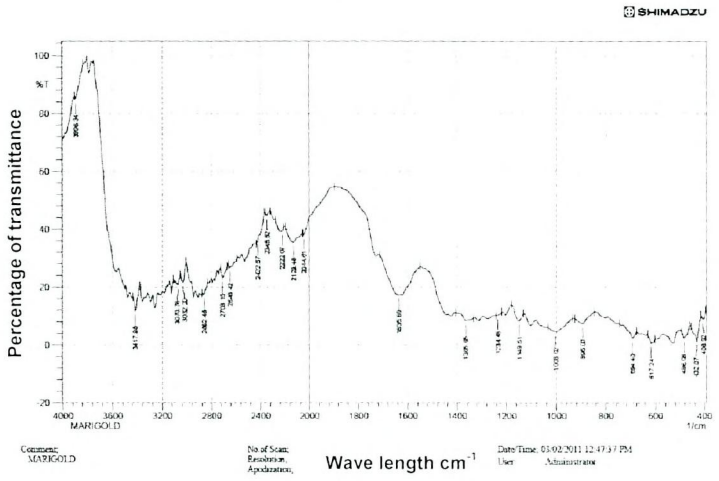


FIGURE – 2

FOURIER TRANSFORM – INFRA RED SPECTRA (FT-IR) STUDY OF ALOE VERA PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES

The aloe vera micro encapsulated finished sample also showed the presence of functional groups namely ketone, carboxylic acid, primary or secondary OH band, alkyl and aryl sulfones with an absorption range of 1712.86 cm^{-1} of C=O, 1419.66 cm^{-1} of COOH, 1327.07 cm^{-1} of OH and 1157.33 cm^{-1} respectively (Figure – 2b). The presence of flavonoids functional group (–C=O) at the region of 1600 – 1900 cm^{-1} and 2300 – 2900 cm^{-1} and to –OH at the broad peak in the region 3200 – 3600 cm^{-1} and 1000 – 1500 cm^{-1}. Hence it can be concluded that aloe vera both pad dry and micro encapsulation finished cotton fabric contained more carbonyl (-C=O) groups due to the formation of carboxylic acid functional group of flavonoids.

3a. Marigold Pad Dry Finished Sample



3b. Marigold Micro Encapsulation Finished Sample

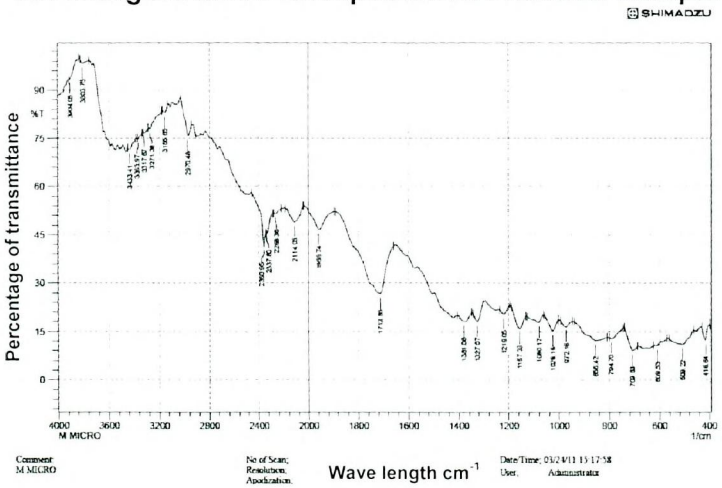
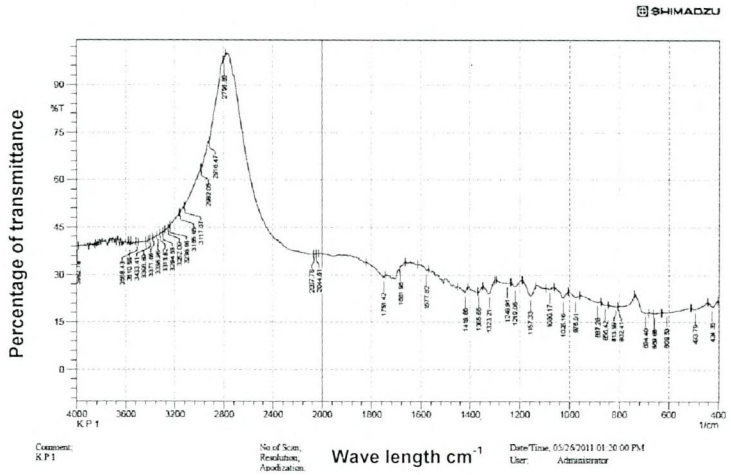


FIGURE – 3

FOURIER TRANSFORM – INFRA RED SPECTRA (FT-IR) STUDY OF MARIGOLD PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES

The FT-IR spectrum of the marigold pad dry finished sample showed the absorption range of 3032 – 3070 cm^{-1} confirming the presence of vinyl (C=H), weak terminal alkynes (C=C) and strong N-H bond of primary amine groups in the region of 2129.48 and 1635 cm^{-1} respectively as described by Coates (2000). The absorptions in the region of 1712.85,1381, 1327 and 1219.05 cm^{-1} which confirmed the presence of saturated carboxylic acid, aromatic nitro compounds (N=O), alkyl/aryl sulfones and sulfonate groups in the marigold micro encapsulated finished sample (Figures – 3a and 3b).

4a. Kuppaimeni Pad Dry Finished Sample



4b. Kuppaimeni Micro Encapsulation Finished Sample

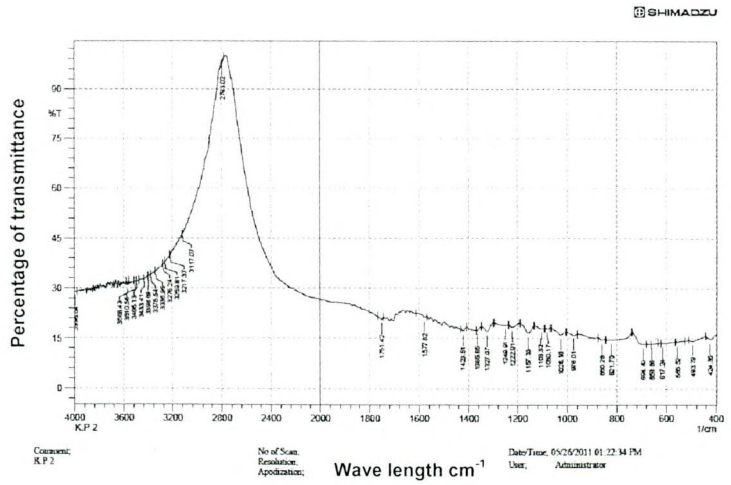
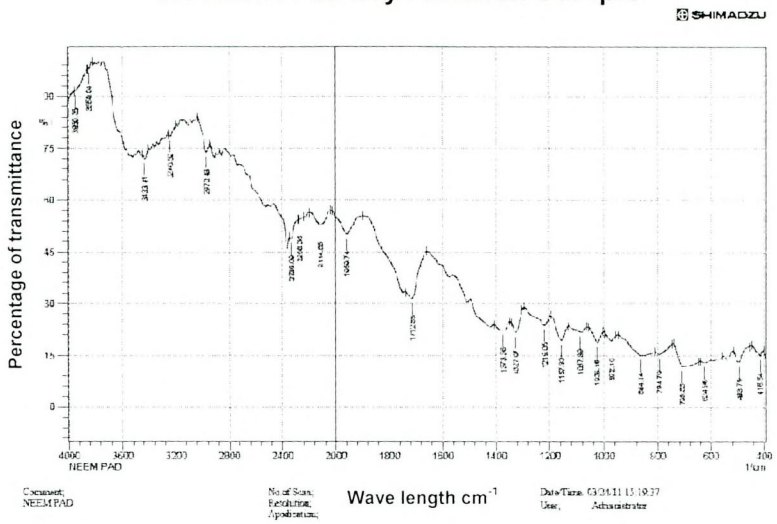


FIGURE – 4

FOURIER TRANSFORM – INFRA RED SPECTRA (FT-IR) STUDY OF KUPPAIMENI PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES

The FT-IR spectrum of the kuppaimeni pad dry and micro encapsulation finished samples showed the absorption range of 1323.21-1157.33 cm^{-1} which confirmed the presence of (C-N) stretch of aromatic secondary amine and 1751.42 cm^{-1} showed the presence of ketone (Figures – 4a and 4b).

5a. Neem Pad Dry Finished Sample



5b. Neem Micro Encapsulation Finished Sample

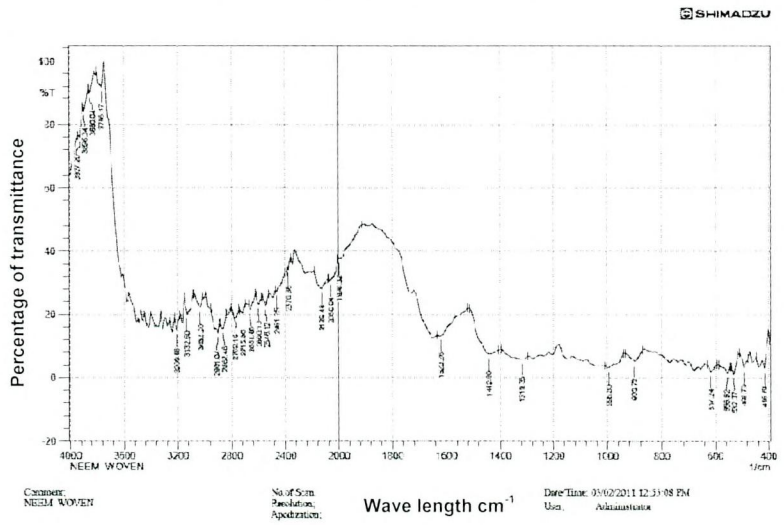


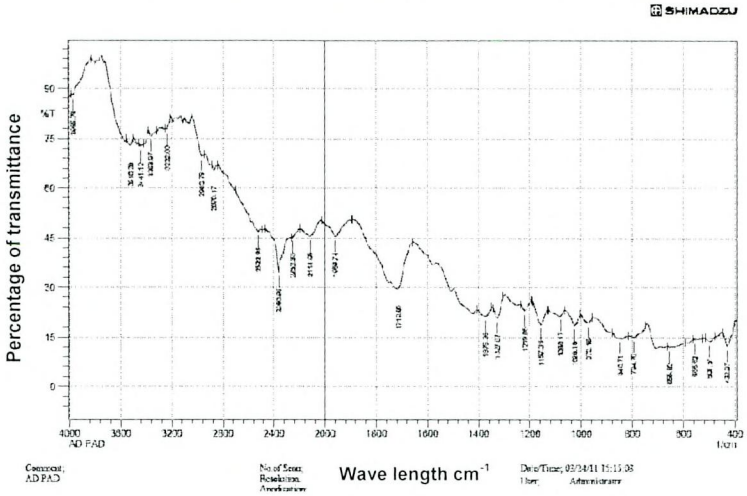
FIGURE – 5

FOURIER TRANSFORM – INFRA RED SPECTRA (FT-IR) STUDY OF NEEM PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES

The neem herbal pad dry finished cotton fabric contained more number of groups like methyl (C-H) asymmetric / symmetric stretch, ketone, primary or

secondary OH band, alkyl sulfones and primary amines (C-N) at a range of 3433.41, 2970.48, 1712.85, 1327.07, 1157.33 and 1026.16 cm^{-1} CN stretching vibration of amino groups respectively. The neem micro encapsulated sample showed the presence of only one normal polymeric hydroxyl group stretch (OH) of 3433.41 cm^{-1} as reported by Shanmugavasan and Ramachandran (2011) in Figures – 5a and 5b.

6a. Yashtimadhu Pad Dry Finished Sample



6b. Yashtimadhu Micro Encapsulation Finished Sample

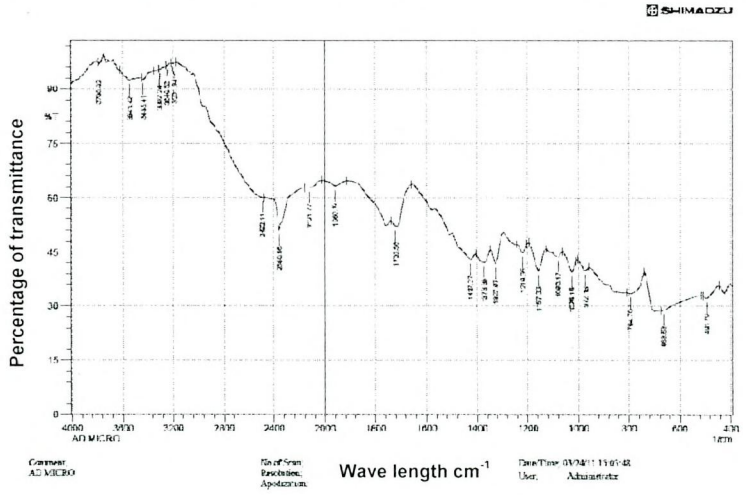


FIGURE – 6

FOURIER TRANSFORM – INFRA RED SPECTRA (FT-IR) STUDY OF YASHTIMADHU PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES

The yashtimadhu pad dry finished sample presented an absorption range of 3518 – 3441 cm^{-1} confirming the presence of aromatic primary amine (N-H), ketone of secondary amine (C-N) and C-H aromatic plane bond at 1725 – 1750 cm^{-1},

1157.33 and 1026.16 cm^{-1} respectively. The absorptions in the region of 1157 – 1026 cm^{-1} 1720.56, 1427.37, 1373.36 cm^{-1} confirmed the presence of primary and secondary amine (C-N stretch).

Hence, the FT-IR tests confirmed the presence of antimicrobial compounds such as O-H and C=O groups in all the herbal finished samples.

4.4 OPTIMIZATION OF FINISH PROCESS PARAMETERS FOR THE APPLICATION OF HERBAL EXTRACTS ON THE FABRICS

The optimized parameters of the selected five herbal extracts for the application of finish on cotton fabrics are presented in the Table – 16 and Figures 7 to 11.

TABLE – 16

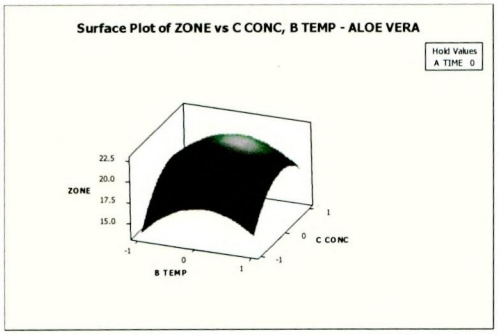
OPTIMIZED PARAMETERS FOR THE APPLICATION OF HERBAL FINISH USING BOX AND BEHNKEN EXPERIMENTAL DESIGN

S.No.	Medicinal herbs	Test order No.	Time (mins.) (X_1)		Temperature (°C) (X_2)		Concentration (%) (X_3)		Response factor (%) Zone of inhibition (mm)
			Coded	Actual	Coded	Actual	Coded	Actual	
1.	Aloe vera	3,7,10	0	60	0	50	0	50	22.4
2.	Marigold	11	0	60	1	60	1	75	24.9
3.	Kuppaimeni	11	1	90	9	50	1	75	22.1
4.	Neem	11	-1	30	0	50	-1	25	21.3
5.	yashtimadhu	2,7,9	0	60	0	50	0	50	20.9

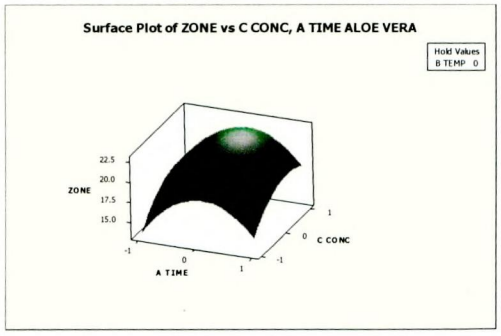
The experimental design showed a clear view about the result of response factor. The sequence order and the surface plot graph was analysed for each combination of time, temperature and concentration. The maximum zone of inhibition was recorded for all the herbs from the surface plot graphs of Figures – 7 to 11 and Table – 16. The linear regression response surface equation also revealed the maximum zone of inhibition as indicated by Thilagavathi and Kannaian (2008).

The optimized parameters for the application of selected medicinal herbs namely time, temperature and concentration of aloe vera (22.4 mm) were 60 minutes, 50°C, 50 per cent ; marigold (24.9 mm) was 60 minutes, 60°C, 75 per cent ; kuppaimeni (22.1 mm) was 90 minutes, 50°C, 75 per cent ; neem (21.3 mm) was 30 minutes, 50°C, 25 per cent and yashtimadhu (20.9 mm) was 60 minutes, 50°C, 50 per cent respectively.

7a. Time



7b. Temperature



7c. Concentration

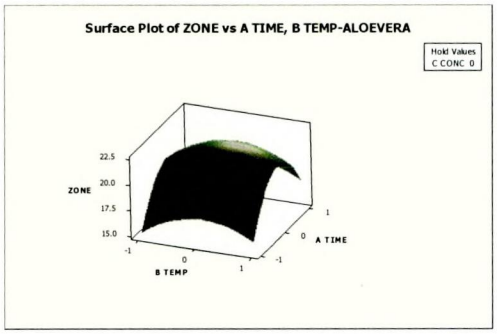
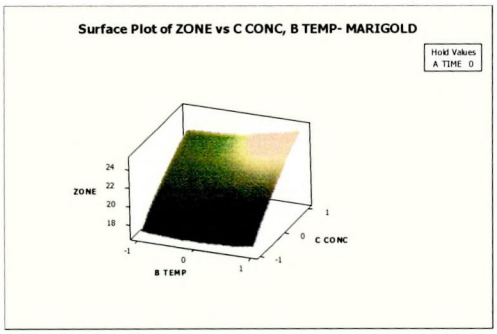


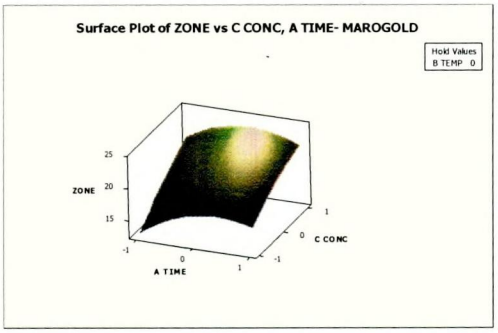
FIGURE – 7

BOX AND BEHNKEN EXPERIMENTAL DESIGN FOR ALOE VERA

8a. Time



8b. Temperature



8c. Concentration

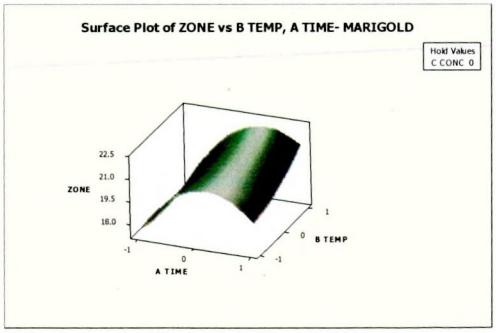
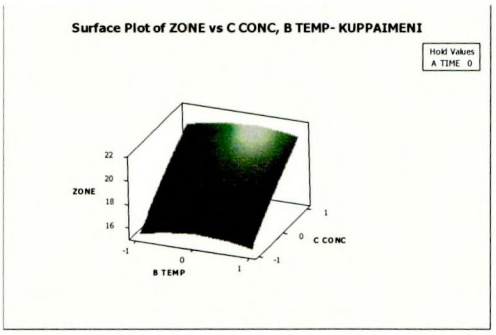


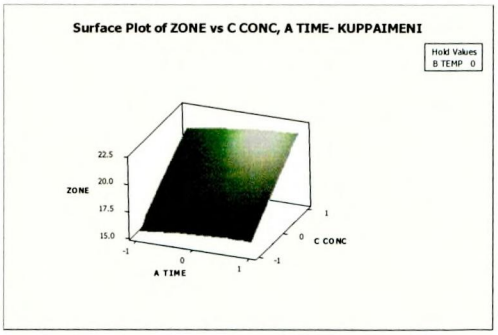
FIGURE – 8

BOX AND BEHNKEN EXPERIMENTAL DESIGN FOR MARIGOLD

9a. Time



9b. Temperature



9c. Concentration

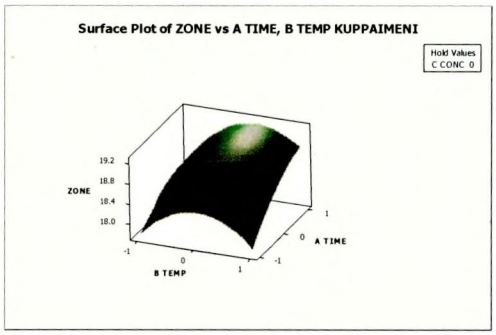
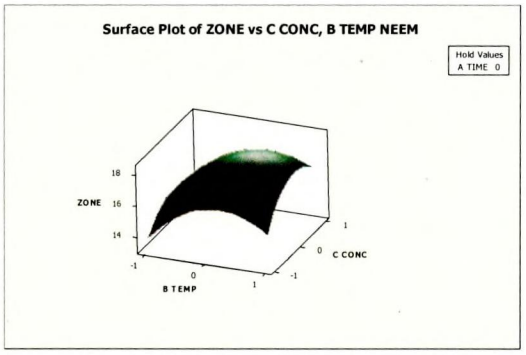


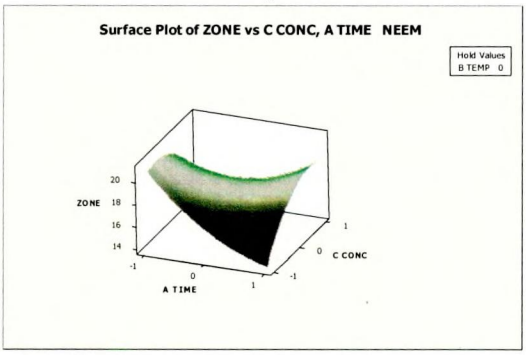
FIGURE – 9

BOX AND BEHNKEN EXPERIMENTAL DESIGN FOR KUPPAIMENI

10a. Time



10b. Temperature



10c. Concentration

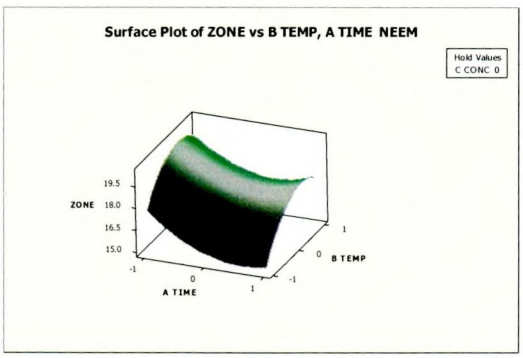
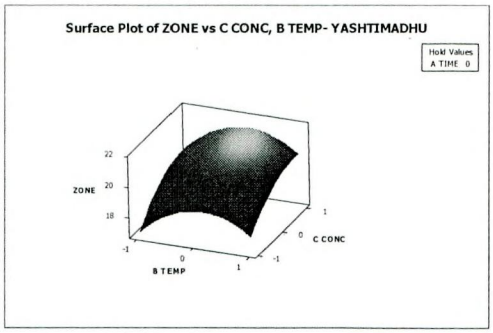


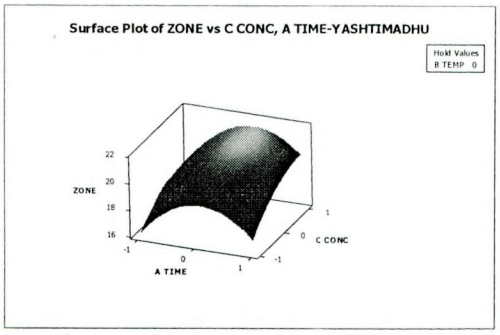
FIGURE – 10

BOX AND BEHNKEN EXPERIMENTAL DESIGN FOR NEEM

11a. Time



11b. Temperature



11c. Concentration

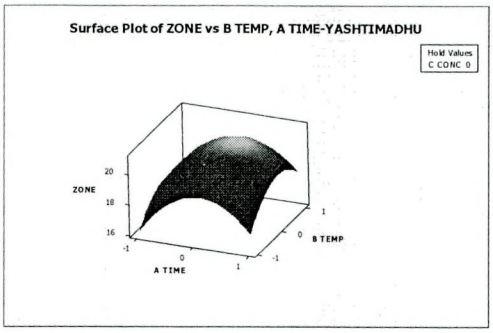


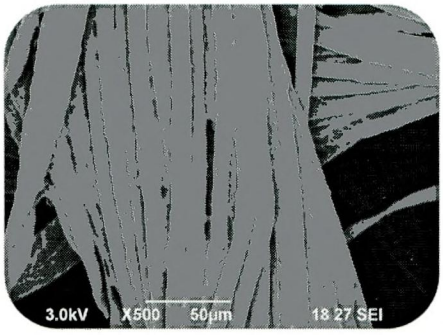
FIGURE – 11

BOX AND BEHNKEN EXPERIMENTAL DESIGN FOR YASHTIMADHU

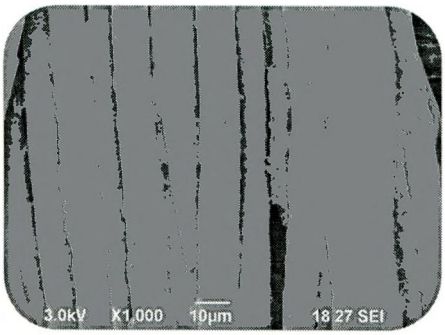
4.5 SEM STUDY OF SELECTED PAD DRY AND MICRO ENCAPSULATION HERBAL FINISHED SAMPLES

The presence, binding and structure of microcapsules on the unfinished and herbal finished samples were analysed using different magnification and voltage. The unfinished sample showed maximum pore size and clear structure with a large number of protruding fibres. The scanning microscope photos clearly showed the bondage between the fibre structures and penetration of herbal capsules into the surface of the pad dry finished samples.The magnification levels for aloe vera pad dry finished samples were X500, X1000, X3000 and X7500 (Plates – 15a to 15d). Similarly the magnification levels for aloe vera micro encapsulation finished samples were X500, X1000, X3000, X7500 (Plates – 16a to 16d).

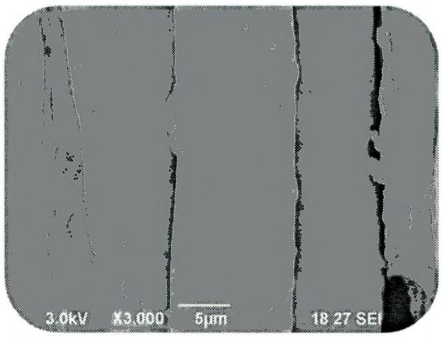
The surface of ALPF sample showed the open weave structure with few protruding fibres and minute capsule formation. In the ALMF finished sample, the maximum deposition of herbal solution was observed by the reduced pore size in the weave structure. The X7500 resolution in micro encapsulation finished sample in the Plate – 16d showed a reduced pore size in the fabric surface which was the result of uniform deposition of herbal solutions.



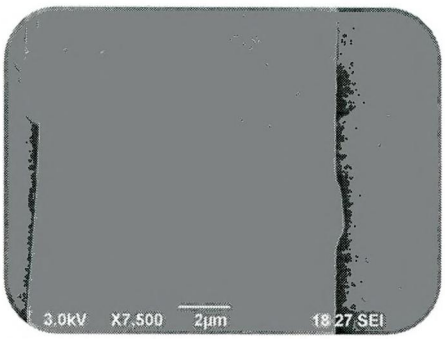
15a. X500



15b. X1000



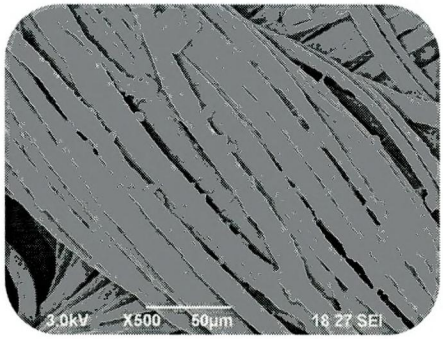
15c. X3000



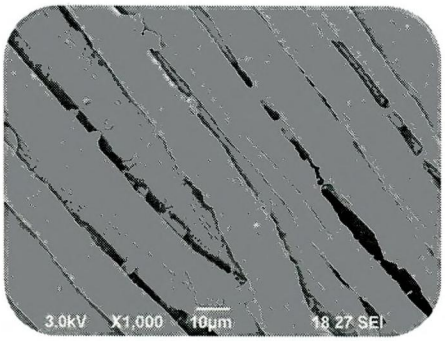
15d. X7500

PLATE – 15

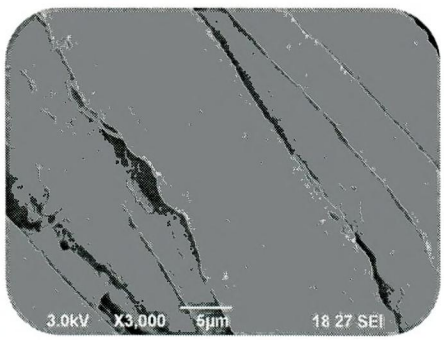
SEM STUDY OF ALOE VERA PAD DRY HERBAL FINISHED SAMPLES



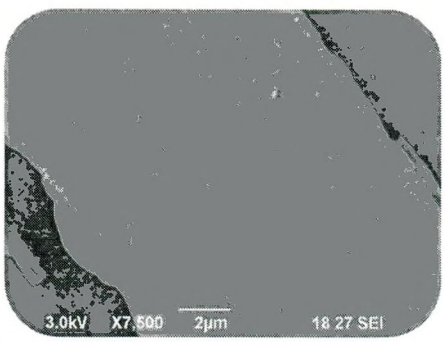
16a. X500



16b. X 1000



16c. X3000



16d. X7500

PLATE – 16

SEM STUDY OF ALOE VERA MICRO ENCAPSULATION

HERBAL FINISHED SAMPLES

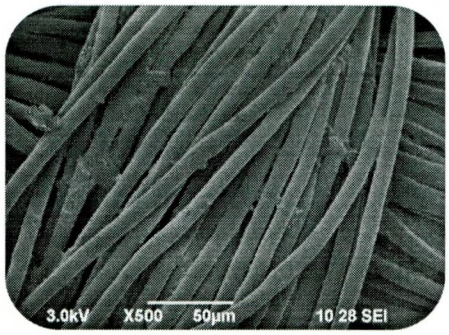
The morphology of MAPF finished sample clearly showed the surface of the pad dry finished sample with few protruding fibres and the capsule solution alignments. The herbal solutions were fixed unevenly on the outer surface of the fabric. The depth and size of the capsules were also small (Plates – 17a to 17d).

The MAMF sample clearly showed the bondage between the fibre structures and penetration of herbal capsules into the inner surface of fabric samples (Plates – 18a to 18c). Each of the magnification was representing the depth of molecules penetrated in the fibre structure and size of the capsules found in the inner layer of fabric. MAMF samples showed the bigger capsules due to the high absorbency and maximum deposition of herbal solution.

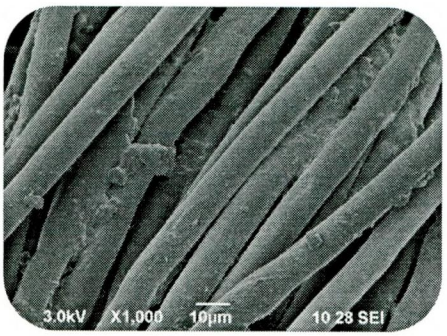
The X10,000 resolutions (Plate – 18d) showed the minimum pore size in the fabric surface due to the uniform deposition of herbal solution. Based on the size of the capsule, the SEM study indicated that the durability of the finish was enhanced.

The surface level of modifications of the pad dry finished samples due to finishing treatments were analysed with different magnification of X100, X500, X1500 and X8000 resolutions and 3.0 KV voltage (Plates – 19a to 19d) clearly showed the surface structure, fibre entanglement and herbal solution formation. The pad dry method of finishing reduced the pore size in the weave structure due to the deposition of herbal extracts. The pad dry samples showed the uneven deposition of solution and capsule formation which indicate poor finish.

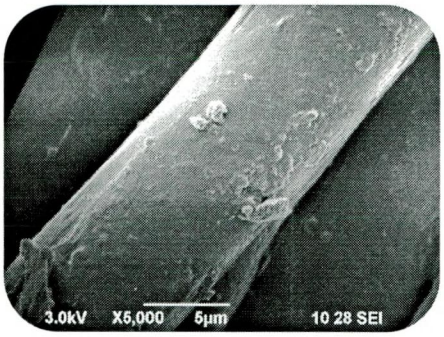
The SEM photographs of KUMF samples (Plates – 20a to 20c) at different magnification levels and 3.0 KV voltage. The three magnifications of X100, X500 and X1500 resolutions clearly showed the bonding between the fibre structures and penetration of herbal capsules into the inner surface of the micro finished samples. The X8000 resolution (Plate – 20d) showed reduced pore size in the fabric surface due to the maximum deposition of herbal solution on the surface of the fibres. Microcapsules produced were fairly uniform in size (Sathianarayanan and Bhat, 2010). The micro finished fabric sample absorbed maximum quantity of herbal solution than the pad dry finished fabric. Hence due to the high penetration of herbal solution and increase in the size of the capsules, it enhances the durability of the finish.



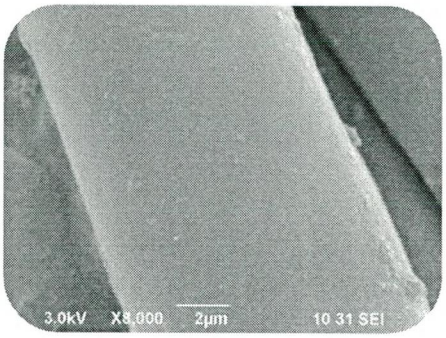
17a. X500



17b. X1000



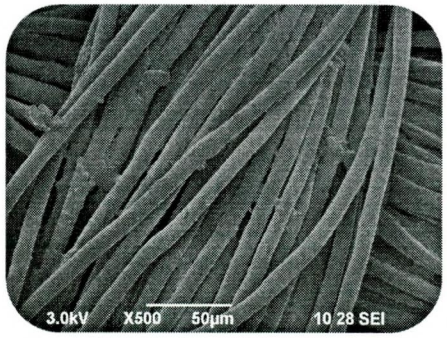
17c. X5000



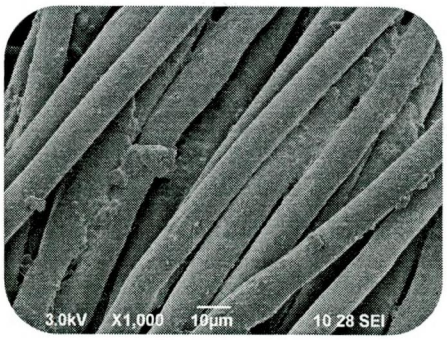
17d. X10000

PLATE – 17

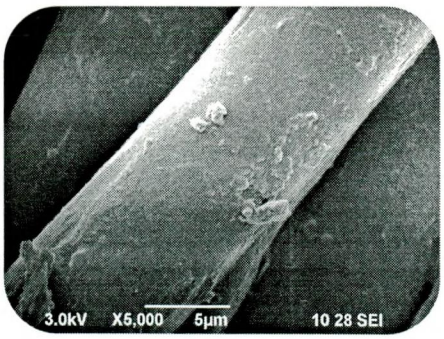
SEM STUDY OF MARIGOLD PAD DRY HERBAL FINISHED SAMPLES



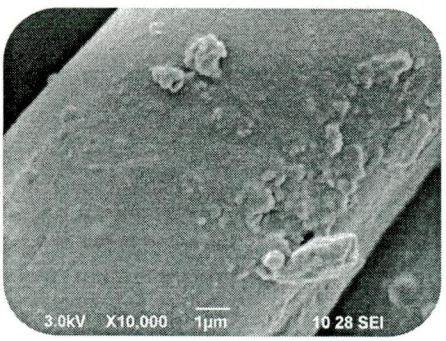
18a. X500



18b. X1000



18c. X5000

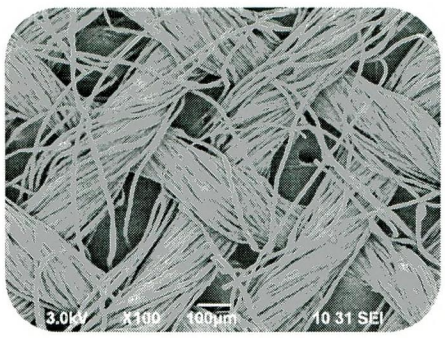


18d. X10000

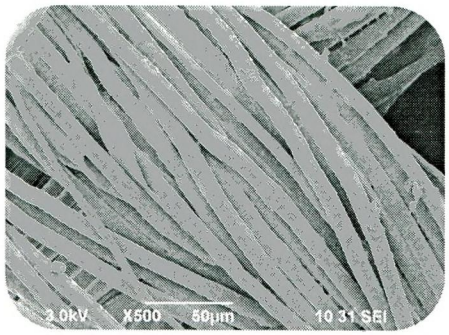
PLATE – 18

SEM STUDY OF MARIGOLD MICRO ENCAPSULATION

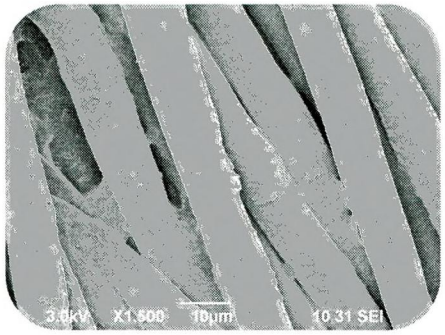
HERBAL FINISHED SAMPLES



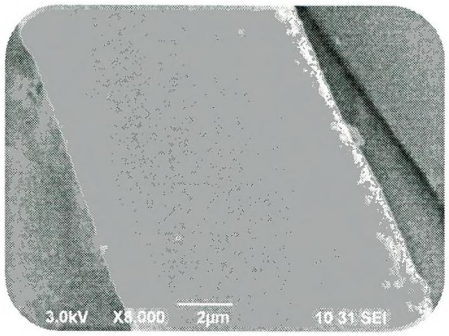
19a. X100



19b. X500



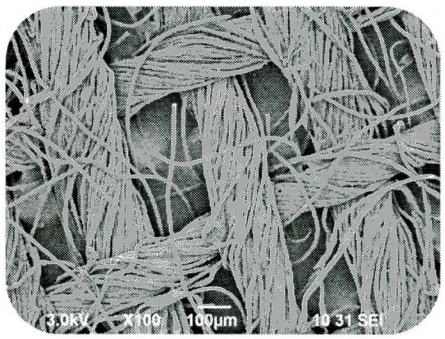
19c. X 1500



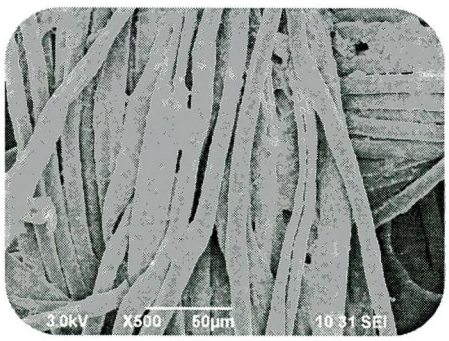
19d. X8000

PLATE – 19

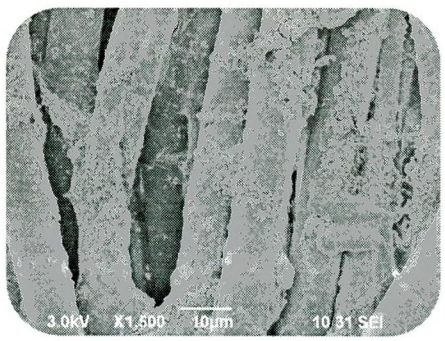
SEM STUDY OF KUPPAIMENI PAD DRY HERBAL FINISHED SAMPLES



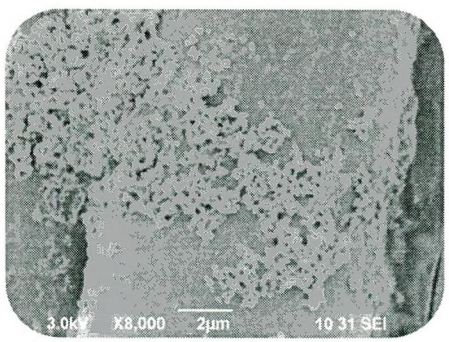
20a. X100



20b. X500



20c. X1500



20d. X8000

PLATE – 20

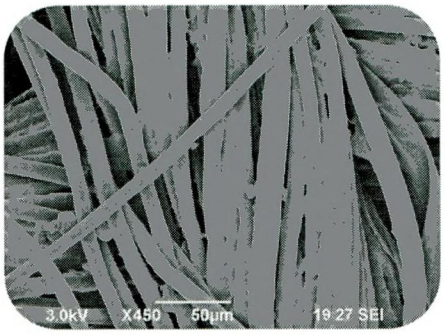
SEM STUDY OF KUPPAIMENI MICRO ENCAPSULATION HERBAL FINISHED SAMPLES

The conformation of capsule bonding between the molecules, fibre entanglements and capsule size was identified with the magnifications of X450, X500, X3000 and X7500 resolutions. These photos clearly showed white deposits on the surface of the pad finished sample having an open weave structure with number of protruding fibres and gap between the capsules (Viswanath and Ramachandran, 2010). The pad method of finishing results in minimum reduction of pore size in the weave structure due to the uneven deposition of herbal solutions (Plates – 21a to 21d).

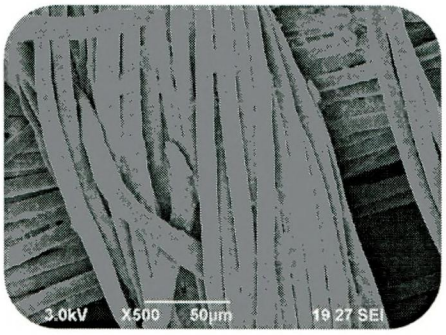
The magnification of X500, X1000, X2500 resolutions with 5.0 KV voltage and Plates – 22a to 22c clearly showed the bonding between the fibre structures and penetration of herbal capsules into the surface of the micro encapsulation finished samples. The X5000 resolution in Plate – 22d showed reduced pore size in the fabric surface due to the uniform and maximum deposition of herbal solution. The higher resolution showed the clear structure, size of the capsule and the bonding between the fibre molecules. The NEMF samples shows maximum size and number of capsules when compared to NEPF samples.

The surface level of modification of the YAPF samples were analyzed due to finishing treatment with the different magnification of X500, X1000, X3000 and X7500 resolutions. The Plates – 23a to 23d clearly showed the surface of the pad finished samples, structure and bondage of herbal solution. In the pad method of finishing, the size and number of capsule was very less due to the irregular deposition and poor absorption of herbal solution.

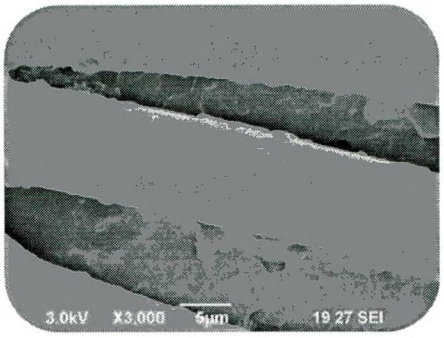
The 3.0 KV voltage of SEM photographs were showed at different magnification levels of X450, X1000 and X3000, X7500 resolutions (Plates – 24a to 24d). This showed the bondage between the fibre structures, penetration of herbal capsules into the surface, capsule size and space between the fibre molecules of the micro finished samples. The X7500 resolution in Plate – 24d show reduced pore size in the fabric surface due to the uniform deposition of herbal solution.



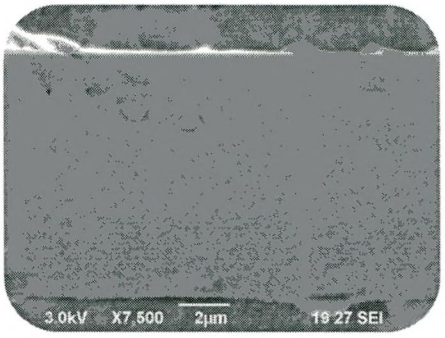
21a. X450



21b. X500



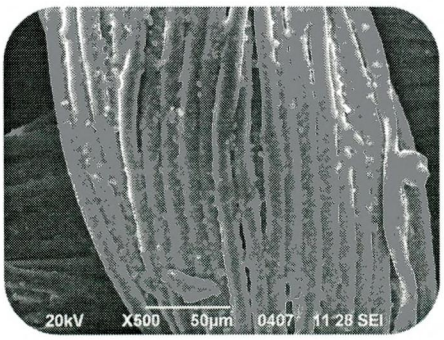
21c. X3000



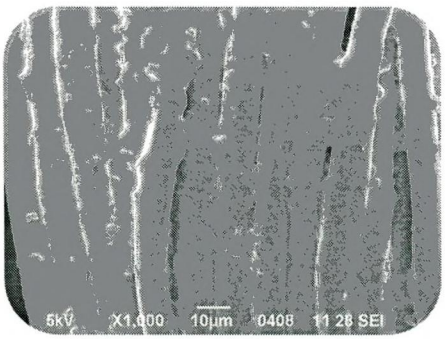
21d. X7500

PLATE – 21

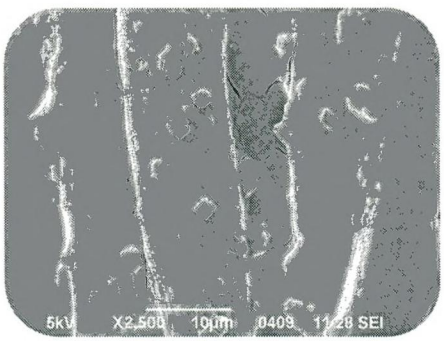
SEM STUDY OF NEEM PAD DRY HERBAL FINISHED SAMPLES



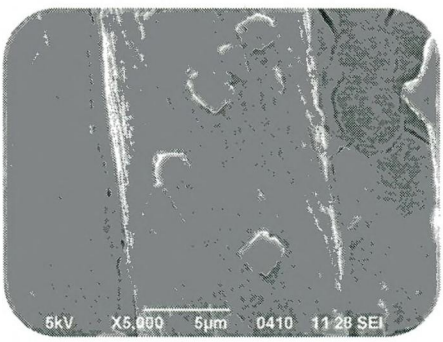
22a. X500



22b. X 1000



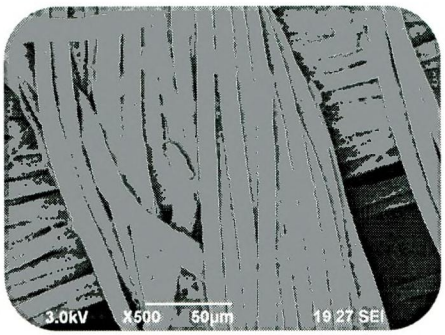
22c. X2500



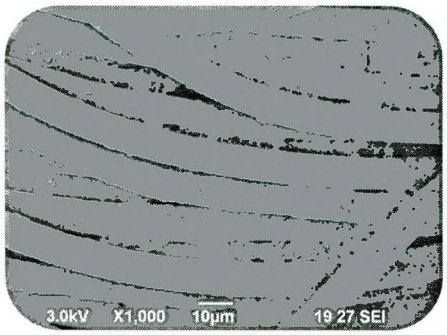
22d. X5000

PLATE – 22

SEM STUDY OF NEEM PAD DRY AND MICRO ENCAPSULATION HERBAL FINISHED SAMPLES



23a. X500



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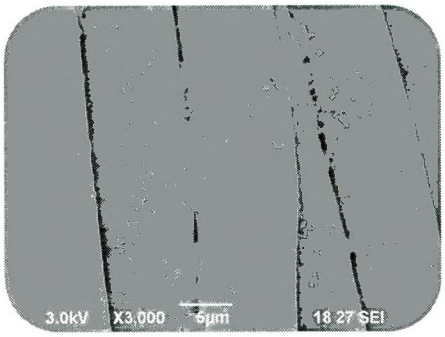
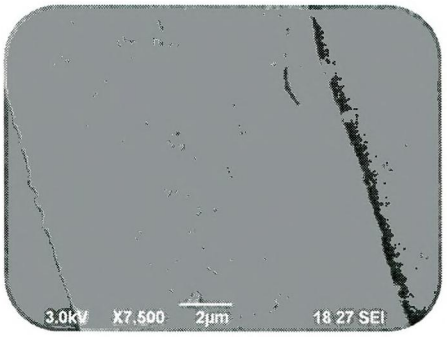


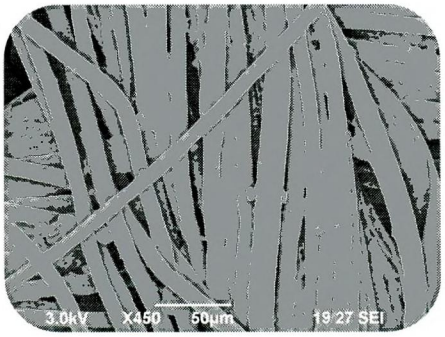
23c. X3000



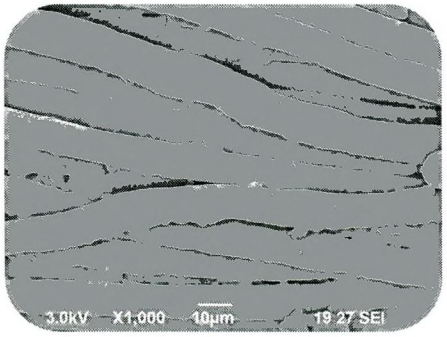
23d. X7500

PLATE – 23

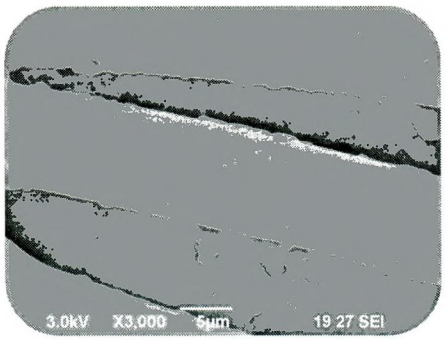
SEM STUDY OF YASHTIMADHU PAD DRY HERBAL FINISHED SAMPLES



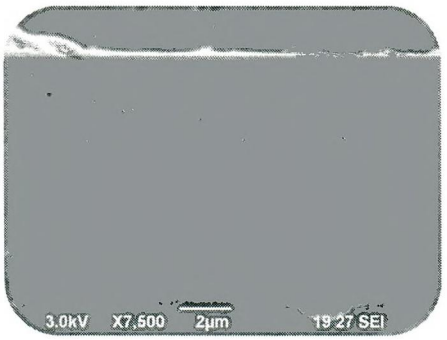
24a. X450



24b. X1000



24c. X3000



24d. X7500

PLATE – 24

SEM STUDY OF YASHTIMADHU MICRO ENCAPSULATION

HERBAL FINISHED SAMPLES

4.6 ANTIMICROBIAL ASSESSMENT TESTS

4.6.1 Antibacterial Activity

4.6.1.1 Qualitative Antibacterial Activity Assessment by Agar Diffusion Method (AATCC 147 – 1998)

The agar diffusion test of pad dry and micro encapsulation herbal finished samples showed zone of inhibition around the sample and unfinished sample showed no inhibition zone around the fabric. Table – 17 shows the diameter of zone formed in mm against positive bacteria *Staphylococcus aureus* and negative bacteria *Escherichia coli*.

TABLE – 17

ZONE OF INHIBITION OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES AGAINST *Staphylococcus aureus* POSITIVE BACTERIA AND *Escherichia coli* NEGATIVE BACTERIA

S.No.	Samples	Antibacterial activity (zone of inhibition in mm)	
		***Staphylococcus aureus* positive bacteria**	***Escherichia coli* negative bacteria**
1.	UF	0	0
2.	ALPF	35 ± 0.3	33 ± 0.4
3.	ALMF	40 ± 0.2	34 ± 0.1
4.	MAPF	34 + 0.5	33 ± 0.1
5.	MAMF	32 ± 0.5	31 ± 0.5
6.	KUPF	31 ± 0.4	32 ± 0.6
7.	KUMF	32 ± 0.4	34 ± 0.7
8.	NEPF	31 ± 0.8	30 ± 0.9
9.	NEMF	32 ± 0.3	31 ± 0.7
10.	YAPF	36 ± 0.3	36 ± 0.5
11.	YAMF	37 ± 0.3	38 ± 0.4

The pad dry and micro encapsulation herbal finished samples showed a good zone of inhibition. The optimized concentrations of all the herbs namely aloe vera (50%), marigold (75%), kuppaimeni (75%), neem (25%), yashtimadhu (50%) expressed a maximum zone of inhibition in their respective concentrations against both positive and negative bacteria. Table – 17 depicts the maximum zone of inhibition in aloe vera, neem, marigold pad dry and micro encapsulation finished samples against *Staphylococcus aureus* bacteria whereas kuppaimeni and yashtimadhu showed higher zone of inhibition against *Escherichia coli* bacteria. Among all the herbal finished samples, ALMF sample showed maximum zone of

TABLE – 17(a)

ANALYSIS OF VARIANCE OF AATCC 147 AGAR DIFFUSION METHOD

Variables	Aloe vera		Marigold		Kuppaimeni		Neem		Yashtimadhu	
	'F' ratio	Significance	'F' ratio	Significance	'F' ratio	Significance	'F' ratio	Significance	'F' ratio	Significance
Within groups	2107.5768		2414.5059		3186.0695		1882.5914		6153.1594	
Between groups	7161.9858	0.000**	8204.8933	0.000**	10827.6667	0.000**	6396.9550	0.000**	20915.6323	0.000**
Between bacterias	251.0040	0.007**	21.3556	0.001**	4.5094	0.060^{NS}	1468.7087	0.000**	9.0430	0.013**
Between treatments	17636.9802	0.000**	20478.0667	0.000**	27059.8918	0.000**	15748.6937	0.000**	52275.5161	0.000**
Between bacteria and treatments	142.4822	0.000**	23.4889	0.000**	7.0202	0.012**	159.3393	0.000**	9.0430	0.006**

** Significant at one per cent level.
NS – Not Significant

inhibition 40 mm against *Staphylococcus aureus* bacteria and YAMF showed a maximum zone of inhibition of about 38 mm against *Escherichia coli* bacteria. In a nutshell, all the herbal extracts revealed antimicrobial activity against *Staphylococcus aureus* positive bacteria and *Escherichia coli* negative bacteria (Plate – 25).

From the statistical analysis (Table – 17a), it is proved that the analysis of variance of all the herbal pad dry and micro encapsulation finished samples between groups, within groups, between bacterias, between treatments and both between bacteria and treatments exhibit maximum antibacterial activity against *Staphylococcus aureus* and *Escherichia coli* bacteria. Thus it can be concluded that increase in the antibacterial activity after pad dry and micro encapsulation herbal finishes might be due to the deposition of the herbal extracts on the fabric.

4.6.1.2 Quantitative Antibacterial Activity Assessment by Broth Dilution Method (AATCC 100 – 1998)

The Broth dilution test results of unfinished and herbal pad dry and micro encapsulation finished samples against *Staphylococcus aureus* positive bacteria and *Escherichia coli* negative bacteria are given in the Table – 18 (Plate – 26) and their absorbance values were compared with unfinished sample. Absorbance of the sample is directly proportional to the concentration of the herbal extracts in the sample (Joshi et al., 2009).

TABLE – 18

ABSORBANCE VALUE OF UNFINISHED, HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES AGAINST *Staphylococcus aureus* POSITIVE BACTERIA AND *Escherichia coli* NEGATIVE BACTERIA

S.No.	Samples	Antibacterial activity (Absorbance value OD at 600 nm)			
		Staphylococcus aureus positive bacteria		*Escherichia coli* negative bacteria	
		Absorbance value	Reduction (%)	Absorbance value	Reduction (%)
1.	UF	1.07	0	1.03	0
2.	ALPF	0.32	70.1	0.40	61.16
3.	ALMF	0.20	81.3	0.28	72.81
4.	MAPF	0.62	42.1	0.35	66.02
5.	MAMF	0.32	70.1	0.56	45.63
6.	KUPF	0.68	36.45	0.50	51.46
7.	KUMF	0.24	77.57	0.69	33.01
8.	NEPF	0.49	54.2	0.76	26.21
9.	NEMF	0.52	51.4	0.64	37.86
10.	YAPF	0.22	79.44	0.38	63.10
11.	YAMF	0.17	84.11	0.29	71.84

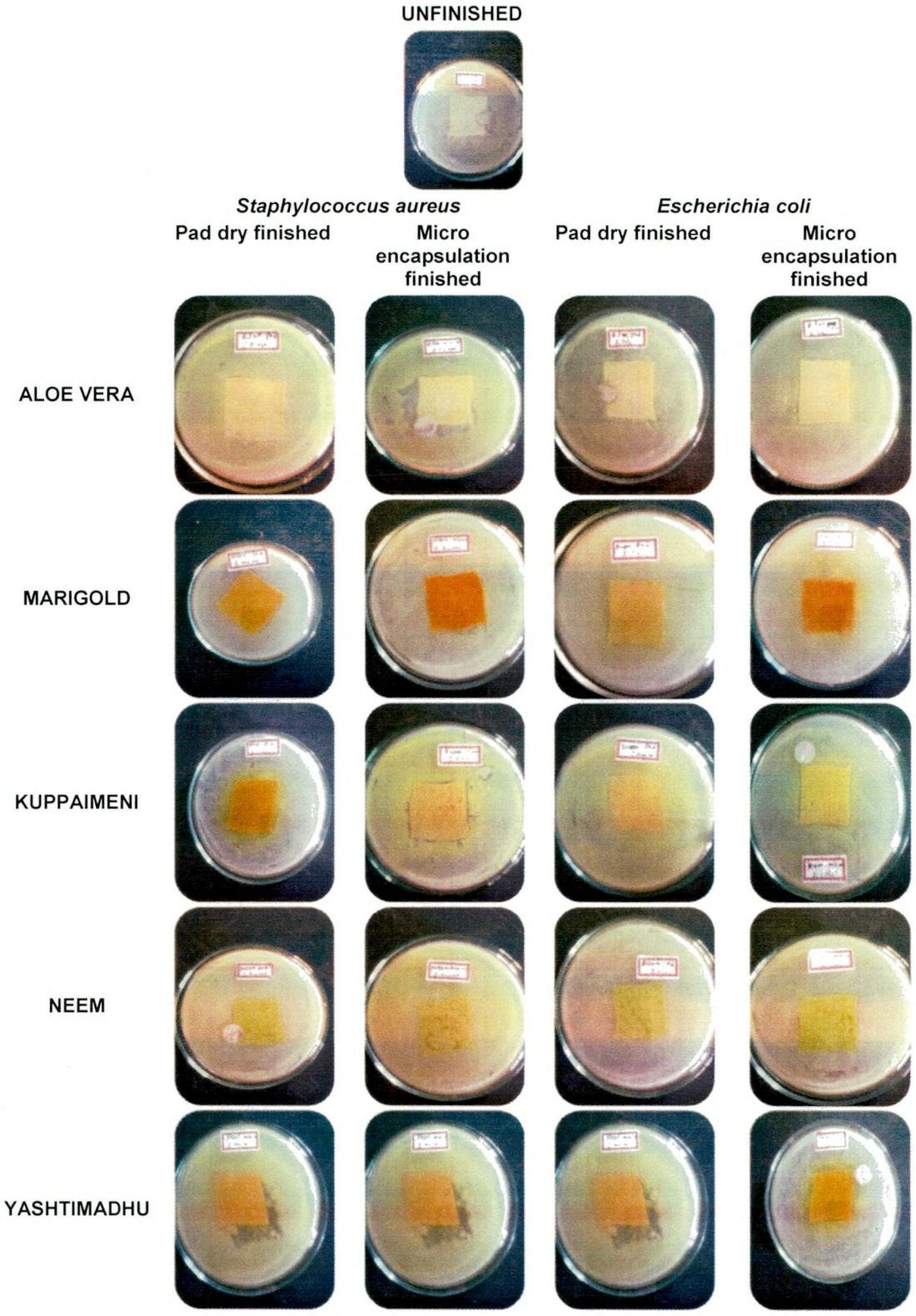


PLATE – 25

ZONE OF INHIBITION OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES AGAINST BACTERIA

TABLE – 18(a)

ANALYSIS OF VARIANCE OF AATCC 100 BROTH DILUTION METHOD

Variables	Aloe vera		Marigold		Kuppaimeni		Neem		Yashtimadhu	
	'F' ratio	Significance	'F' ratio	Significance	'F' ratio	Significance	'F' ratio	Significance	'F' ratio	Significance
Within groups	105.3617		685.1578		645.9039		407.7977		648.5294	
Between groups	355.6211	0.000**	2319.2927	0.000**	2185.8293	0.000**	1376.2683	0.000**	2199.0000	0.000**
Between bacterias	11.2733	0.007**	17.9268	0.002**	193.5366	0.000**	448.1707	0.000**	963.3333	0.000**
Between treatments	881.6460	0.000**	5073.2927	0.000**	4166.7073	0.000**	2952.8049	0.000**	4322.50000	0.000**
Between bacteria and treatments	1.7702	0.220^{NS}	715.9756	0.000**	1201.0976	0.000**	263.7805	0.000**	693.3333	0.000**

** Significant at one per cent level.
NS – Not Significant

The Tables – 18 and 18a clearly depict higher percentage of bacterial reduction in all the herbal finished samples when compared to unfinished sample. The absorbance of the sample is directly proportional to the concentration of the herbal extracts in the sample. The Box Behnken optimized herbal concentration showed high absorbance value against both positive and negative bacterias. The low absorbance value showed the higher percentage of bacterial reduction. The ALMF and YAMF samples clearly showed more than 80 per cent reduction against *Staphylococcus aureus* bacteria and more than 70 per cent reduction against *Escherichia coli* bacteria. The other herbal finished samples showed a minimum reduction of 35 – 55 per cent against positive bacteria and 26 – 65 per cent of reduction against negative bacteria (Plate – 26).

The analysis of variance of all the herbal pad dry and micro encapsulation finished samples between groups, within groups, between bacterias, between treatments is significance at one per cent level. The marigold, kuppaimeni, neem, yashtimadhu finished samples revealed one per cent significance between bacteria and treatments. The 'F' ratio showed the maximum bacterial reduction in between groups and treatments (Table – 18a).

4.6.2 Anti Fungal Activity

4.6.2.1 Qualitative Antifungal Activity Assessment by Agar Diffusion Method (AATCC 30 – 1998)

Table – 19 and Plate – 27 show the diameter of zone formed against *Candida albicans* and *Aspergillus niger* fungi for all the pad and micro encapsulation herbal finished samples.

PLATE – 26

ABSORBANCE VALUE OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES AGAINST BACTERIA

TABLE – 19

ZONE OF INHIBITION OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES AGAINST *Candida albicans* FUNGI AND *Aspergillus niger* FUNGI

S.No.	Samples	Antifungal activity (Zone of inhibition in mm)	
		Candida albicans fungi	*Aspergillus niger* fungi
1.	UF	0	0
2.	ALPF	32 ± 0.3	31 ± 0.3
3.	ALMF	48 ± 0.8	39 ± 0.7
4.	MAPF	35 ± 0.7	29 ± 0.6
5.	MAMF	39 ± 0.1	37 ± 0.3
6.	KUPF	42 ± 0.2	28 ± 0.7
7.	KUMF	65 ± 0.4	36 ± 0.6
8.	NEPF	50 ± 1.1	27 ± 0.2
9.	NEMF	48 ± 0.4	31 ± 0.5
10.	YAPF	25 ± 0.8	30 ± 0.6
11.	YAMF	34 ± 0.4	38 ± 0.3

The results proved that all the herbal finished samples had better fungal activity when compared to unfinished samples. The optimized concentration of all the selected herbal finished samples indicated the maximum zone of inhibition in micro encapsulation finished samples when compared to pad dry finished samples. The samples KUMF and NEPF showed maximum zone of inhibition of 65 mm and 50 mm respectively against *Candida albicans* fungi whereas ALMF and YAMF showed a higher zone of inhibition against *Aspergillus niger* fungi which is shown in Plate – 27. The ALPF sample showed 32 mm and 31 mm of microbial zone against both *Candida* albicans and *Aspergillus niger* fungi respectively as described by Dixon et al. (1998).

From the statistical analysis, it is noted that the analysis of variance of all the herbal pad dry and micro encapsulation finished samples between groups, within groups, between bacterias, between treatments and both in between bacteria and treatments is significant at one per cent level. The yashtimadhu finished sample showed no significant value between bacterias. The 'F' ratio showed the maximum antifungal activity against *Candida albicans* and *Aspergillus niger* fungi between groups and between treatments.

TABLE – 19a

ANALYSIS OF VARIANCE OF AATCC 30 AGAR DIFFUSION METHOD

Variables	Aloe vera		Marigold		Kuppaimeni		Neem		Yashtimadhu	
	'F' ratio	Significance	'F' ratio	Significance	'F' ratio	Significance	'F' ratio	Significance	'F' ratio	Significance
Within groups	919.8869		2862.1665		6670.2554		2511.0345		1986.9868	
Between groups	3123.1409	0.000**	9727.2019	0.000**	22674.0339	0.000**	8533.6387	0.000**	6751.2115	0.000**
Between bacterias	187.4442	0.007**	168.4595	0.002**	9830.4042	0.000**	47229032	0.000**	3.6707	0.084^{NS}
Between treatments	7665.4558	0.000**	24176.9874	0.000**	48545.5802	0.000**	17702.7323	0.000**	16845.3625	0.000**
Between bacteria and treatments	49.6744	0.000**	56.7876	0.000**	3224.3025	0.000**	1269.9129	0.000**	30.8308	0.000**

** Significant at one per cent level.
NS – Not Significant

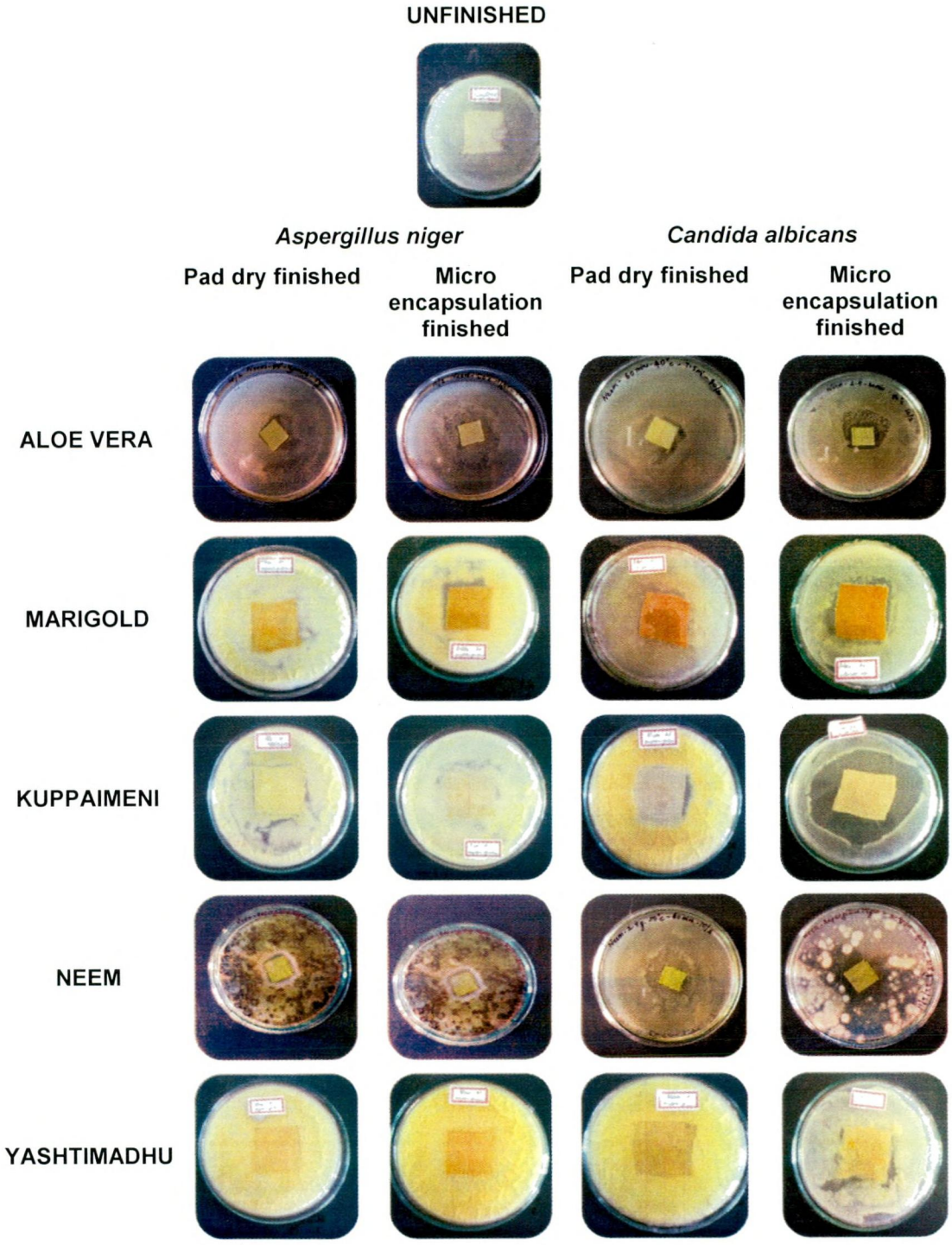


PLATE – 27

ZONE OF INHIBITION OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES AGAINST FUNGI

4.7 SUBJECTIVE EVALUATION

The pad dry and micro encapsulation herbal finished samples were analysed by visual inspection.

4.7.1 Visual Inspection

The visual inspection results of the unfinished and herbal pad dry and micro encapsulation finished samples are presented in the Table – 20.

TABLE – 20

VISUAL INSPECTION OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES

S.No.	Samples	Ratings in Percentage											
		Texture			General appearance			Lustre			Evenness of finishing		
		Fine	Medium	Coarse	Good	Fair	Poor	High	Medium	Dull	Even	Partially even	Uneven
1	UF	93	7	-	89	11	-	90	10	-	91	9	-
2	ALPF	94	6	-	93	7	-	94	6	-	95	5	-
3	ALMF	96	4	-	98	2	-	95	5	-	94	6	-
4	MAPF	95	5	-	94	6	-	94	6	-	94	6	-
5	MAMF	95	5	-	98	2	-	95	5	-	95	5	-
6	KUPF	92	7	-	94	6	-	94	6	-	92	6	2
7	KUMF	95	5	-	95	5	-	94	6	-	95	5	-
8	NEPF	94	6	-	93	7	-	94	6	-	95	5	-
9	NEMF	96	4	-	95	5	-	93	7	-	96	4	-
10	YAPF	94	6	-	96	4	-	94	6	-	96	4	-
11	YAMF	95	5	-	97	3	-	95	5	-	97	3	-

Texture was rated as fine by more than 92 per cent of judges for all the selected pad dry and micro encapsulation herbal finished samples. With regard to general appearance, it was rated as good by more than 93 per cent of judges for pad dry finished sample and 95 per cent for micro encapsulation finished samples. The samples ALMF and MAMF were rated as good by 98 per cent of the judges.

The lustre was ranked as high by more than 93 per cent of judges for all the pad dry and micro encapsulation finished samples. The evenness in finishing was rated as even by more than 92 per cent of judges for all the selected samples. The YAMF sample has the maximum evenness as rated by 97 per cent.

Hence it can be concluded that all the herbal finished samples showed better improvement in texture, general appearance, lustre and evenness after finishing.

4.8 OBJECTIVE EVALUATION

The following results pertaining to the physical, mechanical, comfort, absorbency, durability and functional properties are discussed below.

4.8.1 Tests to Evaluate Physical Properties

The physical properties tests included fabric weight, fabric count and fabric thickness.

4.8.1.1 Fabric Weight

The fabric weight results of unfinished and herbal pad dry and micro encapsulation finished samples are presented in Table – 21 and shown in Figure – 12.

TABLE – 21

FABRIC WEIGHT OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES

S.No.	Samples	Fabric weight (gms/sq.mtr.)	Gain or loss over original weight	Percentage gain or loss over original weight
1.	UF	60	0	0
2.	ALPF	61	+1	+1.6
3.	ALMF	63	+3	+5
4.	MAPF	66	+6	+10
5.	MAMF	69	+9	+15
6.	KUPF	58	-2	-3.3
7.	KUMF	63	+3	+5
8.	NEPF	66	+6	+10
9.	NEMF	67	+7	+11.66
10.	YAPF	63	+3	+5
11.	YAMF	66	+6	+10.0

TABLE – 21(a)

ANALYSIS OF VARIANCE – FABRIC WEIGHT

Source of variance	'F' ratio	'P'value	'CD' value	
Within groups	8.4791		0.05	0.01
Between groups	39.6187**	0.000**		
Between herbs	42.2184**	0.000**	0.85739	1.14144
Between treatments	142.6690**	0.000**	0.66413	0.88416
Between herbs and treatments	12.5563**	0.000**	1.48504	1.97704

** Significant at one per cent level.

Table – 21 and Figure – 12, indicated increase in weight after herbal finish in all the samples except KUPF. The maximum and minimum increase was observed in the samples MAMF and ALPF as 15 and 2 per cent respectively. The KUPF sample showed a decrease of three per cent.The fabric weight has increased with decrease in the treatment time and vise versa. From the statistical analysis (Table – 21a), it was noted that the analysis of variance of all the samples in between herbs, within groups, between treatments and both herbs and treatments is significance at one per cent level. The 142.6690 'F'ratio showed the maximum weight increase in between treatments. Thus it can be concluded that the fabric weight has increased after pad dry and micro encapsulation herbal finish which may be due to the deposition of the herbal extracts on the fabric.

4.8.1.2 Fabric Count

The fabric count results of unfinished and herbal pad dry and micro encapsulation finished samples are depicted in Table – 22 and Figure – 13.

TABLE – 22
FABRIC COUNT OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES

S.No.	Samples	Warp			Weft		
		Fabric count (Ne)	Gain or loss over original count	Percentage gain or loss over original count	Mean value	Gain or loss over original count	Percentage gain or loss over original count
1.	UF	82	-	-	64	-	-
2.	ALPF	80	-2	-2.43	63	-1	-1.56
3.	ALMF	82	0	0	64	0	0
4.	MAPF	79	-3	-3.65	63	-1	-1.56
5.	MAMF	82	0	0	63	-1	-1.56
6.	KUPF	79	-3	-3.65	64	0	0
7.	KUMF	81	-1	-1.21	62	-2	-3.12
8.	NEPF	79	-3	-3.65	61	-3	-4.68
9.	NEMF	82	0	0	61	-3	-4.68
10.	YAPF	80	-2	-2.43	63	-1	-1.56
11.	YAMF	81	-1	-1.21	64	0	0

TABLE – 22 (a)
ANALYSIS OF VARIANCE – FABRIC COUNT

Source of variance	'F' ratio	'P' value	'CD' value	
Within groups	6.8590		0.05	0.01
Between groups	31.5216**	0.000**		
Between herbs	3.2774**	0.017**	0.31645	0.42129
Between treatments	200.9873**	0.000**	0.24512	0.32633
Between herbs and treatments	3.2774**	0.004**	0.54810	0.72969

** Significant at one per cent level.

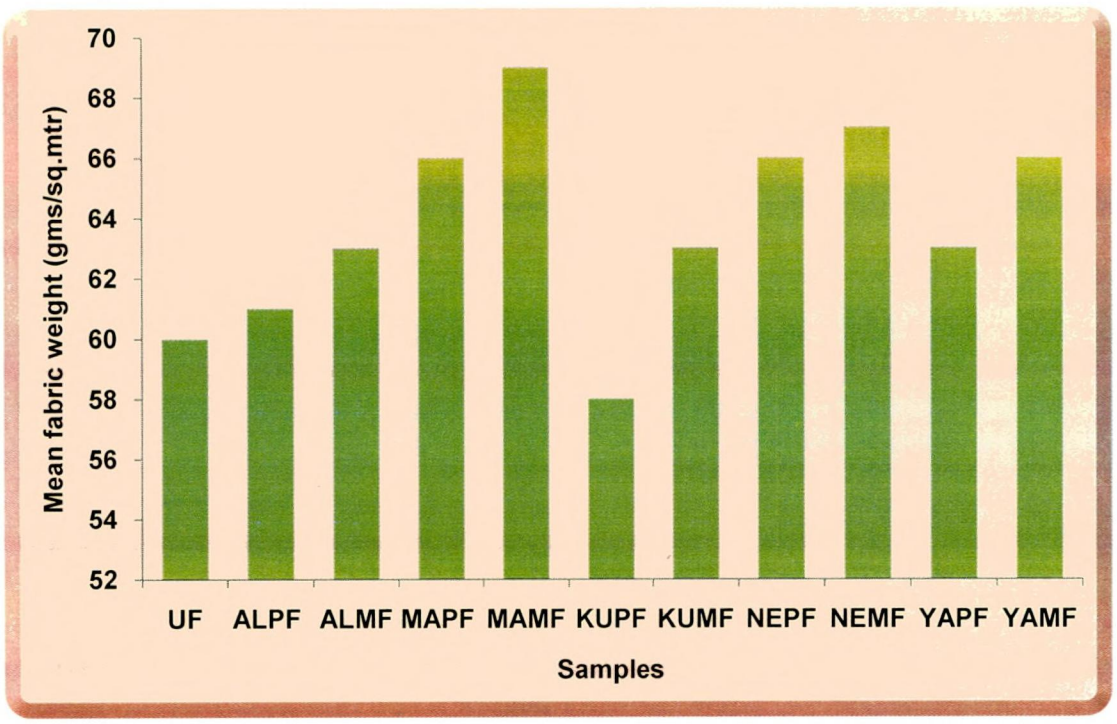


FIGURE – 12

FABRIC WEIGHT OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES

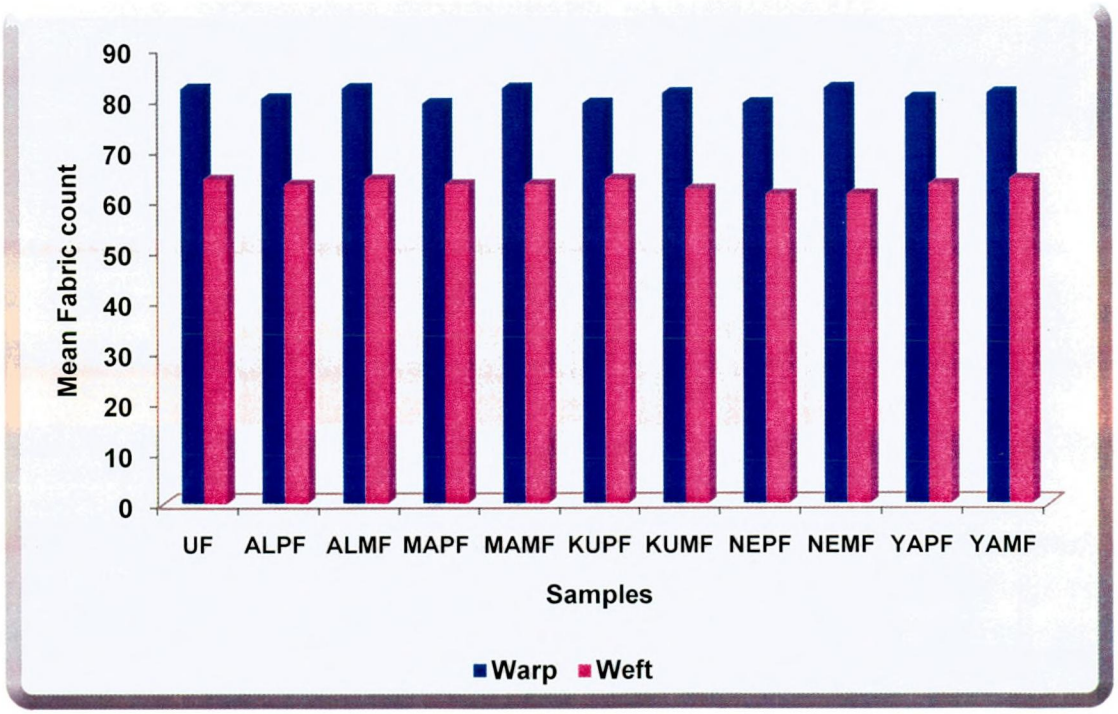


FIGURE – 13

FABRIC COUNT OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES

As per Table – 22 and Figure – 13, it is evident that when compared to unfinished fabric the count of the finished fabric got reduced. The ends per inch were greater than picks per inch which indicated the compact alignment of the warp yarns compared to weft. Greater number of ends per unit area attribute to many important functional properties like drapebility, servieceability, durability, strength and cloth balance. Samples ALMF, MAMF and NEMF revealed the same fabric count as the unfinished. The maximum reduction was seen in the samples MAPF, KUPF and NEPF as 3.65 per cent respectively.This may be due to the swelling of yarns as a resultant of high absorption of the herbal extract, the yarns became coarser thus reducing the number of threads per unit area. From the statistical analysis (Table - 22a), it was noted that the analysis of variance of all the samples in between groups, between treatments and both herbs and treatments is significant at one per cent level. The 200.9873 'F' ratio showed the maximum count decrease in between treatments.

4.8.1.3 Fabric Thickness

The results of fabric thickness of unfinished and herbal pad dry and micro encapsulation finished samples are presented in Table–23 and shown in Figure – 14.

TABLE – 23
FABRIC THICKNESS OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES

S.No.	Samples	Fabric thickness (mm)	Gain or loss over original thickness	Percentage gain or loss over original thickness
1.	UF	0.21	0	0
2.	ALPF	0.22	+0.01	+4.76
3.	ALMF	0.23	+0.02	+9.52
4.	MAPF	0.22	+0.01	+4.76
5.	MAMF	0.23	+0.02	+9.52
6.	KUPF	0.20	-0.01	-4.76
7.	KUMF	0.24	+0.03	+14.28
8.	NEPF	0.23	+0.02	+9.52
9.	NEMF	0.24	+0.03	+14.28
10.	YAPF	0.22	+0.01	+4.76
11.	YAMF	0.23	+0.02	+9.52

TABLE – 23(a)
ANALYSIS OF VARIANCE – FABRIC THICKNESS

Source of variance	'F' ratio	P' value	'CD' value	
Within groups	4.8894		0.05	0.01
Between groups	18.8312**	0.000**		
Between herbs	9.0909**	0.000**	0.00443	0.00590
Between treatments	101.8182**	0.000**	0.00343	0.00457
Between herbs and treatments	2.9545**	0.008**	0.00767	0.01021

** Significant at one per cent level.

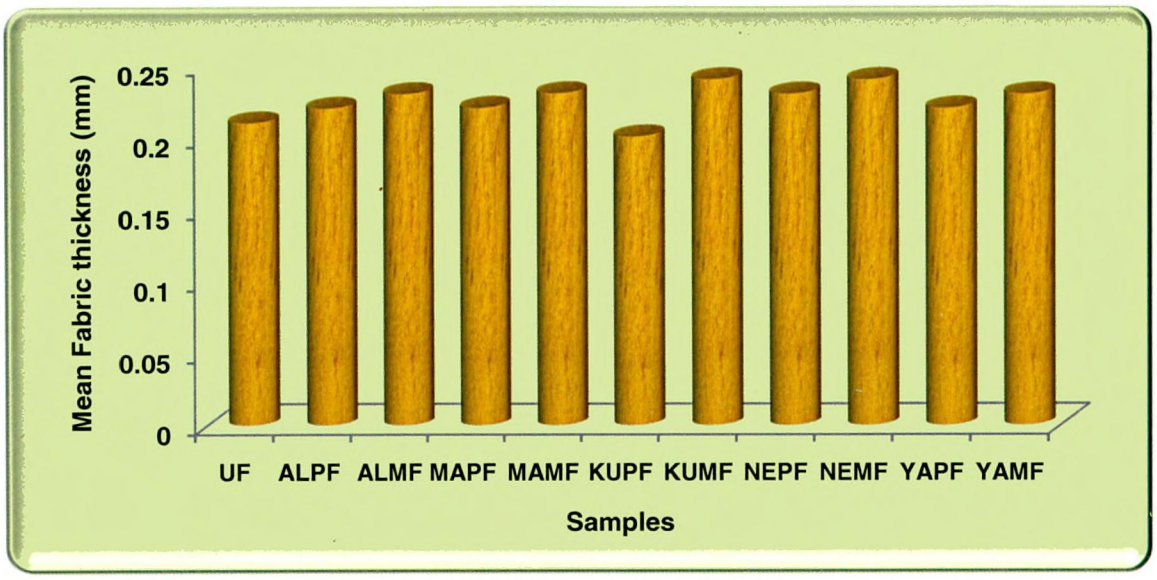


FIGURE – 14
FABRIC THICKNESS OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES

From Table – 23 and Figure – 14, it is interesting to note that all finished samples showed a minimum increase in thickness when compared to the original, except KUPF which exhibited a minimum decrease of 4.76 per cent. The sample NEMF and KUMF showed the maximum increase of 14.28 per cent. The Table – 23a, statistical analysis of 'F' ratio proveed one per cent significance in between groups, between herbs and treatments separately and between both. The increase in thickness indicated the consolidation of the fabric due to deposition of herbal extracts which was varied with treatment time as highlighted by Ferri et al. (2012). During the micro encapsulation finishing treatment, the fabric under goes a kind of physical friction between fabric to fabric and fabric to equipment, therefore there has been slight increase in the fabric thickness compared to control.

4.8.2 Tests to Evaluate Mechanical Properties

The results pertaining to the mechanical properties namely fabric tensile strength, elongation in the warp and weft direction and abrasion resistance are presented in the given tables.

4.8.2.1 Fabric Tensile Strength – Warp

The warp tensile strength of the unfinished and herbal pad dry and micro encapsulation finished samples are reported in Table – 24 and Figure – 15

TABLE – 24

TENSILE STRENGTH OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES – WARP

S.No.	Samples	Breaking force (kgf)	Gain or loss over original tensile strength	Percentage gain or loss over original tensile strength
1.	UF	27.05	-	-
2.	ALPF	31.03	+3.98	+14.71
3.	ALMF	31.8	+4.75	+17.56
4.	MAPF	26.13	-0.92	-3.40
5.	MAMF	31.31	+4.26	+15.74
6.	KUPF	22.91	-4.14	-15.30
7.	KUMF	27.30	+0.25	+0.92
8.	NEPF	32.18	+5.13	+18.96
9.	NEMF	23.17	-3.88	-14.34
10.	YAPF	31.59	+4.54	+16.78
11.	YAMF	33.89	+6.84	+25.28

TABLE – 24(a)

ANALYSIS OF VARIANCE – TENSILE STRENGTH (WARP)

Source of variance	'F' ratio	'P' value	'CD' value	
Within groups	8.8137		**0.05**	**0.01**
Between groups	42.5572**	0.000**		
Between herbs	47.2773**	0.000**	0.83341	1.10953
Between treatments	30.3976**	0.000**	0.64556	0.85944
Between herbs and treatments	43.2370**	0.000**	1.44352	1.92176

** Significant at one per cent level.

The tensile strength (Table – 24 and Figure – 15) in warp direction of sample YAMF showed the maximum increase among the finished sample with 25.28 per cent whereas minimum increase was observed in the sample KUMF as 0.92 per cent. Reduction in tensile strength was observed to be maximum in sample KUPF with 15.30 per cent and minimum in sample MAPF as 3.4 per cent. The tensile strength of the herbal finished fabric increased because of the surface deposition of the finish, as highlighted by Aggarwal et al. (2007). The reduction may be attributed to cross linking reactions, increased temperature and time as revealed by Wasif and Laga (2009). The statistical analysis indicated in the Table – 24a proves significance at one per cent level for breaking strength in between the groups, herbs, both herbs and treatments. Thus it was concluded that the fabric strength had increased after finishing in the warp direction.

4.8.2.2 Fabric Tensile Strength – Weft

The weft direction of fabric strength of unfinished and herbal pad dry and micro encapsulation finished samples are presented in the Table – 25 and Figure – 16.

TABLE – 25
TENSILE STRENGTH OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES – WEFT

S.No.	Samples	Breaking force (kgf)	Gain or loss over original tensile strength	Percentage gain or loss over original tensile strength
1.	UF	25.01	-	-
2.	ALPF	18.37	-6.64	-26.54
3.	ALMF	18.44	-6.57	-26.26
4.	MAPF	14.82	-10.19	-40.74
5.	MAMF	15.69	-9.32	-37.26
6.	KUPF	21.31	-3.7	-14.79
7.	KUMF	22.47	-2.54	-10.15
8.	NEPF	14.54	-10.47	-41.86
9.	NEMF	15.93	-9.08	-36.30
10.	YAPF	15.40	-9.61	-38.42
11.	YAMF	17.22	-7.79	-31.14

TABLE – 25(a)

ANALYSIS OF VARIANCE – TENSILE STRENGTH (WEFT)

Source of variance	'F' ratio	'P' value	'CD' value	
Within groups	19.5324		**0.05**	**0.01**
Between groups	98.9763**	0.000**		
Between herbs	56.3586**	0.000**	0.70722	0.94152
Between treatments	521.4916**	0.000**	0.54781	0.72930
Between herbs and treatments	14.6563**	0.000**	1.22494	1.63076

** Significant at one per cent level.

From the Table – 24 and Figure – 16, it was evident that the tensile strength of herbal finished samples were decreased in the weft direction. This is due to stretch in weft direction during chemical processing and consequent strain hardening at higher concentration.The maximum loss of 41.86 per cent was observed in NEPF and minimum of 10.15 per cent in KUMF sample. The 'F' ratio of 521.4916 showed that the maximum decrease of strength in between the treatments in the weft direction, which is also confirmed by Aly et al. (2004). All the pad dry and micro encapsulation herbal finished fabrics showed very minor changes in strength, as narrated by Sathiyanarayanan et al (2010).The statistical analysis of 'F' values proved that there was one per cent significance when compared between the treatments and herbs separately and between the groups (Table – 25a). This reduction might be attributed to method of application and cross linking reaction, as stated by Karolia and Mandapara (2007). Thus it can be concluded that the fabric strength decreased after herbal finishing in the weft direction.

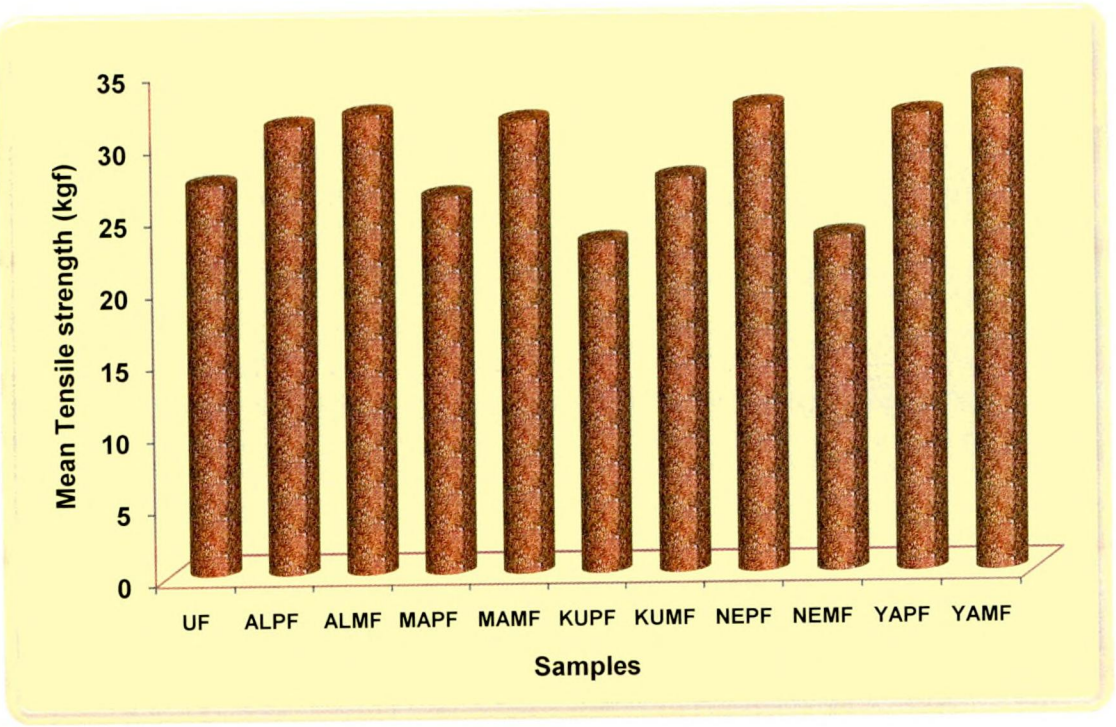


FIGURE – 15

TENSILE STRENGTH OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES – WARP

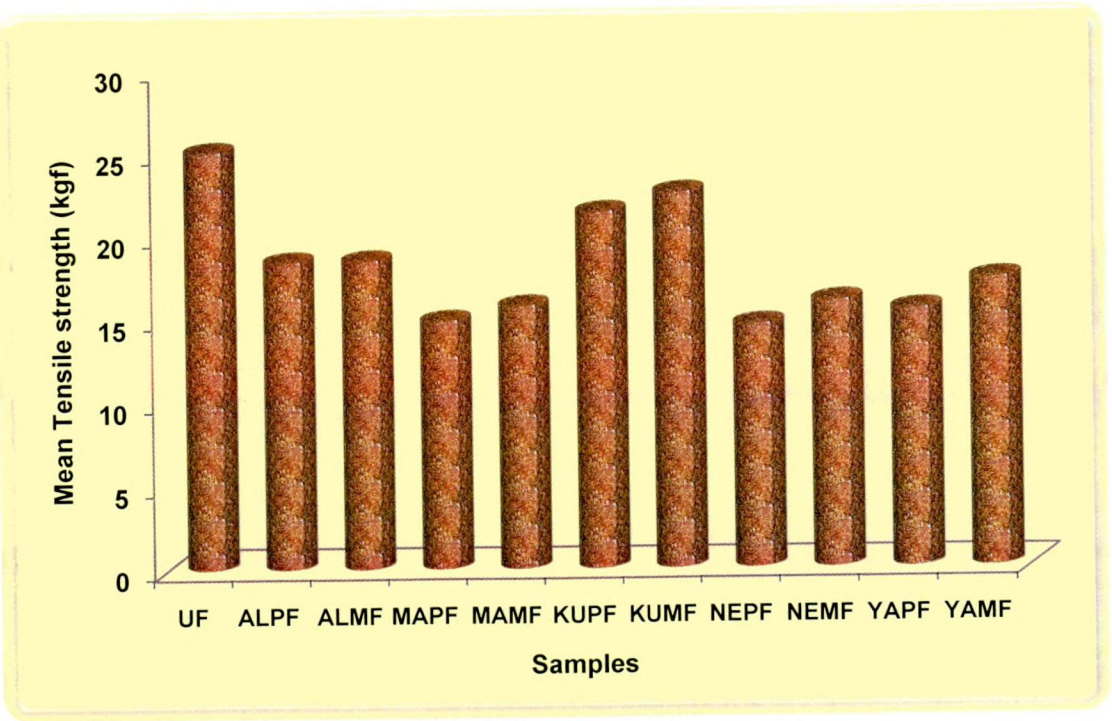


FIGURE – 16

TENSILE STRENGTH OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES – WEFT

4.8.2.3 Fabric Elongation – Warp

The fabric elongation of unfinished and herbal pad dry and micro encapsulation finished samples in warp direction are depicted in the Table – 26 and Figure – 17.

TABLE – 26
ELONGATION OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES – WARP

S.No.	Samples	Elongation (mm)	Gain or loss over original elongation	Percentage gain or loss over original elongation
1.	UF	16.4	-	-
2.	ALPF	12.6	-3.8	-23.17
3.	ALMF	12.65	-3.75	-22.86
4.	MAPF	13.70	-02.7	-16.46
5.	MAMF	12.50	-3.9	-23.78
6.	KUPF	9.30	-7.1	-43.29
7.	KUMF	11.35	-5.05	-30.79
8.	NEPF	13.85	-2.55	-15.54
9.	NEMF	12.10	-4.3	-26.21
10.	YAPF	14.65	-1.75	-10.67
11.	YAMF	13.80	-2.6	-15.85

TABLE – 26(a)
ANALYSIS OF VARIANCE – ELONGATION (WARP)

Source of variance	'F' ratio	'P' value	'CD' value	
Within groups	7.0471		**0.05**	**0.01**
Between groups	33.1004**	0.000**		
Between herbs	18.6212**	0.000**	0.62648	0.83404
Between treatments	160.7537**	0.000**	0.48527	0.64604
Between herbs and treatments	8.4267**	0.000**	1.08510	1.44460

** Significant at one per cent level.

All herbal finished samples in the warp direction showed reduction in elongation when compared with unfinished sample. From the Table – 26, it is clear that the sample YAPF showed a minimum decrease of 10.67 per cent whereas sample KUPF showed maximum decrease in elongation by 43.29 per cent which may be due to higher concentration. From the statistical analysis it was noted that there was one per cent significance, when comparing between the groups, between the herbs separately and between both herbs and treatments. Thus it was concluded that the fabric elongation had decreased in the warp direction after finishing (Table – 26a).

4.8.2.4 Fabric Elongation – Weft

The results of the fabric elongation in the weft direction of unfinished and herbal pad dry and micro encapsulation finished samples are presented in the Table – 27 and Figure – 18.

TABLE – 27
ELONGATION OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES – WEFT

S.No.	Samples	Elongation (mm)	Gain or loss over original elongation	Percentage gain or loss over original elongation
1.	UF	9.5	-	-
2.	ALPF	13.05	+3.35	+37.36
3.	ALMF	13.30	+3.80	+40.00
4.	MAPF	13.55	+4.05	+42.63
5.	MAMF	13.90	+4.4	+46.31
6.	KUPF	16.15	+6.65	+70.00
7.	KUMF	14.95	+5.45	+57.36
8.	NEPF	13.65	+4.15	+43.68
9.	NEMF	13.75	+4.25	+44.73
10.	YAPF	13.20	+3.7	+38.94
11.	YAMF	14.75	+5.25	+55.26

TABLE – 27(a)
ANALYSIS OF VARIANCE – ELONGATION (WEFT)

Source of variance	'F' ratio	'P' value	'CD' value	
Within groups	32.3513		**0.05**	**0.01**
Between groups	164.6660**	0.000**		
Between herbs	31.7744**	0.000**	0.29873	0.39770
Between treatments	1028.6438**	0.000**	0.23140	0.30806
Between herbs and treatments	15.1174**	0.000**	0.51742	0.68884

** Significant at one per cent level.

Table – 27 and Figure – 18, reveal the fact that there was an increase in the elongation of all the samples in the weft direction after treatment. Sample KUPF showed a maximum increase of 70 per cent whereas sample ALPF indicated minimum increase with 37.36 per cent. This differential trend in warp and weft directions is due to the stretching of warp direction and relatively less tension in weft direction during finishing, as narrated by Viswanath and Ramachandran (2010). The 'F' ratio of statistical analysis represents one per cent significance difference in between the groups, between the herbs, treatments separately and both of them. In between the treatments of 'F' ratio 1028.6438 showed the maximum increase of elongation in the weft direction. This proved the enhancement of the micro encapsulated herbal finish on the fabric (Table – 27a).

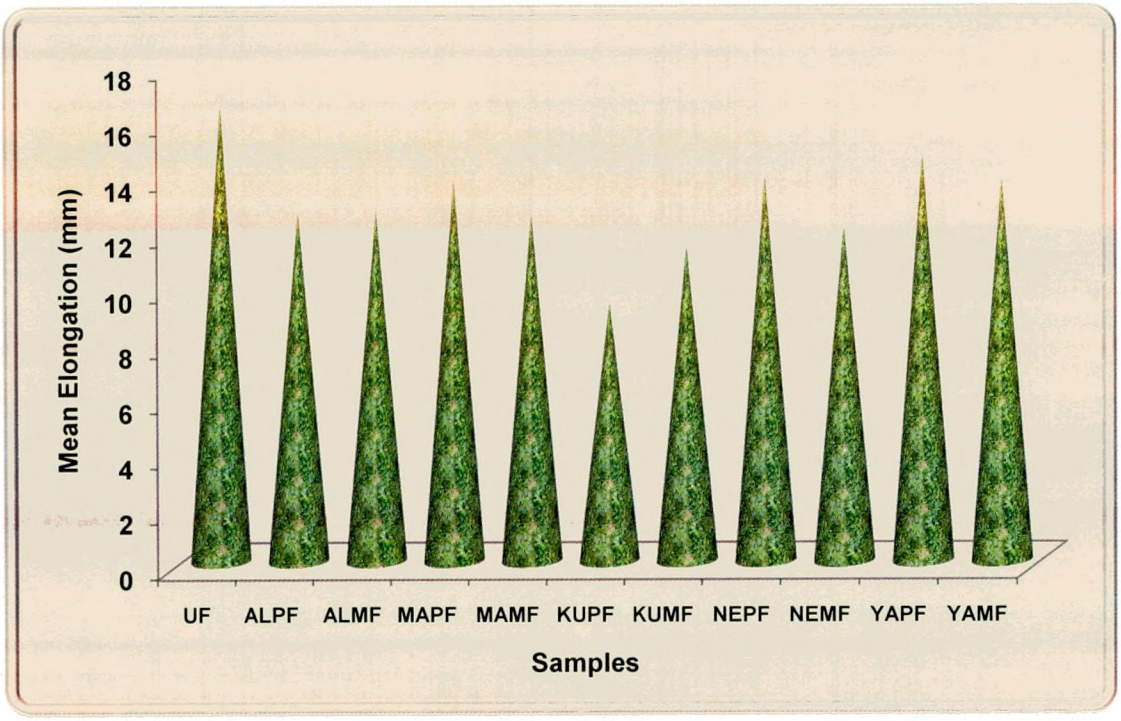


FIGURE – 17

ELONGATION OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES – WARP

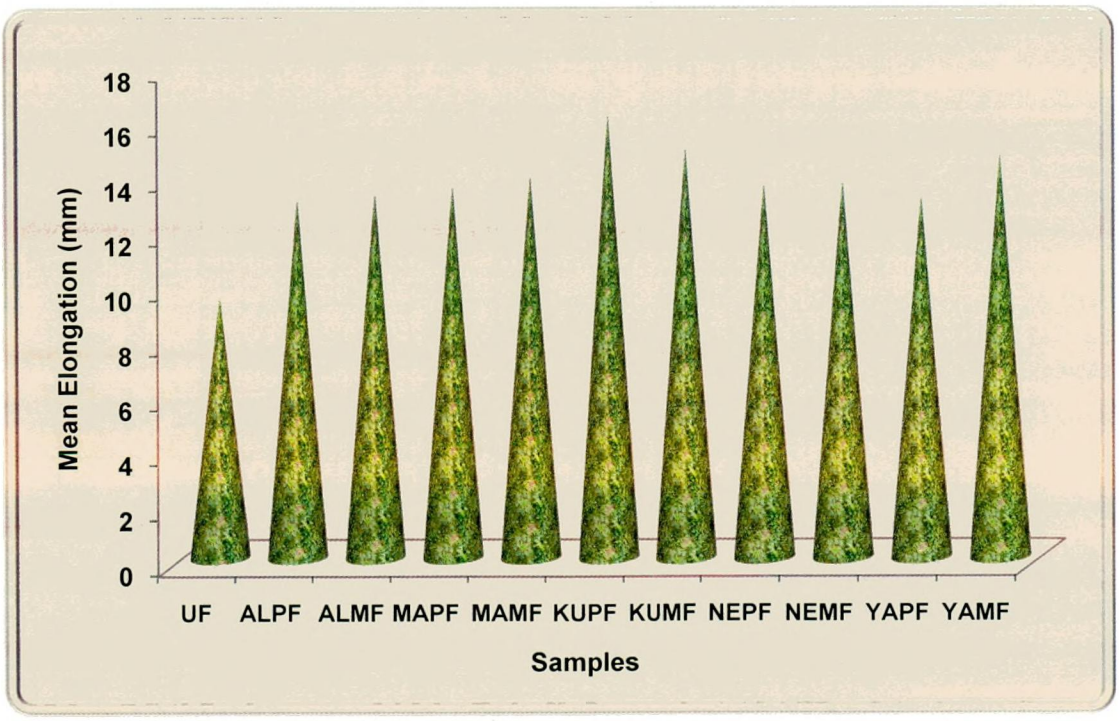


FIGURE – 18

ELONGATION OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES – WEFT

4.8.2.5 Abrasion Resistance

The abrasion resistance of unfinished and herbal pad dry and micro encapsulation finished samples are illustrated in the Table – 28 and Figure – 19.

TABLE – 28
ABRASION RESISTANCE OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES

S.No.	Samples	Abrasion resistance (gms)	Gain or loss over original abrasion resistance	Percentage gain or loss over original abrasion resistance
1.	UF	97.92	-	-
2.	ALPF	96.22	-1.7	-1.73
3.	ALMF	96.79	-1.13	-1.15
4.	MAPF	97.85	-0.07	-0.07
5.	MAMF	97.84	-0.08	-0.08
6.	KUPF	93.19	-4.73	-4.83
7.	KUMF	94.60	-3.32	-3.39
8.	NEPF	97.43	-0.49	-0.50
9.	NEMF	97.99	+0.07	+0.07
10.	YAPF	97.51	-0.41	-0.41
11.	YAMF	97.23	-0.69	-0.70

TABLE – 28(a)
ANALYSIS OF VARIANCE – ABRASION RESISTANCE

Source of variance	'F' ratio	'P' value	'CD' value	
Within groups	2.1952		**0.05**	**0.01**
Between groups	13.9614**	0.000**		
Between herbs	29.0802**	0.000**	0.80489	1.06541
Between treatments	2.5040 ^{NS}	0.117^{NS}	0.46470	0.61511
Between herbs and treatments	1.1340 ^{NS}	0.348^{NS}	1.13828	1.50672

** Significant at one per cent level., NS – Not Significant

The Table – 28 and Figure – 19 clearly portrays the minimum gain of 0.07 per cent by sample NEMF whereas all the other herbal finished samples show a reduction in weight after abrasion depicting the hydrolysis of cellulose, breaking of fibers on mechanical agitation during finishing process, where in the yarns became more finer and pliable.The unfinished sample showed greater resistance to abrasion.This may be due to the presence of sizeing materials that formed a thin filim on the surface. From the statistical analysis it was noted that there is a significance of one per cent difference in between the groups, herbs separately, but not significant between both herbs and treatments (Table – 28a).

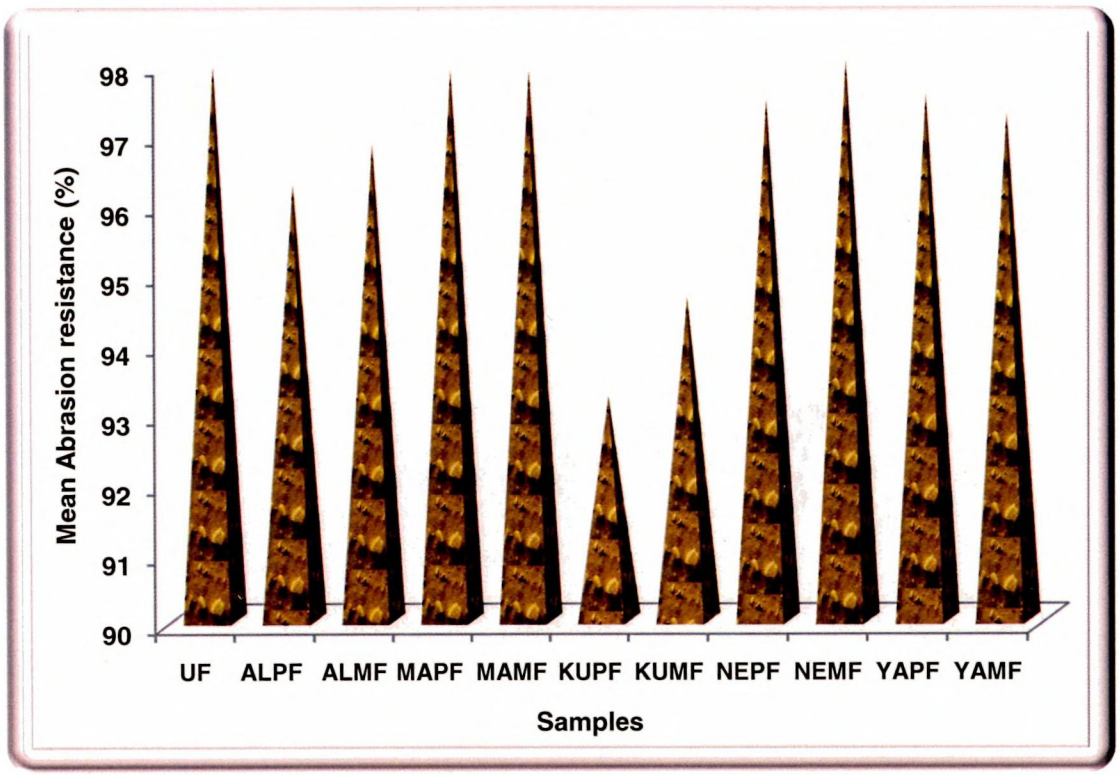


FIGURE – 19

ABRASION RESISTANCE OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES

Hence, it could be concluded that decrease in weight loss was shown by all herbal finished samples indicating improved abrasion resistance due to herbal antimicrobial finishing.

4.8.3 Tests to Evaluate Comfort Properties

The results pertaining to the comfort properties namely fabric stiffness in the warp and weft direction, fabric drape, air permeability are discussed and presented.

4.8.3.1 Fabric Stiffness – Warp

The results of fabric stiffness in warp direction of unfinished and herbal pad dry and micro encapsulation finished samples are depicted in the Table – 29 and Figure – 20.

TABLE – 29
FABRIC STIFFNESS OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES – WARP

S.No.	Samples	Fabric stiffness (cms)	Gain or loss over original stiffness	Percentage gain or loss over original stiffness
1.	UF	1.13	-	-
2.	ALPF	2.77	+1.64	+145.13
3.	ALMF	1.55	+0.42	+37.16
4.	MAPF	1.47	+0.34	+30.08
5.	MAMF	1.94	+0.81	+71.68
6.	KUPF	1.56	+0.43	+38.05
7.	KUMF	1.39	+0.26	+23.00
8.	NEPF	2.56	+1.43	+126.54
9.	NEMF	2.48	+1.35	+119.46
10.	YAPF	1.37	+0.24	+21.23
11.	YAMF	2.56	+1.43	+126.54

TABLE – 29(a)
ANALYSIS OF VARIANCE – FABRIC STIFFNESS (WARP)

Source of variance	'F' ratio	'P' value	'CD' value	
Within groups	9.7636		**0.05**	**0.01**
Between groups	96.0354**	0.000**		
Between herbs	128.9322**	0.000**	0.12268	0.16238
Between treatments	0.8265 ^{NS}	0.0365^{NS}	0.07083	0.09375
Between herbs and treatments	82.1804**	0.000**	0.17349	0.22965

** Significant at one per cent level., NS – Not Significant

As shown in Table – 29 and Figure – 20, the sample YAPF had the minimum increase of 21 per cent and ALPF had the maximum increase in fabric stiffness as 145 per cent respectively in the warp direction. This increase may be due to the higher concentration of the herbal extracts, as revealed by Wasif and Laga (2009). From the statistical analysis of 'F' value, it is noted that there was one per cent significance in between the groups, herbs separately and between both. The 'F' ratio of 128.9322 (Table – 29a) represented the maximum stiffness in between the herbal extracts, because of the characteristics and nature of the herbal extracts deposited on the fabric surface. Thus it was concluded that there is an increase in the fabric stiffness after finishing in the warp direction.

4.8.3.2 Fabric Stiffness – Weft

The results of fabric stiffness in weft direction of unfinished and herbal pad dry and micro encapsulation finished samples are illustrated in the Table – 30 and Figure – 21.

TABLE – 30

FABRIC STIFFNESS OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES – WEFT

S.No.	Samples	Fabric stiffness (cms)	Gain or loss over original stiffness	Percentage gain or loss over original stiffness
1.	UF	1.22	-	-
2.	ALPF	2.32	+1.10	+90.16
3.	ALMF	1.10	-0.12	-9.83
4.	MAPF	1.69	+0.47	+38.52
5.	MAMF	1.18	-0.04	-3.27
6.	KUPF	1.63	+0.41	+33.60
7.	KUMF	0.91	-0.31	-25.40
8.	NEPF	1.19	-0.03	-2.45
9.	NEMF	1.54	+0.32	+26.22
10.	YAPF	0.99	-0.23	-18.85
11.	YAMF	1.36	+0.14	+11.47

TABLE – 30(a)

ANALYSIS OF VARIANCE – FABRIC STIFFNESS (WEFT)

Source of variance	'F' ratio	'P' value	'CD' value	
Within groups	7.6234		**0.05**	**0.01**
Between groups	72.2439**	0.000**		
Between herbs	36.8932**	0.000**	0.08984	0.11892
Between treatments	120.1768**	0.000**	0.05187	0.06866
Between herbs and treatments	98.081**	0.000**	0.12705	0.16818

** Significant at one per cent level.

It is evident from the Table – 30 and Figure – 21 that the fabric stiffness of the herbal finished samples ALPF, MAPF, KUPF, NEMF and YAMF in weft direction was increased. The maximum increase in fabric stiffness was observed to be 90 per cent in ALPF sample and minimum in YAMF sample by 11 per cent. The rest of the samples showed decrease in stiffness. This mixed variation in the results could be because of the mechanical deposition of finishing agents in the open interstices of the fabric or due to cross linking reaction which made the structure more rigid. The statistical analysis (Table – 30a) clearly showed the difference between the groups, herbs, treatments separately and between both herbs and treatments of finished samples in the weft direction. These results are significant at one per cent level. The significance was maximum for the pad dry and micro encapsulation methods. Thus it could be concluded that stiffness in weft direction increased after finishing.

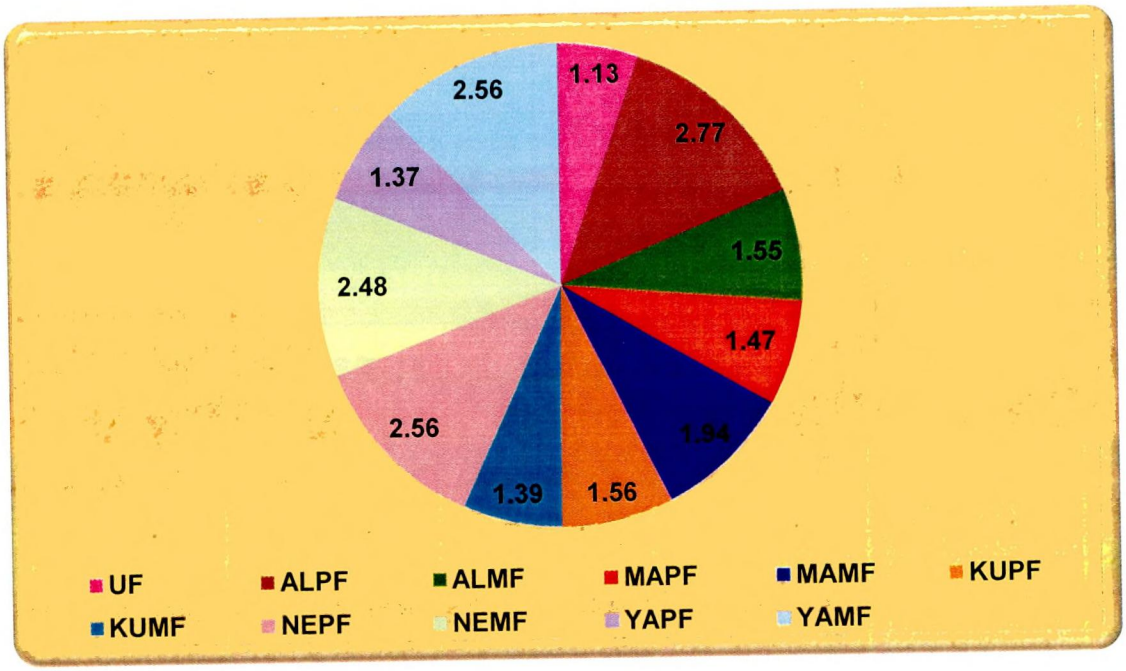


FIGURE – 20

FABRIC STIFFNESS OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES – WARP

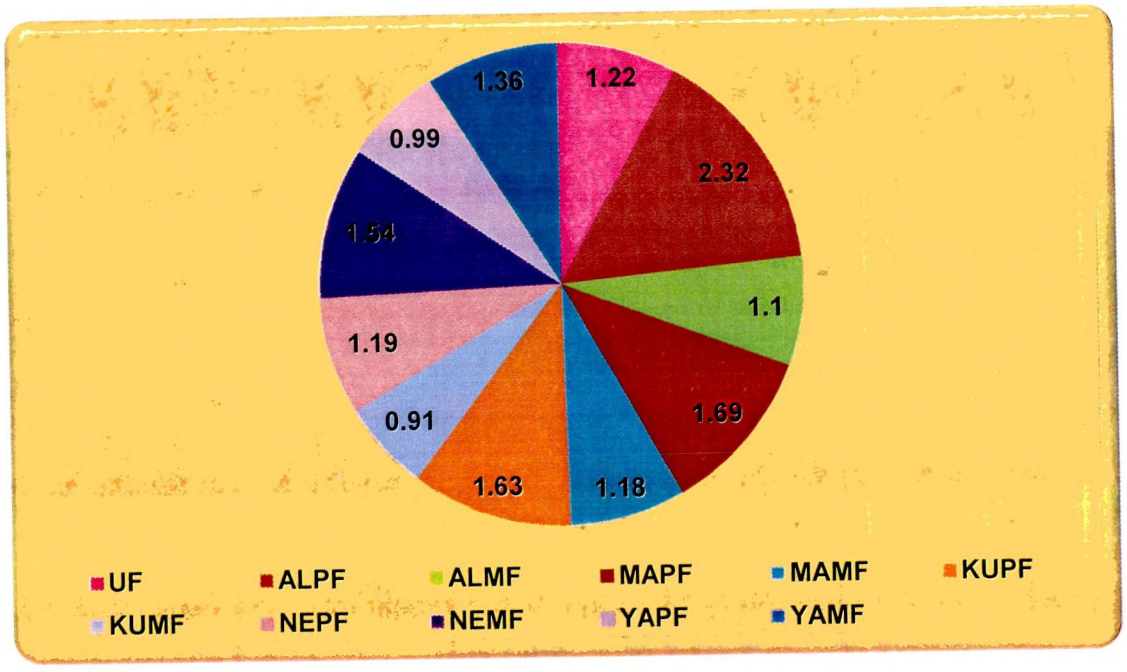


FIGURE – 21

FABRIC STIFFNESS OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES – WEFT

4.8.3.3 Fabric Drape

The drapability of the unfinished and herbal pad dry and micro encapsulation finished samples are depicted in the Table – 31 and Figure – 22.

TABLE – 31

FABRIC DRAPE OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES

S.No.	Samples	Drape co-efficient (%)	Gain or loss over original drape coefficient	Percentage gain or loss over original drape coefficient
1.	UF	0.54	-	-
2.	ALPF	0.68	+0.14	+25.92
3.	ALMF	0.56	+0.02	+3.70
4.	MAPF	0.59	+0.05	+9.25
5.	MAMF	0.66	+0.12	+22.22
6.	KUPF	0.44	-0.10	-18.51
7.	KUMF	0.59	+0.05	+9.25
8.	NEPF	0.46	-0.08	-14.81
9.	NEMF	0.61	+0.07	+12.96
10.	YAPF	0.52	-0.02	-3.70
11.	YAMF	0.64	+0.10	+18.51

TABLE – 31(a)

ANALYSIS OF VARIANCE – FABRIC DRAPE

Source of variance	'F' ratio	'P' value	'CD' value	
Within groups	211.9865		**0.05**	**0.01**
Between groups	2283.5204**	0.000**		
Between herbs	1647.4883**	0.000**	0.00317	0.00419
Between treatments	3967.4250**	0.000**	0.00183	0.00242
Between herbs and treatments	2582.7715**	0.000**	0.00448	0.00593

**. Significant at one per cent level.

The drape coefficient of samples YAPF, NEPF and KUPF was decreased, whereas all other samples showed increase. The maximum decrease was seen in sample KUPF as 18.51per cent and the maximum increase was seen in sample ALPF as 25.92 per cent. The KUMF, ALMF, NEMF, MAMF and MAPF had better drapability than other samples after antimicrobial herbal finishing treatment.

Statistical analysis indicated that the drapability of samples between the groups, herbs, treatments and both the herbs and treatments were significant at one per cent level. To conclude that the drapability of the fabric showed an increase depending upon the herbal extract finishing method (Table – 31a).

4.8.3.4 Air Permeability

The air permeability results of unfinished and herbal pad dry and micro encapsulation finished samples are presented in the Table – 32 and Figure – 23.

TABLE – 32
AIR PERMEABILITY OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES

S.No.	Samples	Air permiability (cm^3 / cm^2/ sec)	Gain or loss over original air permeability	Percentage gain or loss over original air permeability
1.	UF	67.30	-	-
2.	ALPF	75.44	+8.14	+12.09
3.	ALMF	84.64	+17.34	+25.76
4.	MAPF	63.40	-3.90	-5.79
5.	MAMF	60.70	-6.60	-9.80
6.	KUPF	71.08	+3.78	+5.616
7.	KUMF	70.84	+3.54	+5.260
8.	NEPF	57.72	-9.58	-14.23
9.	NEMF	57.22	-10.08	-14.97
10.	YAPF	63.54	-3.76	-5.58
11.	YAMF	67.38	+0.08	+0.118

TABLE – 32(a)
ANALYSIS OF VARIANCE – AIR PERMEABILITY

Source of variance	'F' ratio	'P' value	'CD' value	
Within groups	12.3552		**0.05**	**0.01**
Between groups	123.2921**	0.000**		
Between herbs	249.2578**	0.000**	1.38416	1.83218
Between treatments	15.7823**	0.000**	0.79914	1.05781
Between herbs and treatments	18.8285**	0.000**	1.95750	2.59109

** Significant at one per cent level.

From the Table – 32 and Figure – 23, it is evident that the air permeability of antimicrobial herbal finished samples was affected. The aloe vera and kuppaimeni herbal finished samples showed an increase in air permeability whereas marigold, neem and yashtimadhu showed a decrease, irrespective of the method of application. This result is in line, with the works of Sarkar et al. (2003). The air permeability of unfinished sample was higher than finished samples. The maximum and minimum increase was observed in samples ALMF and YAMF as 25.76 and 0.118 per cent .

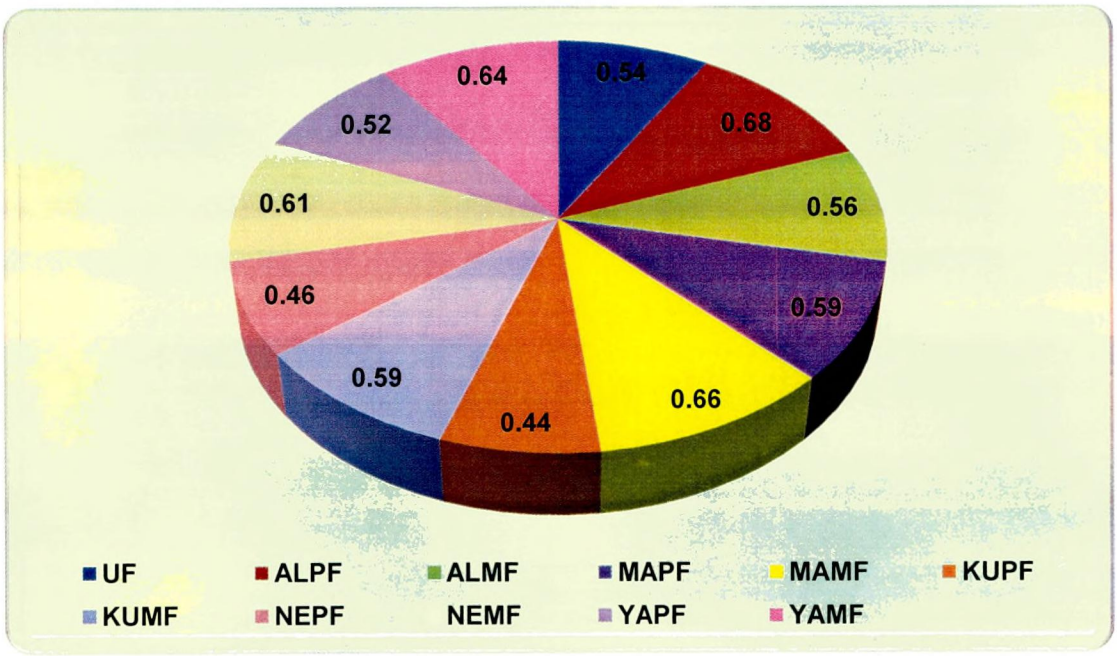


FIGURE – 22

FABRIC DRAPE OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES

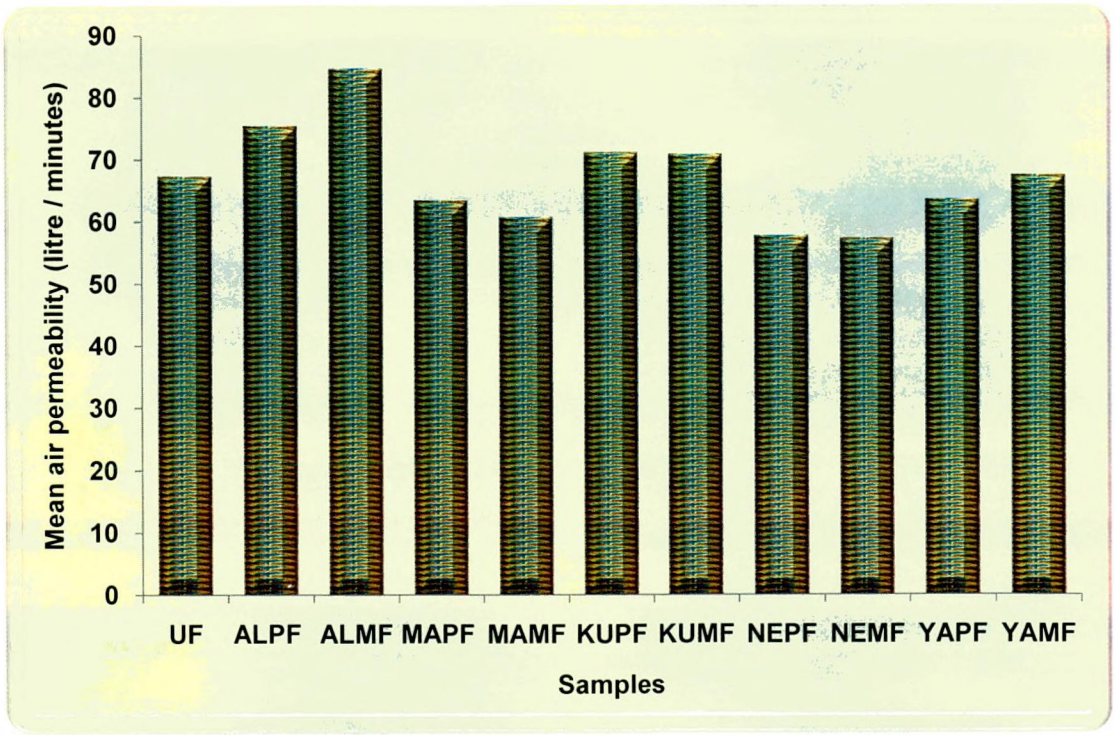


FIGURE – 23

AIR PERMEABILITY OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES

respectively. The results showed a mixed trend. The reason for this result could be closing of open interstices due to mechanical deposition of the finish, as quoted by Karolia and Mendapara (2007).This also indicated the correlation between fabric count which decreased improving the air permeability. The drop in the air flow explains that the fabrics were consolidated after treatment, as described by Dent (1976). From the statistical analysis (Table – 32a), it is concluded that there was a one per cent significance when compared between the groups, treatments, herbs separately and between both. Hence it could be stated that the antimicrobial finish increased or decreased air permeability depending upon the type of herbs used.

4.8.4 Tests to Evaluate Absorbency Properties

The results of the absorbency property tests namely drop and wickability test are discussed below.

4.8.4.1 Drop Test

The results of the unfinished and herbal pad dry and micro encapsulation finished samples of the drop test is given in Table – 33 and Figure – 24.

TABLE – 33

DROP TEST OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES

S.No.	Samples	Absorbency (Time in seconds)	Gain or loss over original drop test	Percentage gain or loss over original drop test
1.	UF	12.04	-	-
2.	ALPF	14.16	+2.12	+17.60
3.	ALMF	16.60	+4.56	+37.87
4.	MAPF	13.28	+1.24	+10.29
5.	MAMF	14.56	+2.52	+20.93
6.	KUPF	13.34	+1.30	+10.79
7.	KUMF	14.34	+2.30	+19.10
8.	NEPF	7.14	-4.90	-40.69
9.	NEMF	10.70	-1.34	-11.12
10.	YAPF	7.48	-4.56	-37.87
11.	YAMF	9.62	-2.42	-20.09

TABLE – 33(a)

ANALYSIS OF VARIANCE – DROP TEST

Source of variance	'F' ratio	'P' value	'CD' value	
Within groups	208.9331		**0.05**	**0.01**
Between groups	1116.4725**	0.000**		
Between herbs	2113.2995**	0.000**	0.17225	0.22801
Between treatments	1200.5834**	0.000**	0.09945	0.13164
Between herbs and treatments	102.8232**	0.000**	0.24361	0.32245

** Significant at one per cent level.

It is obvious from the Table – 33 and Figure – 23, that the absorbency rate was reduced in sample ALMF by 37.87 per cent whereas in sample YAPF the absorbency rate was increased by 37.87 per cent. The results also put forth an interesting fact that there was an increase in the absorbance rates of aloe vera, kuppaimeni and marigold finished samples and decrease in the yashtimadhu and neem finished samples, irrespective of the type of treatment method. From the statistical analysis, it was reported that there was a one per cent significance when compared between the groups, treatments, herbs separately and between both at one per cent level (Table – 33a).

Thus it can be concluded that the absorbance rate of some herbal finished sample was decreased because of the deposition of herbal extracts and its consistency.

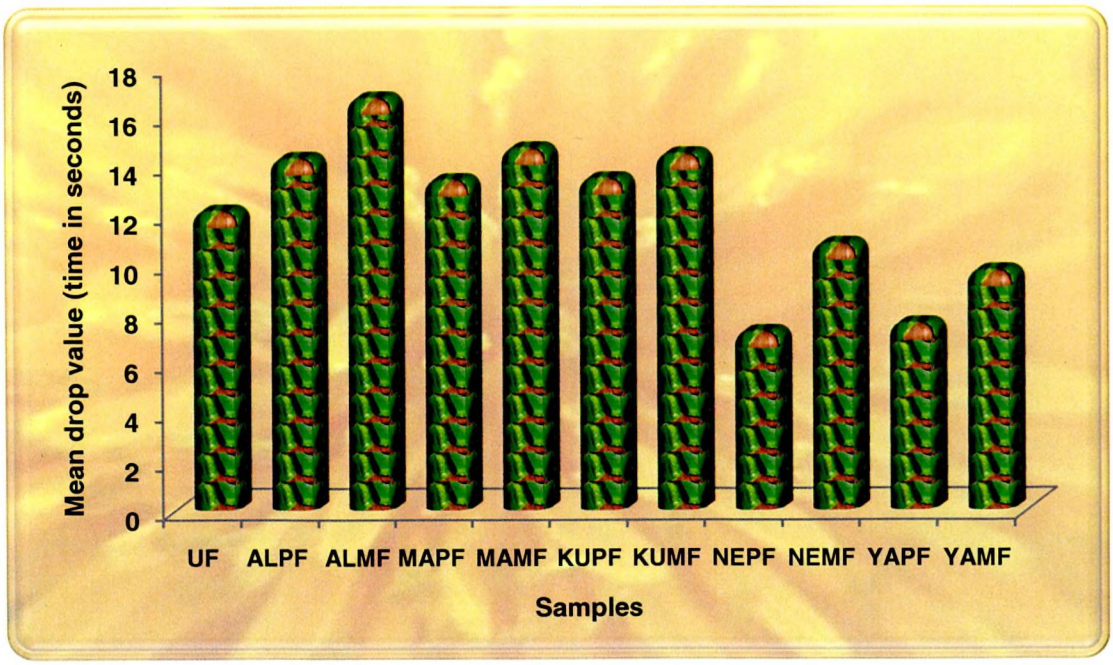


FIGURE – 24

DROP TEST OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES

4.8.4.2 Wickability Test

The results of fabric wicking behavior of unfinished and herbal pad dry and micro encapsulation finished samples are given in Table – 34 and Figure – 25.

TABLE – 34

FABRIC WICKABILITY OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES

S.No.	Samples	Wicking (Time in minutes)	Gain or loss over original wickability	Percentage gain or loss over original wickability
1.	UF	4.39	-	-
2.	ALPF	9.50	+5.11	+116.40
3.	ALMF	7.89	+3.50	+79.72
4.	MAPF	8.21	+3.82	+87.01
5.	MAMF	9.98	+5.59	+127.33
6.	KUPF	4.96	+0.57	+12.98
7.	KUMF	7.99	+3.60	+82.00
8.	NEPF	4.79	+0.40	+9.11
9.	NEMF	5.83	+1.44	+32.80
10.	YAPF	6.71	+2.32	+52.84
11.	YAMF	8.50	+4.11	+93.62

TABLE – 34(a)

ANALYSIS OF VARIANCE – FABRIC WICKABILITY

Source of variance	'F' ratio	'P' value	'CD' value	
Within groups	10.9224		**0.05**	**0.01**
Between groups	12.5159**	0.000**		
Between herbs	21.5331**	0.000**	1.14491	1.52950
Between treatments	9.6589**	0.003**	0.66101	0.88306
Between herbs and treatments	4.0701**	0.004**	1.61914	2.16304

** Significant at one per cent level.

The Table – 34 and Figure – 25 revealed the wicking behavior of the herbal pad dry and micro encapsulation finished sample. The maximum and minimum increase was observed in samples ALPF and NEPF as 116.4 and 9.11 per cent respectively.

From the statistical analysis, it was noted that there was one per cent significance in wicking behavior when compared between groups, treatments, herbs separately and between both in the vertical direction of the fabric herbal finished samples. Hence, it could be concluded that the wicking behavior of all herbal finished samples were better when compared to unfinished sample.

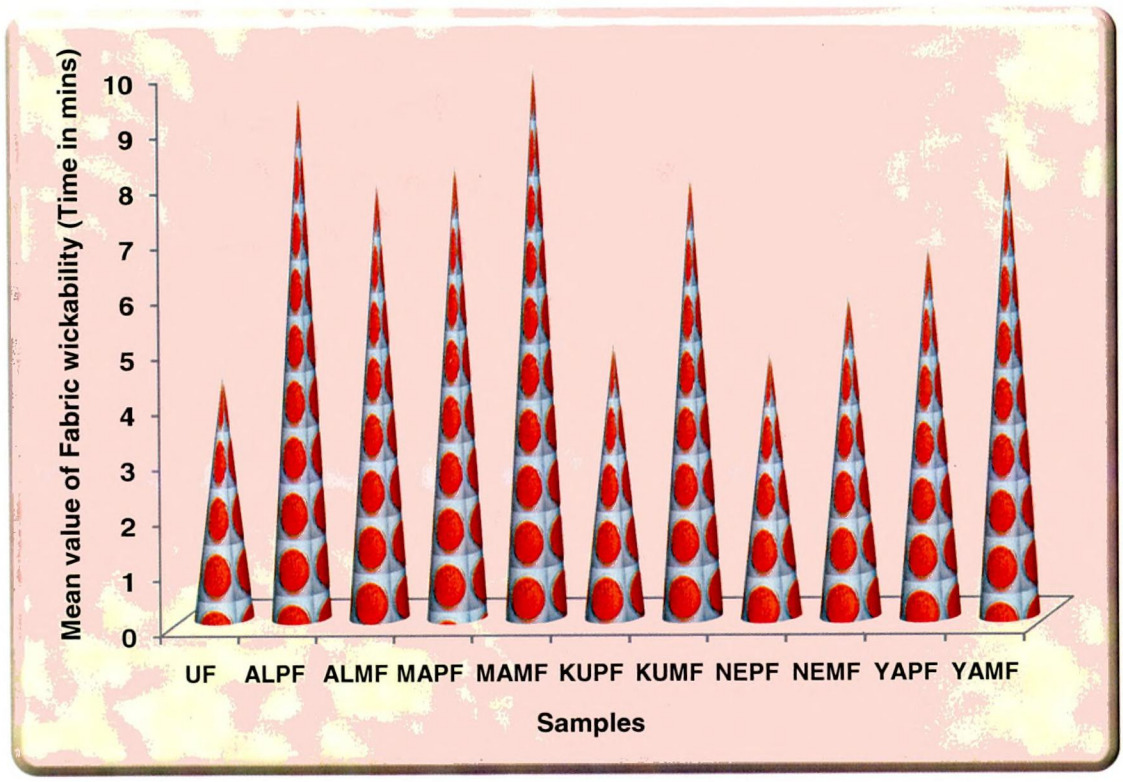


FIGURE – 25

FABRIC WICKABILITY OF UNFINISHED AND HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES

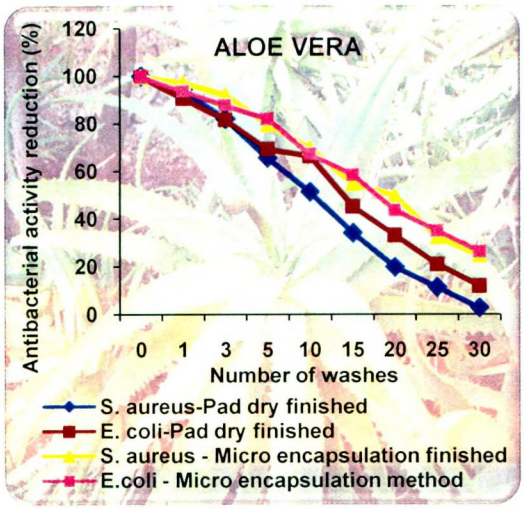
4.9 FINISH WASH DURABILITY TEST

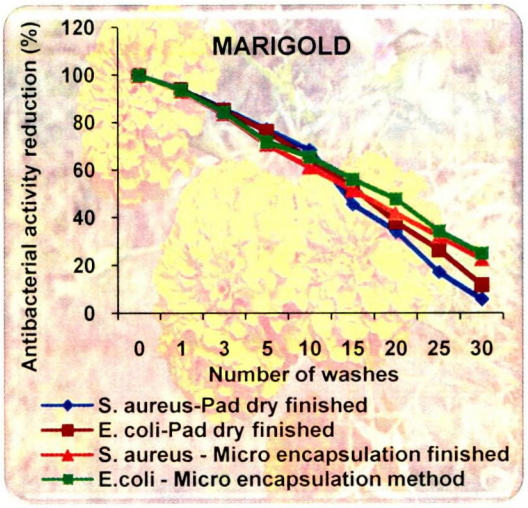
The wash durability of all the herbal pad dry and micro encapsulation finished samples are shown in Table – 15 and Figure – 26.

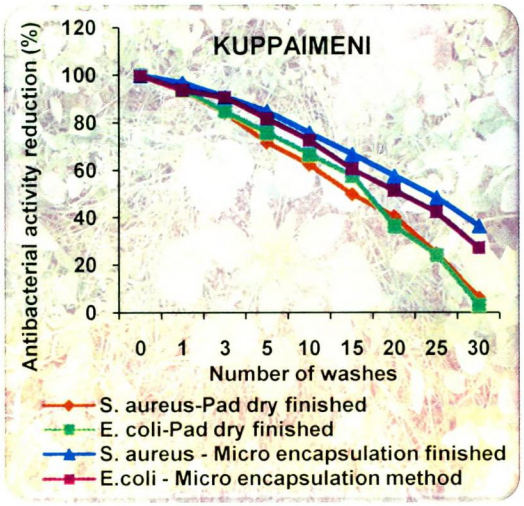
TABLE – 35

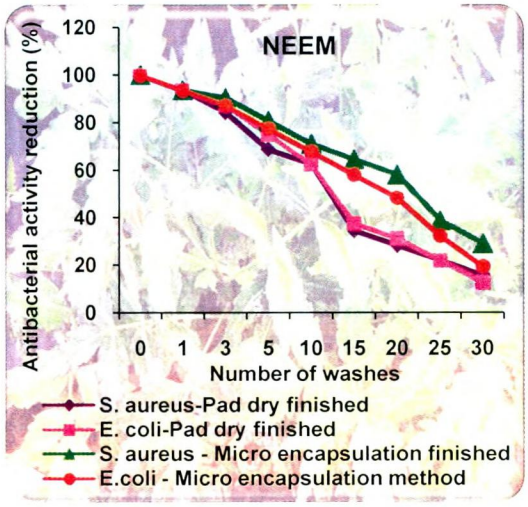
FINISH WASH DURABILITY OF HERBAL PAD DRY AND MICRO ENCAPSULATION FINISHED SAMPLES

Medicinal herbs	Number of washes	Pad Dry Finish Method				Micro Encapsulation Finish Method			
		Staphylococcus aureus		*Escherichia coli*		*Staphylococcus aureus*		*Escherichia coli*	
		Zone of inhibition (mm)	Antibacterial activity reduction (%)	Zone of inhibition (mm)	Antibacterial activity reduction (%)	Zone of inhibition (mm)	Antibacterial activity reduction (%)	Zone of inhibition (mm)	Antibacterial activity reduction (%)
Aloe Vera	0 wash	35	99.99	33	99.99	40	99.99	34	99.99
	1 wash	33	94.27	30	90.89	39	97.49	32	94.11
	3 washes	29	82.09	27	81.89	37	92.49	30	88.22
	5 washes	23	65.79	23	69.69	32	79.99	28	82.34
	10 washes	18	51.49	20	66.69	28	69.99	23	67.64
	15 washes	12	34.29	15	45.45	22	54.99	20	58.81
	20 washes	7	19.99	11	33.33	18	49.99	15	44.11
	25 washes	4	11.49	7	21.21	13	32.49	12	35.28
	30 washes	1	2.84	4	12.12	10	24.99	9	26.46
Mralgoli	0 wash	35	99.99	34	99.99	31	99.99	32	99.99
	1 wash	33	94.27	32	94.10	29	93.53	30	93.74
	3 washes	30	85.70	29	85.28	26	83.86	27	84.37
	5 washes	27	77.13	26	76.46	22	70.95	23	71.86
	10 washes	24	68.56	22	64.69	19	61.28	21	65.61
	15 washes	16	45.70	18	52.93	16	51.60	18	56.24
	20 washes	12	34.27	13	38.22	13	41.93	15	47.87
	25 washes	6	17.13	9	26.46	11	35.47	11	34.36
	30 washes	2	5.70	4	11.75	10	32.24	8	24.99
Kuppaimeni	0 wash	32	99.99	33	99.99	33	99.99	33	99.99
	1 wash	30	93.74	31	93.93	32	96.96	31	93.93
	3 washes	27	84.36	28	84.84	30	90.89	30	90.89
	5 washes	23	71.87	25	75.75	28	84.84	27	81.81
	10 washes	20	62.49	22	66.66	25	75.75	24	72.72
	15 washes	16	49.99	19	57.57	22	66.66	20	60.59
	20 washes	13	40.615	12	36.35	19	57.56	17	51.50
	25 washes	8	24.99	8	24.23	16	48.47	14	42.41
	30 washes	2	6.24	1	3.02	12	36.35	9	27.26
Neem	0 wash	32	99.99	32	99.99	31	99.99	31	99.99
	1 wash	30	93.74	30	93.74	29	93.54	29	93.54
	3 washes	27	84.36	28	87.49	28	90.31	27	87.09
	5 washes	22	68.74	24	74.99	25	80.64	24	77.41
	10 washes	20	62.49	20	62.49	22	70.96	21	67.73
	15 washes	11	34.37	12	37.49	20	64.50	18	58.05
	20 washes	9	28.11	10	31.24	18	58.05	15	48.38
	25 washes	7	21.86	7	21.86	12	38.69	10	32.24
	30 washes	5	15.61	4	12.49	9	29.02	6	19.34
[illegible]	0 wash	36	99.99	37	99.99	37	99.99	38	99.99
	1 wash	34	94.43	34	91.88	36	97.28	36	94.73
	3 washes	31	86.10	30	81.07	34	91.88	34	89.46
	5 washes	29	80.55	27	72.96	30	81.07	30	78.94
	10 washes	26	72.21	24	64.85	27	72.96	26	68.41
	15 washes	20	55.54	16	42.23	24	69.85	22	57.88
	20 washes	15	41.65	12	32.42	20	54.04	19	49.99
	25 washes	9	17.49	9	24.31	17	45.93	16	42.09
	30 washes	3	8.32	4	10.80	14	37.83	11	28.93









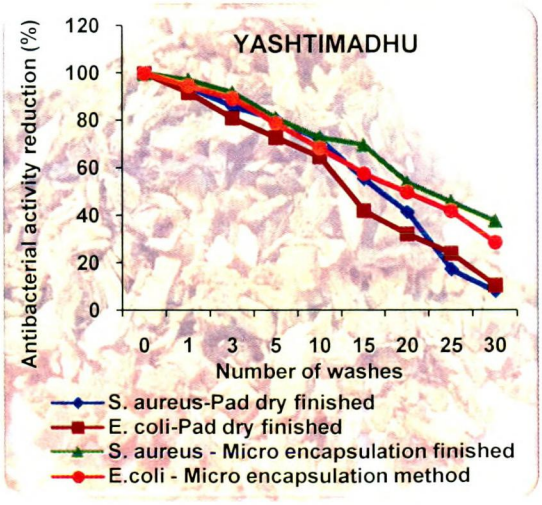


FIGURE – 26
WASH DURABILITY OF HERBAL PAD DRY AND
MICRO ENCAPSULATION FINISHED SAMPLES

Table – 35 and Figure – 25 clearly showed the zone of inhibition after each wash cycle. The antibacterial activity was reduced with increase in wash cycles. The reduction activity was higher in pad dry finished sample when compared to micro encapsulated finished samples of all the selected herbal extracts.

With each wash, the bacterial reduction values were reduced gradually upto ten washes. The reduction increased drastically in 20 washes for all the pad dry finished samples. The zone of inhibition has reduced below 10 mm for ALPF, NEPF samples. Similarly, after 25 washes it reduced for sample KUPF and YAPF indicating the absence of antibacterial activity against both positive and negative bacteria for pad dry finish method. Similar results are reported by Sathianarayanan et al. (2010). The micro encapsulation finished sample showed higher antibacterial activity even after several laundering. The activity reduction values gradually reduced from 1st wash to 20th wash and thereafter the reduction rate increased. The results also revealed the fact that the micro encapsulation finished samples have better antibacterial activity upto 25 washes against positive and negative bacterias. After 25 washes, the zone of inhibition has reduced to 10 mm. This sensitive zone showed the bacterial retention activity on the fabrics and below 10 mm was considered as resistant zone as described by Benson (2002).

The increase in antimicrobial reduction activity is directly proportion to increase in washes. The antimicrobial effect of micro encapsulation finished samples was not significantly affected due to repeated laundering when compared with that of direct pad dry finished samples. In a nutshell, the micro encapsulation process released the finishes very slowly and increased the wash durability of finishes to more than 25 washes, as stated by Sathianarayanan and Bhat (2010) (Plate – 28).

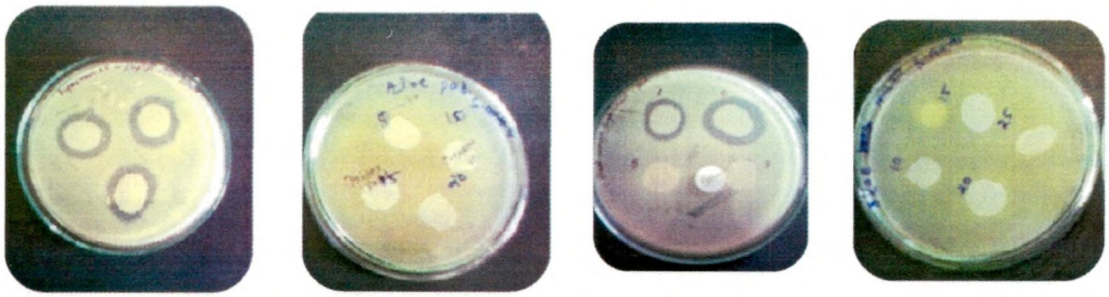
Hence it may be concluded that the antibacterial activity and durability of pad dry finished sample may be limited to 15 washes and that of micro encapsulation finished samples may be extended to 25 washes. So, the herbal finished samples are suitable for the development of wash and use products.

4.10 TESTS FOR FUNCTIONAL PROPERTIES OF RECOMMENDED PRODUCTS

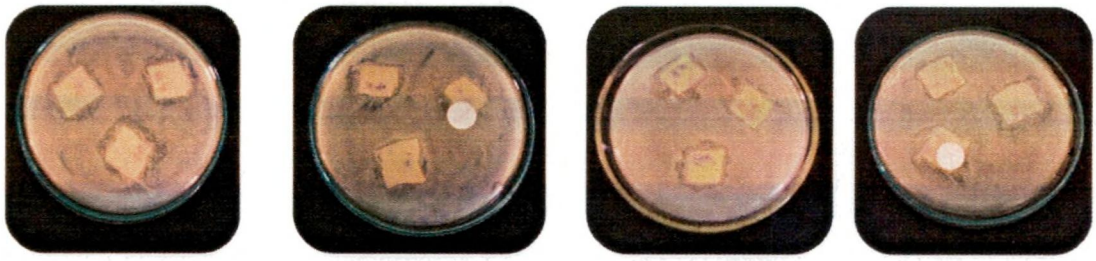
The results pertaining to the functional properties are namely ultra violet protection, thermal resistance tests for aloe vera, thermal conductivity and thermal resistance tests for yashtimadhu finished fabrics.

Staphylococcus aureus *Escherichia coli*

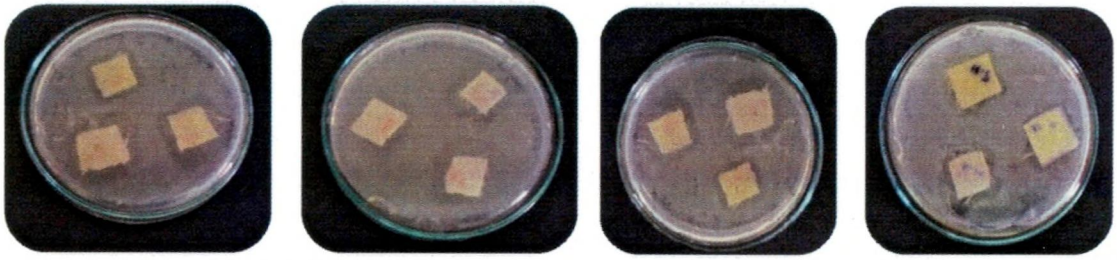
ALOE VERA – PAD DRY FINISHED



ALOE VERA – MICRO ENCAPSULATION FINISHED



YASHTIMADHU – PAD DRY FINISHED



YASHTIMADHU – MICRO ENCAPSULATION FINISHED

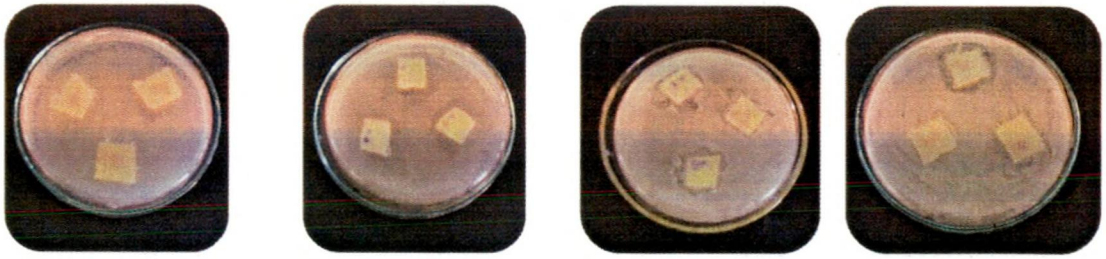


PLATE – 28

FINISH WASH DURABILITY TEST FOR ALOE VERA AND YASHTIMADHU FINISHED SAMPLES

4.10.1 Ultra Violet Protection Test for Aloe Vera Herbal Finished Fabrics

4.10.1.1 *In Vitro* Study – Transmittance or Blocking Erythemal Weighted Ultra Violet Radiation through Fabrics (AATCC 183 – 2004)

The results of transmittance or blocking of erythemally weighted ultra violet radiation through aloe vera finished sample is given in the Table – 36.

TABLE – 36

TRANSMITTANCE OR BLOCKING OF ERYTHEMALLY WEIGHTED ULTRA VIOLET RADIATION THROUGH ALOE VERA FINISHED SAMPLES

S.No.	Conditions	Unfinished fabric		Aloe vera finished fabric	
		Dry condition	Wet condition	Dry condition	Wet condition
1.	Mean UPF	11.481	8.039	25.954	23.974
2.	Mean UVA transmission	7.345	11.786	5.009	5.615
3.	Mean UVB transmission	8.000	88.213	3.667	3.282
4.	Standard deviation	0.626	0.127	2.135	1.122
5.	Rated UPF	10	10	25	20
6.	UVA Blocking (%)	92.655	88.213	94.990	94.385
7.	UVB Blocking (%)	92.000	89.035	96.332	96.717

The aloe vera dry condition finished sample shows 25.95 per cent UPF value against the unfinished sample value of 11.48 per cent UPF. In the case of wet condition, the aloe vera finished sample shows 23.9 per cent UPF factor, when compared to unfinished sample of 8.03 per cent UPF factor. According to the ASTM D 6603 standard norms UPF of 25 and above 25 – 39 shows very good UV protection. The unfinished sample showed only 10 per cent. This reveals less UV protection factor. In both dry and wet condition the aloe vera finished sample shows the 94 per cent UVA blocking and 96 per cent UVB blocking of sun rays.

Hence it could be concluded that the aloe vera finished sample could be used to produce products to withstand sun's rays. Thus, the aloe vera finished sample is suitable for UV protection product development.

4.10.1.2 *In Vivo* Study – Photo Therapy Ultra Violet Protection Test for Aloe Vera Finished Samples

The results of unfinished and aloe vera finished samples are given in Table – 37.

TABLE – 37

PHOTO THERAPY ULTRA VIOLET PROTECTION TEST FOR ALOE VERA FINISHED SAMPLE

S.No.	Human subject names	Age	Sex	Non-treated cloth (left side) (millijule)	Treated cloth (right side) (millijule)	Percentage gain or percentage loss
1.	Subject 1	24	M	12	14	+2
2.	Subject 2	24	M	16	18	+2
3.	Subject 3	32	M	9	11	+2
4.	Subject 4	20	M	16	17	+1
5.	Subject 5	23	M	14	16	+2
6.	Subject 6	20	M	11	12	+1
7.	Subject 7	26	F	11	13	+2
8.	Subject 8	19	F	11	11	+2
9.	Subject 9	20	M	18	16	-2
10.	Subject 10	32	M	11	15	+4
11.	Subject 11	19	M	11	13	+2
12.	Subject 12	21	M	0	0	0
13.	Subject 13	20	M	14	12	+1
14.	Subject 14	23	M	11	11	0
15.	Subject 15	22	M	11	13	+2
16.	Subject 16	21	M	11	12	+1
17.	Subject 17	24	M	11	12	+1
18.	Subject 18	23	F	12	12	0
19.	Subject 19	22	F	11	13	+2
20.	Subject 20	22	F	11	12	+1
21.	Subject 21	19	M	11	12	+1
22.	Subject 22	19	M	0	0	0
23.	Subject 23	23	M	11	12	+1
24.	Subject 24	44	F	11	11	0
25.	Subject 25	30	F	11	13	+2
26.	Subject 26	39	F	0	0	0
27.	Subject 27	27	F	11	13	+2
28.	Subject 28	25	F	11	13	+2
29.	Subject 29	38	F	0	0	0
30.	Subject 30	36	F	11	12	+1
31.	Subject 31	32	F	11	11	0
32.	Subject 32	33	F	11	13	+2
33.	Subject 33	40	F	11	13	+2
34.	Subject 34	36	F	11	12	+2
35.	Subject 35	28	F	0	0	0

From the Table – 37, it is evident that only nine persons were not affected by UV rays as they were of skin type III. One person with fair skin tone reported good protection. Among 24 persons, 15 (skin type IV) showed high UV protection on usage of aloe vera finished fabrics. The observed divergence between the invivo measurements could be the result of the optical geometric properties of the textiles which in turn depicts the amount of direct and dispersed radiation that passes through the pores between the fibers. The formation of erythema on the skin was measured in millijule values, which represents the acceptable value to form erythema on the skin of all the participants. In unfinished sample, erythema was formed in a lower millijule value and showed a lesser protection than the finished sample which had higher millijule value to form the same amount of erythema on the skin. Hence, it could be concluded that aloevare finished fabrics had good UV protection.

TABLE – 37a

STATISTICAL ANALYSIS OF PHOTO THERAPY

ULTRA VIOLET PROTECTION TEST

S.No.	Sample		Number of persons	't' value	Probability	Critical 't' value	Co-variance	Standard deviation
1	Male and female	General	35	0.9687	0.3361	1.9955^{NS}	21.3824	0.1850
		Paired		5.8676	1.27931E-006	2.0322**		
2	Male	General	16	0.8885	0.3813	2.0423^{NS}	15.0000	0.3227
		Paired		3.8730	0.0015	2.1314**		
3	Female	General	19	0.5934	0.5566	2.0281^{NS}	23.8012	0.2091
		Paired		4.5316	0.0003	2.1009**		

** Significant at one per cent level.

NS – Not Significant

From the statistical analysis, 't' value proved good UV protection for aloe vera finished samples (Table – 37a). Hence, it could be concluded that aloe vera finished samples can be a successful UV protective product.

4.10.2 Thermal Resistance Test for Aloe Vera Finished Sample

The thermal resistance of unfinished and aloe vera finished samples are shown in Table – 38.

TABLE – 38

THERMAL RESISTANCE TEST FOR ALOE VERA FINISHED SAMPLE

Number of test	Time	Volts	Amps	Power	R/H	Unfinished (R_{ct})	Aloe vera pad dry finished sample (R_{ct})	Aloe vera micro finished sample (R_{ct})
1	13:55:10	23.540	2.384	56.119	65.00	0.0084	0.0065	0.0059
2	14:10:11	23.536	2.383	56.086	65.00	0.0078	0.0066	0.0065
3	14:40:10	23.537	2.384	56.112	64.99	0.0075	0.0063	0.0067
4	14:55:11	23.540	2.384	56.119	64.99	0.0073	0.0067	0.0073
5	15:40:10	23.547	2.384	56.136	65.00	0.0077	0.0068	0.0072
6	15:55:11	23.549	2.384	56.141	64.99	0.0075	0.0069	0.0071
Mean Thermal resistance ((m – k)/w)						**0.0076**	**0.0072**	**0.0068**

In the thermal resistance test, the unfinished sample showed higher value of 0.0076 R_{ct} when compared to aloe vera finished sample as stated by Viswanath and Ramachandran (2010). The 0.0068 R_{ct} value of aloe vera micro encapsulation finished sample showed higher coolant characteristics than the pad dry finished fabric of 0.0072 R_{ct}. The finished sample results showed lower values indicating that the fabric had higher coolant properties which enhances the comfort of the wearer.

TABLE – 38(a)

ANALYSIS OF VARIANCE OF THERMAL RESISTANCE TEST OF ALOE VERA FINISHED SAMPLES

S.No.	Samples	Sample size	't' Value general	Probability	Critical 't' value
1	Unfinished and pad dry finished sample	6	5.9219	0.0001	2.2281**
2.	Unfinished and micro encapsulation finished sample	6	3.4255	0.0065	2.2281**
3.	Pad dry and micro encapsulation finished sample	6	0.6412	0.5358	2.2281^{NS}

** Significant at one per cent level.

NS – Not Significant

From the statistical analysis (Table – 38a), the combination of unfinished and pad dry, unfinished and micro encapsulation aloe vera finished sample, 't' values were significant at one per cent level. The combination of pad dry and micro encapsulation finished samples was not significant in the 't'values of thermal resistance.

4.10.3 Thermal Comfort Tests for Yashtimadhu Herbal Finished Fabrics

4.10.3.1 Thermal Conductivity Test

The thermal conductivity results of unfinished and yashtimadhu finished sample are shown in Table – 39.

TABLE – 39

THERMAL CONDUCTIVITY TEST FOR YASHTIMADHU FINISHED SAMPLES

S.No.	Unfinished sample		Yashtimadhu Pad dry finished sample		Yashtimadhu micro encapsulation finished sample	
	Temperature (°C)	Time (seconds)	Temperature (°C)	Time (seconds)	Temperature (°C)	Time (seconds)
1	93	0	82	0	84	0
2	92	16	81	34	83	24
3	91	30	80	70	82	60
4	90	45	79	96	81	92
5	89	74	78	120	80	110
6	88	102	77	145	79	140
7	87	125	76	170	78	166
8	86	149	75	198	77	192
9	85	175	74	220	76	218
10	84	200	73	242	75	242
11	83	248	72	267	74	275
Thermal conductivity (w/m – k)	**0.0354**		**0.0376**		**0.066**	

The thermal conductivity of the yashtimadhu herbal finished sample showed better results when compared to unfinished sample. The pad dry finished sample showed the value of 0.0376 and 0.066 for micro encapsulation finished sample. The unfinished fabric has got lower value (0.0354) when compared to herbal finished sample. The fact is when the thermal conductivity values decrease, the fabric exhibits a warmer feeling and higher values showed less conductor of heat (Majumdar et al., 2010). So, the micro encapsulated yashtimadhu finished sample proved less thermal conductivity than the pad dry finished sample.

TABLE – 39(a)

ANALYSIS OF VARIANCE OF THERMAL CONDUCTIVITY TEST OF YASHTIMADHU FINISHED SAMPLE

S.No.	Samples	Temperature		Time	
		Paired 't' value	Critical 't' value	Paired 't' value	Critical 't' value
1.	Unfinished and pad dry finished sample	7.7782**	2.0860	7.3500**	2.2281
2.	Unfinished and micro encapsulation finished sample	6.3640**	2.0860	7.0149**	2.2281
3.	Pad dry and micro encapsulation finished sample	1.4142 NS	2.0860	2.3956*	2.2281

** Significant at one per cent level

* Significant at five per cent level

NS – Not significant

From the statistical analysis, the time and temperature were interrelated. The general 't' test values were significant at one per cent level in the combination of unfinished, pad and micro finished samples. In paired the time factor test values were significant at one per cent level in the same combination of samples in the pad dry and micro encapsulation finished samples (Table – 39a).

4.10.3.2 Thermal Resistance Test

The thermal resistance of unfinished and yashtimadhu finished sample are shown in Table – 40.

TABLE – 40

THERMAL RESISTANCE TEST FOR YASHTIMADHU FINISHED SAMPLES

S.No.	Time	Unfinished sample				Yashtimadhu finished sample			
		Votls	Amps	Power	R_{ct}	Votls	Amps	Power	R_{ct}
1	0 – 15	23.543	2.383	56.103	0.0161	23.540	2.384	56.119	0.0081
2	15 – 30	23.545	2.384	56.131	0.0146	23.537	2.383	56.089	0.0093
3.	30 – 45	23.548	2.386	56.186	0.0149	23.539	2.384	56.117	0.0093
4	45 – 60	23.549	2.384	56.141	0.0152	23.544	2.386	56.176	0.0081
5	60 – 75	23.549	2.386	56.188	0.0147	23.544	2.386	56.176	0.0074
6	75 – 90	23.552	2.386	56.195	0.0151	23.546	2.384	56.134	0.0079
7	90 – 105	23.549	2.387	56.211	0.0155	23.549	2.386	567.188	0.0080
8.	105 – 120	23.546	2.385	56.134	0.0153	23.549	2.384	56.141	0.0081
Thermal resistance (m-k) / W)					**0.0153**				**0.0080**

TABLE – 40a

ANALYSIS OF VARIANCE OF THERMAL RESISTANCE TEST OF YASHTIMADHU FINISHED SAMPLES

S.No.		Unfinished sample	Yashtimadhu finished sample	't' value	Probability	DF	Critical 't' value	Co-variance	Standard deviation
1	General	8	8	23.5926	1.13335E-012	14	2.1448**	-1.0071E-007	0.0003
2	Paired	8	8	20.7371	1.52308E-007	7	2.3646**		

** Significant at one per cent level

From the Table – 40 it is clear that the unfinished fabric sample has a higher value of 0.0153 R_{ct} when compared with finished sample with value of 0.0080 R_{ct}, indicating good coolant properties as stated by Ozdil et al. (2007). This coolant effect will stop the heat conductivity on the fabrics and give freshness to the wearer especially for the long working hours. From the statistical analysis the general and paired values were significant at one per cent level. These results proved better thermal resistance for yashtimadhu finished sample (Table – 40a).

Hence it could be concluded that the yashtimadhu finished sample could be used as a coolant agent.

4.11 PERFORMANCE EVALUATION

4.11.1 Wear Study

For the purpose of wear study the hand gloves from aloe vera and eye pillow from yashtimadhu were stitched with both unfinished and herbal finished fabrics. In view with this, the results of wear study are discussed in Table – 41.

4.11.1.1 Wear Study of Ultra Violet Protective Aloe Vera Finished Hand Gloves

The Table – 41 depicts the results of wear study of the aloe vera finished hand gloves.

TABLE – 41

WEAR STUDY OF ULTRA VIOLET PROTECTIVE ALOE VERA FINISHED HAND GLOVES

S.No.	Human subjects	Features / Percentage of judges evaluated*																														
		Skin problem				Exposure in sunlight		Treatment				Affordability of commercial products		Preferences of natural product		Durability				Comfortability				Development product usage time		Side effect of the developed product			Effect of photo therapy			Cost of developed product	
		Burning Irritation	Patches	Skin Tanning	Others	Less than 4 hrs	More than 4 hrs	Sun Screen Lotion	Moisturizer	Medicine	Nil	Affordable	Not affordable	Preferences	Not preference	5 washes	15 washes	20 washes	25 washes	Highly Satisfied	Satisfied	Moderate	Dissatisfied	Less than 4 hrs	More than 4 hrs	Redness	Itching Sensation	Nil	Burning Sensation	Allergic	Nil	Affordable	Not affordable
1.	Subject – 1*	25	5	60	10	-	100	30	-	-	70	10	90	100	-	-	-	30	70	60	40	-	-	-	100	-	-	100	5	-	95	85	15
2.	Subject – 2**	30	-	70	-	80	20	60	30	6	4	34	66	90	10	-	16	24	60	54	46	-	-	80	20	-	-	100	10	-	90	80	20
3	Subject – 3***	9	36	50	5	100	-	45	30	25	-	40	60	100	-	-	9	36	55	66	34	-	-	95	5	-	-	100	21	-	79	100	-

Number of judges : 100

* Number of traffic police : 20

** Number of sports persons : 50

*** Number of working women : 30

All the subjects had problems on their skin due to exposure (3-8 hours) under sun light. The subjects faced problems like skin tanning (50-70 per cent), burning irritation (10-30 per cent) and others developed patches on their skin. About 70 per cent of the police personnel did not take any treatment for the problem but the condition was reversed in the case of sports person and working women, nearly 80-90 per cent cares for their skin tone and texture. They use either a sun screen lotion or moisturizer. A minimum of 30 per cent undergo treatments.

As per the subjects comments, the commercial products were not affordable by 75 per cent whereas 95 per cent of the people look for a naturally developed product for protection against the sun rays.

From the wear study, it was clear that the product had high comfort property, durability about 25 washes and did not cause any side effects. Fifty per cent of the samples expressed that the gloves exhibit cooling effect. Five hours of wear was acceptable by more than 80 per cent of the subjects. The photo therapy method of testing was harmless for 90 per cent of the subjects. However ten per cent reported burning sensation, which reduced within few minutes (30-45 minutes). Eighty five per cent of the subjects opined that the aloe vera finished hand gloves were affordable.

Hence it could be concluded that the aloe vera finished hand gloves were effective against the ill effects caused by sun rays.

4.11.2 Wear Study of Thermal Comfort Yashtimadhu Finished Eye Pillow

The wear study results of the yashtimadhu herbal finished eye pillow are presented in the Table – 42.

TABLE – 42

WEAR STUDY OF THERMAL COMFORT YASHTIMADHU FINISHED EYE PILLOW

S.No.	Human subjects	Features / Percentage of judges evaluated																													
		Cause of eye problem				Effect of eye problem				Remedy for eye problem			Use of natural products		Time of usage			Comment on the developed product				Durability				Side effects of the developed product				Cost of developed product	
		Working in computers	Watching television	Long working hours	Nil	Head ache	Redness in eyes	Loss of memory	Sight problem	Power glasses	Eye drops	Others	Preferred	Not preferred	2 hours	4 hours	6 hours	Highly satisfied	Satisfied	Moderate	Dissatisfied	5 washes	10 washes	20 washes	25 washes	Redness	Colour	Breathing problem	Nil	Affordable	Not affordable
1.	Subject – 1*	60	4	30	6	30	10	-	60	70	25	5	95	5	45	30	25	70	30	-	-	-	-	70	30	-	-	-	100	95	5
2.	Subject – 2**	45	30	-	25	20	25	5	50	60	5	35	100	-	50	40	10	90	10	-	-	-	-	60	70	-	-	-	100	85	15

Number of judges : 100

* Information Technology professionals: 30

** College students pursuing computer science engineering : 70

From the Table – 42 it is evident that 50-60 per cent of the IT professionals and students suffer from eye problems and 20-30 per cent from head ache mainly due to working on computers for long hours.

The power glass was opted by 60-70 per cent of the people as a preventive measure for the eye problem and others chose either eye drops or allopathic medicines. Since these medicines caused side effects and discomfort, 95-100 per cent of them prefer the use of alternative natural product as a remedy. They preferred to use it during leisure time (2-4 hours).

Seventy per cent of the information technology professionals and 90 per cent of the students were highly satisfied by the comfort property and reported that a cooling effect was produced by the yashtimadhu finished eye pillow. From this opinion, it was clear that the newly developed product did not cause any discomfort or side effect during the wear. The product was effective till 20-25 washes. Nearly 90 per cent of the people voted it as affordable.

Hence it could concluded that the yashtimadhu finished eye pillow is the best remedy for the eye infection caused due to heat.

4.12 COSTING OF HERBAL MEDICATED PRODUCTS

The cost of the herbal medicated developed products are shown in the Table – 43.

TABLE – 43

COST OF THE HERBAL HEALTH CARE PRODUCTS

S.No	Items	Aloe vera			Marigold			Kuppaimeni			Neem			Yashtimadhu		
		Rate per unit	Quantity used	Price	Rate per unit	Quantity used	Price	Rate per unit	Quantity used	Price	Rate per unit	Quantity used	Price	Rate per unit	Quantity used	Price
1.	Herb	Rs. 70 per kg	25 grams	1.75	Rs. 25 per kg	20 grams	0.50	Rs. 10 per kg	100 grams	1.00	Rs. 20 per kg	25 grams	0.50	Rs. 60 per kg	10 grams	0.60
2.	Solvent	Distilled water Rs. 30 per litre	250 ml	7.50	Ethanol Rs. 450 per litre	200 ml	90.00	Ethanol Rs. 450 per litre	500 ml	225.00	Distilled water Rs. 30 per litre	250 ml	7.50	Distilled water Rs. 30 per litre	100 ml	3.00
3.	Mordant	Rs. 170 per 500 grams	10 grams	3.40	Rs. 170 per 500 grams	10 grams	3.40	Rs. 170 per 500 grams	50 grams	17.00	Rs. 170 per 500 grams	10 grams	3.40	Rs. 170 per 500 grams	5 grams	1.70
4.	Pure cotton fabric	Rs. 40 per metre	½ metre	20.00	Rs. 40 per metre	½ metre	20.00	Rs. 40 per metre	4 metre	160.00	Rs. 40 per metre	½ metre	20.00	Rs. 40 per metre	30 cm	12.00
5.	Pad dry finish	Rs. 20 per meter	½ metre	10.00	Rs. 20 per meter	½ metre	10.00	Rs. 5 per meter	4 metre	20.00	Rs. 20 per meter	½ metre	10.00	Rs. 20 per meter	30 cm	6.00
6.	Micro encapsulation finish	Rs. 40 per metre	½ metre	20.00	Rs. 40 per metre	½ metre	20.00	Rs. 10 per metre	4 metre	40.00	Rs. 40 per metre	½ metre	20.00	Rs. 40 per metre	30 cm	12.00
7.	Accessories	Elastic Rs. 10 per metre	¼ metre	2.50	-	-	-	-	-	-	Elastic Rs. 10 per metre	½ metre	5.00	Elastic Rs. 20 per metre	½ metre	10.00
8.	Construction charge	Rs. 10 per piece / 2 pieces	-	20.00	Rs. 15 per piece / 2 pieces		30.00	Rs. 30 per piece	-	30.00	Rs. 25 per piece	-	25.00	Rs. 10 per piece	-	10.00
9.	**Actual cost**	-	-	**85.25**			**173.90**			**493.00**			**91.40**			**55.00**
10.	Profit (10%)			8.50			17.30			49.30			9.14			5.0
11.	**Total cost**			**93.75**			**191.20**			**542.30**			**100.5**			**60.00**
	Rounded off			**94.00**			**191.00**			**542.00**			**100.00**			
	Commercial Rate			**110.00**			**210.00**			**485.00**			**150.00**			**50.00**

The cost of the aloe vera finished gloves, marigold finished foot wear, kuppaimeni finished bed spread, neem finished face mask and yashtimadhu finished eye pillow were Rs.94, Rs.191, Rs.542, Rs.100 and Rs.60 respectively.

When compared with commercial products, the rate of eye pillow and bed spread were high. This may be due to their small scale production. However, when these products were produced in a larger scale there will be a considerable reduction in their cost.

Hence it can be concluded that the herbal finished products were cost effective and could be produced on a large scale.