

## ***Results and Discussion***

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## **4. RESULTS AND DISCUSSION**

The Result and discussion pertaining to “A Study on Nano Finishing of Multifunctional Properties in Herbs on Cotton Fabric” is discussed under following headings

### **4.1 Evaluation**

4.1.1 Sensorial evaluation

### **4.1.2 Assessment of physical properties**

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4.1.2.2. Fabric thickness

### **4.1.3 Assessment of mechanical properties**

4.1.3.1. Tensile strength and elongation

a. Tensile strength – warp

b. Tensile strength – weft

c. Elongation – warp

d. Elongation – weft

4.1.3.2. Abrasion resistance

### **4.1.4. Assessment of comfort properties**

4.1.4.1. Fabric stiffness

a. Fabric stiffness – warp

b. Fabric stiffness – weft

4.1.4.2. Crease recovery

a. Crease recovery – warp

b. Crease recovery – weft

4.1.4.3 Fabric drapability

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4.1.6.3 Fragrance finishing

#### 4.1.7 SEM analysis

#### 4.1.8 Evaluation of Wash durability

**TABLE - III**  
**Sensorial Evaluation (Rating Scale %)**

Sample	Color			Appearance			Texture			Fragrance		
	Excellent	Good	Fair	Excellent	Good	Fair	Excellent	Good	Fair	Excellent	Good	Fair
B	91	12	2	86	4	5	94	3	3	82	6	12
C	92	8	-	94	5	1	97	3	-	89	8	3
D	97	3	-	95	4	1	98	2	-	99	1	-

According to Sensorial evaluation, it was clear that, the color of sample D was rated as excellent by 97 percent judges. The 92 percent judges put forth sample C was excellent. Sample C was accepted by 91 percent judges. The sample D has maximum ratings compare than other sample.

#### **Appearance**

Among the three samples, sample D was rated as excellent by 95 percent judges. The samples B, C was rated as excellent by 86, 94 percent judges. Again the best ratings found in sample D.

#### **Texture**

The sample D was rated as excellent by 98 percent judges. The 97 percent judges stated that sample C was excellent and 94 percent judges said that sample B was excellent.

## Fragrance

The smell of the sample D was impressed by 99 percent judges. They felt it has excellent fragrance than other samples. 89 percent judges sensed that sample C was excellent. Sample B has minimum ratings about 82 percent because it emits least amount of fragrances.

From the sensorial evaluation it was concluded that nano finished sample (D) has maximum acceptance in the criteria such as Color, Appearance, Texture, and Fragrance. Nano particles improved the value of the finishing.

### 4.1.2 Assessment of physical property test

#### 4.1.2.1 Fabric weight

The following test results namely fabric weight of A, B, C, and D samples, and statistical analysis is presented in Table IV and Figure – I

**TABLE – IV**  
**FABRIC WEIGHT (grams)**

S.No	Samples	Mean $\pm$ SD (grams)	Gain / Loss	% of Gain / Loss	T-TEST (P<0.05)
1	A	1.3 $\pm$ 0.026			2.777*
2	B	1.26 $\pm$ 0.023	- 0.04	3	4.070*
3	C	1.38 $\pm$ 0.039	0.08	6.1	2.835*
4	D	1.4 $\pm$ 0.056	0.1	7.7	

\*- Significant, \*\* - Not significant

From the Table – (IV) and Figure – (I), it is evident that samples C and D had significant gain in weight about 6.1, 7.7 percent respectively than the control sample (A). The B sample had loss in weight about 3 percent.

The statistical analysis also proved that there is a significant difference in weight of samples B, C, and D when compared with control sample (A) which has been proved by paired T-test at 5 percent level. The maximum gain in weight is found in sample D due to Nano finishing.

#### 4.1.2.2 Fabric thickness

The comparative statement of fabric thickness of control and finished samples, and its statistical analysis is presented in Table – V and Figure – II

**TABLE - V**  
**FABRIC THICKNESS (mm)**

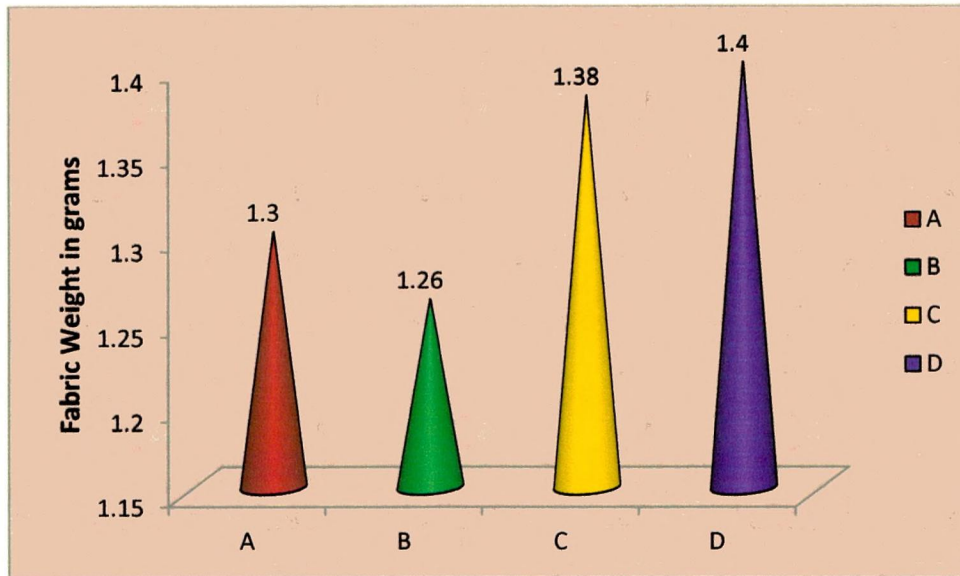
S.No	Samples	Mean ± SD (mm)	Gain / Loss	% of Gain / Loss	T-TEST (P<0.05)
1	A	0.32 ± 0.023			
2	B	0.29 ± 0.014	- 0.03	9.3	3.773*
3	C	0.33 ± 0.023	0.01	3.1	2.195*
4	D	0.36 ± 0.013	0.04	12.5	2.812*

\*- Significant, \*\*- Not significant

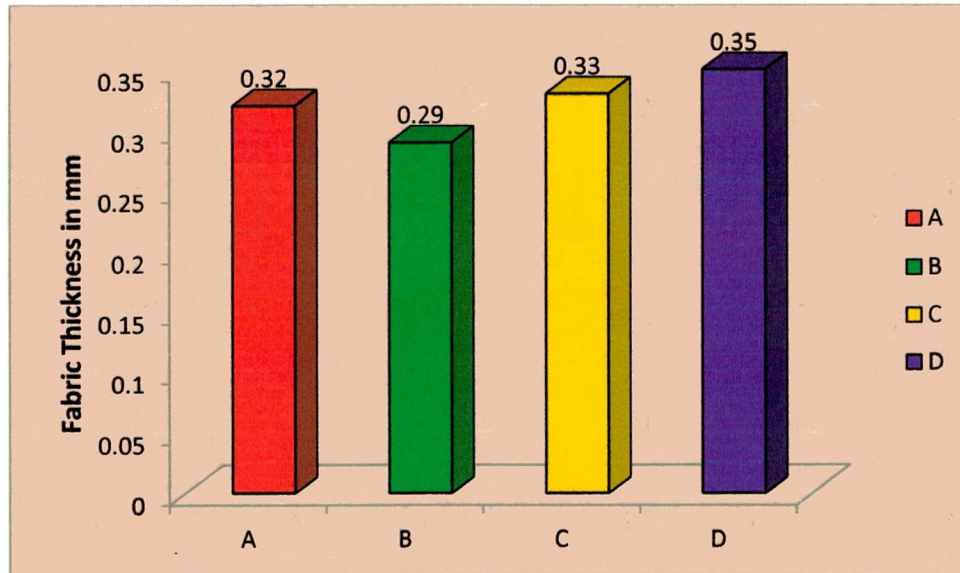
Table – (V) and Figure – (II) reveals that the samples C and D have increased in thickness about 3.1 and 12.5 percent respectively. The sample B decreases in thickness about 9.3 percent when compared with its control sample.

According to statistical analysis the samples B, C, and D has significant difference in fabric thickness with its control sample (A). Among the all finished samples more thickness is found in sample D because of deposit of finishing agent.

**Figure-I**  
**Fabric weight (grams)**



**Figure-II**  
**Fabric Thickness (mm)**



**A - Control sample, B - Conventional sample, C - Ultra sonic atomized sample, D - Nano finished sample**

### 4.1.3 Assessment of mechanical properties

The mechanical properties consist of tensile strength in warp, weft, elongation in warp and weft, and abrasion resistance of control and finished sample.

#### 4.1.3.1 Tensile strength and elongation

##### A .Tensile strength - warp

The Tensile strength of samples A, B, C, and D, and statistical analysis is presented in Table- VI and Figure – III

TABLE – VI

TENSILE STRENGTH (WARP) (kg)

S.No	Samples	Mean $\pm$ SD (kg)	Gain / Loss	% of Gain / Loss	T-test (P<0.05)
1	A	56.6 $\pm$ 2.9			5.055*
2	B	49 $\pm$ 2.90	- 7.6	13.4	0.875**
3	C	55.2 $\pm$ 4.2	- 1.4	2.5	2.836*
4	D	58.20 $\pm$ 4.5	1.6	2.8	

\*- Significant, \*\*- Not significant

The Table – (VI) and Figure – (III) depicts the significant improvement in strength is found in sample D about 2.8 percent. The samples B and C have lost in strength respectively 13.4, 2.5 percent than control sample because of the finishes.

The statistical analysis also reveals that the samples B and D have significant differences in strength when compared with its control sample. There is no significant difference found in sample C due to the reaction of finishes and finishing process.

##### B. Tensile strength – weft

The Tensile strength of control sample, conventionally finished samples, ultrasonic atomized sample and nano finished sample, with statistical analysis is presented in Table- VII and Figure – IV

**TABLE – VII**  
**TENSILE STRENGTH (WEFT) (Kg)**

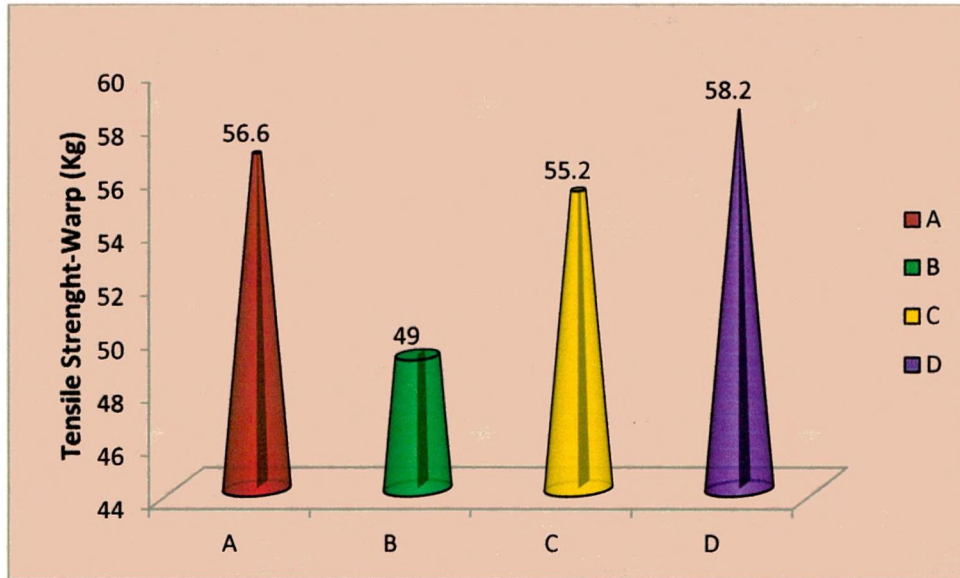
S.No	Samples	Mean $\pm$ SD (Kg)	Gain / Loss	% of Gain / Loss	T-test (P<0.05)
1	A	51.40 $\pm$ 3.2			0.206**
2	B	50.80 $\pm$ 2.9	- 0.7	1.4	2.998*
3	C	52.30 $\pm$ 3.2	1.1	2	2.811*
4	D	58.90 $\pm$ 2.4	7.5	14.6	

\*- Significant, \*\*- Not significant

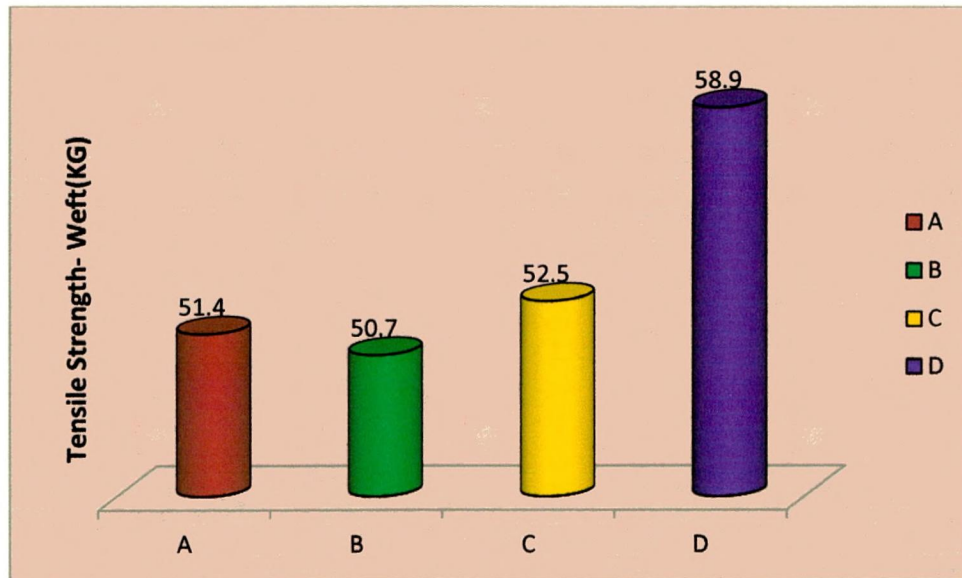
The Table – (VII) and Figure – (IV) shows the significant improvement in strength is found in samples C and D about 2, 14.6 percent respectively. The sample B has lost its strength 1.4 in weft direction compare with its control sample.

Statistical analysis also reveals that the samples C and D have significant differences in strength when compared to control sample in weft direction. There is no significant difference found in sample B. in sample D the strength was increased maximum than the control sample

**Figure - III**  
**Tensile Strength (Warp) (Kg)**



**Figure - IV**  
**Tensile Strength (Weft) (Kg)**



**A - Control sample, B - Conventional sample, C - Ultra sonic atomized sample, D - Nano finished sample**

**C. Fabric elongation- (warp)**

The elongation of samples A, B, C, and D, with statistical analysis is presented in Table- V III and Figure - V

**TABLE – VIII**  
**FABRIC ELONGATION (WARP) (inches)**

S.No	Samples	Mean $\pm$ SD (inches)	Gain / Loss	% of Gain / Loss	T-test (P<0.05)
1	A	4.1 $\pm$ 0.52			
2	B	3.8 $\pm$ 0.4	- 0.3	7.3	1.565**
3	C	4.28 $\pm$ 0.3	0.2	4.4	0.845**
4	D	4.35 $\pm$ 0.2	0.3	7.3	2.142*

\*- Significant, \*\*- Not significant

The Table – VIII and Figure – V shows that the samples C and D has gained in elongation of 4.4 and 7.3 percent respectively, but the sample B has lost in elongation about 7.3 percent in warp direction, when compared with its control sample.

The statistical analysis also proved that the elongation of nano finished sample (D) has increased significantly. But the sample B and C are not having significant difference in elongation in warp compared when compare its control sample. The sample D shows tremendous gain due to Nano finishing.

#### **D. Fabric elongation– weft**

The elongation of samples Control sample (A), conventionally finished sample (B), ultrasonic atomized sample(C), and nano finished sample (D), with statistical analysis is presented in Table- IX and Figure – VI

**TABLE – IX**  
**FABRIC ELONGATION (WEFT) (inches)**

S.No	Samples	Mean ± SD (inches)	Gain / Loss	% of Gain / Loss	T-test (P<0.05)
1	A	3.8 ± 0.19			
2	B	3.4 ± 0.24	- 0.44	11.6	7.333*
3	C	3.6 ± 0.23	- 0.18	4.8	1.000**
4	D	3.9 ± 0.38	0.12	3.2	3.415*

\*- Significant, \*\*- Not significant

The Table – VII and Figure – VI states that the samples B and C decrease in elongation about 11.6 and 4.8 percent with respectively. The sample D has remarkable improvement in elongation along weft direction about 3.2 percent than control sample. It was evident from statistical analysis that the significant difference was found in B, and D samples. There is no significant difference in sample C when compared with its control sample.

Figure – V

Fabric elongation (Warp) (Inches)

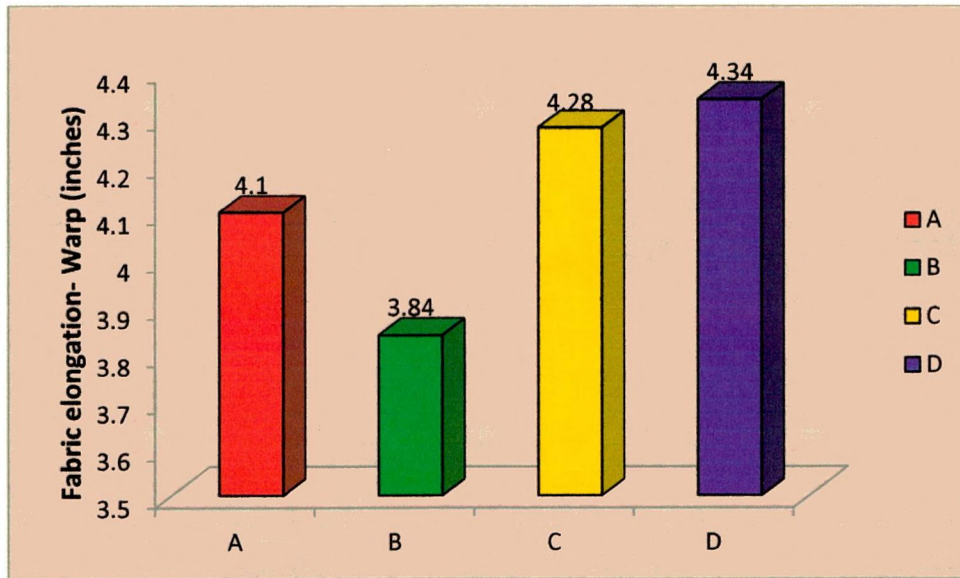
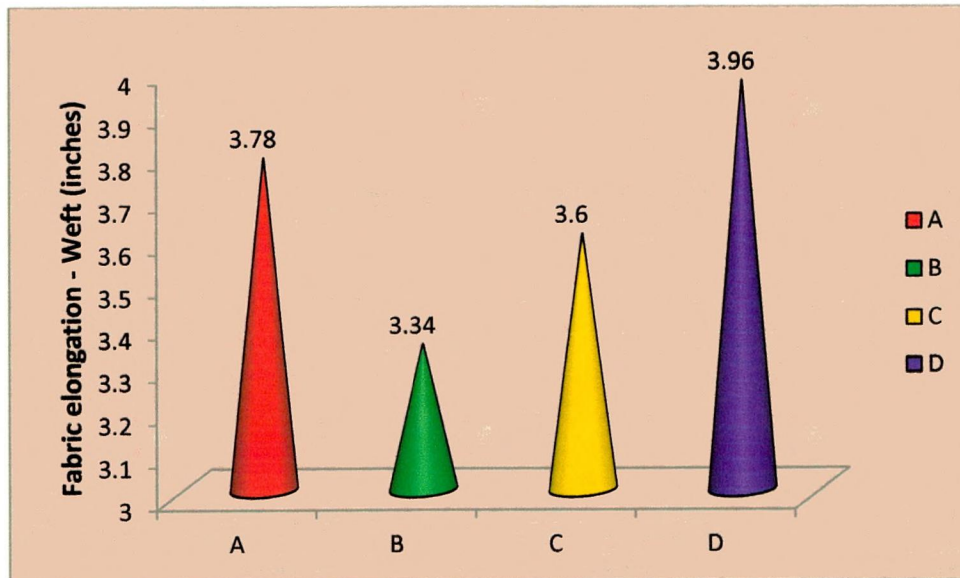


Figure - VI

Fabric elongation (Weft) (Inches)



A - Control sample, B - Conventional sample, C - Ultra sonic atomized sample, D - Nano finished sample

#### 4.1.3.2 Fabric abrasion resistance test

The results of Abrasion resistance of samples control sample (A), conventionally finished sample (B), ultrasonic atomized sample (C), and nano finished sample D, with statistical analysis is presented in Table- X and Figure – VII.

**TABLE – X**  
**ABRASION RESISTANCE (grams)**

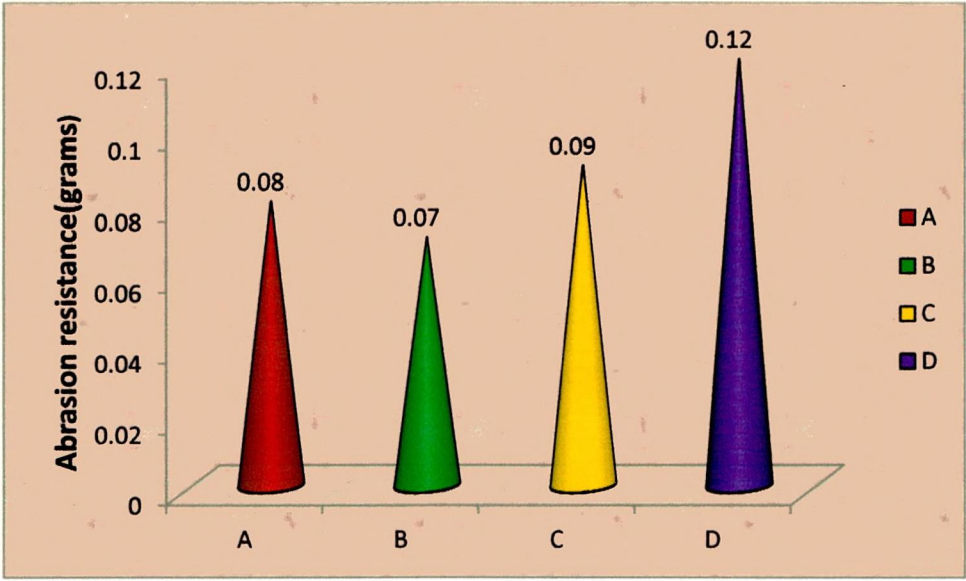
S.No	Samples	Mean $\pm$ SD (grams)	Gain / Loss	% of Gain / Loss	T-test (P<0.05)
1	A	0.08 $\pm$ 0.016			
2	B	0.07 $\pm$ 0.01	- 0.01	12.5	0.535**
3	C	0.09 $\pm$ 0.01	0.01	12.5	1.173**
4	D	0.1 $\pm$ 1.5	0.02	25	2.473*

\*- Significant, \*\*- Not significant

The above Table – X and Figure – VII is illustrating that the samples C and D have considerable progress in abrasion resistance about 12.5 and 25 percent. The sample B has lost its resistant to abrasion about 12.5 percent when compare with its control sample.

The statistics analysis proved that the sample D has significant difference, but there is no significant difference in samples B and C when compare with its control sample.

**Figure -VII**  
**Abrasion resistance (grams)**



**A - Control sample, B - Conventional sample, C - Ultra sonic atomized sample, D - Nano finished sample**

#### 4.1.4 Assessment of comfort properties

The comfort properties such as fabric stiffness, crease recovery along warp and weft direction and drapability of the samples

##### 4.1.4.1 Fabric stiffness

###### A. Fabric stiffness – (warp)

The stiffness of samples A, B, C, and D, with statistical analysis is mentioned in Table- XI and Figure – VIII

**TABLE – XI**  
**FABRIC STIFFNESS (WARP) (cm)**

S.No	Samples	Mean $\pm$ SD (cm)	Gain / Loss	% of Gain / Loss	T-test
1	A	1.6 $\pm$ 0.19			2.229*
2	B	1.9 $\pm$ 0.13	0.3	18.8	0.931**
3	C	1.8 $\pm$ 0.20	0.2	12.5	2.213*
4	D	1.96 $\pm$ 0.18	0.36	22.5	

\*- Significant, \*\*- Not significant

The Table – (XI) and Figure – (VIII) depicts that all the samples have gain in stiffness about 18.8, 12.5 and 22.5 percent along warp direction when compared to control sample (A).

It is also proved statistically that the samples B and C samples have remarkable difference, but the sample C is not having significant difference when compare its control sample because of the deposit of finishing agent.

###### B. Fabric stiffness– weft

The stiffness of samples control sample (A), conventionally finished sample (B), ultrasonic atomized sample (C), and nano finished sample D, with statistical analysis is presented in Table- XII and Figure –IX

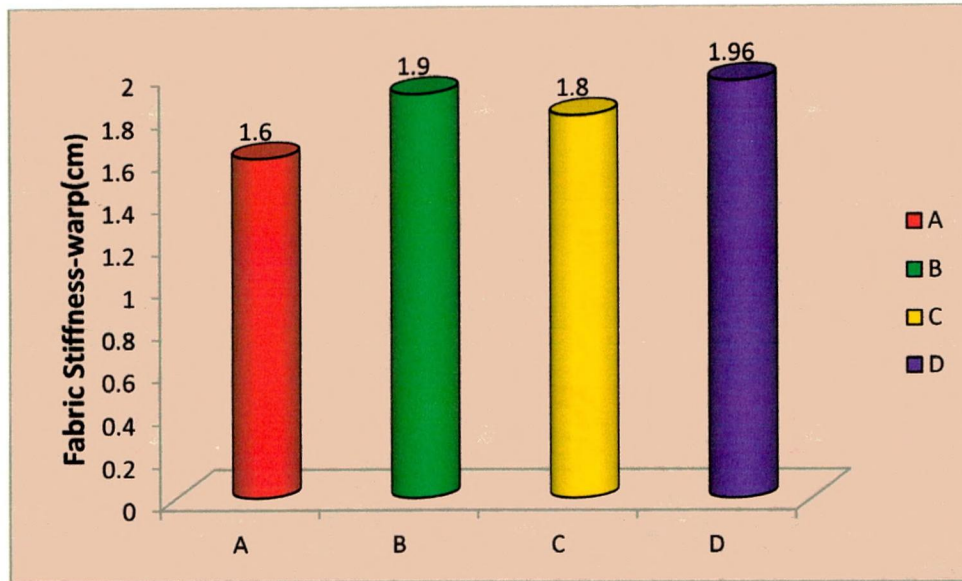
**TABLE- XII**  
**FABRIC STIFFNESS (WEFT) (cm)**

S.No	Samples	Mean $\pm$ SD (cm)	Gain / Loss	% of Gain / Loss	T-test (P<0.05)
1	A	1.3 $\pm$ 0.19			
2	B	1.67 $\pm$ 0.20	0.37	28.5	1.976**
3	C	1.64 $\pm$ 0.11	0.34	26.2	3.720*
4	D	1.8 $\pm$ 0.15	0.5	38.5	4.147*

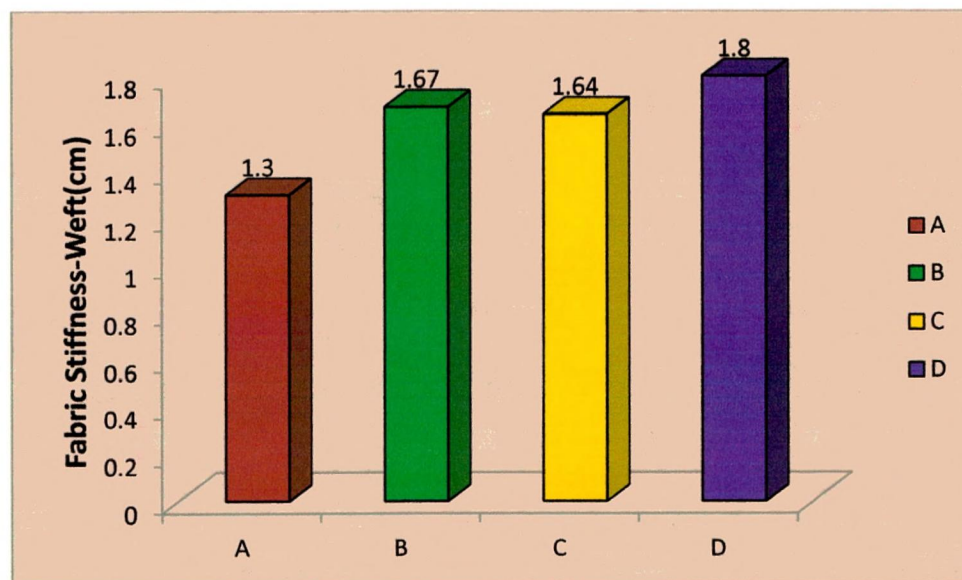
\*- Significant, \*\*- Not significant

The Table – (XII) and Figure – (IX) clarify that all the samples shows remarkable increase in stiffness in weft direction about 28.5, 26.2, and 38.5 percent compare with its control sample (A). It is also statistically proved that the samples C and D samples have remarkable difference, but the sample B is not having significant difference when compare with its control sample

**Figure –VIII**  
**Fabric Stiffness – (Warp) (cm)**



**Figure – IX**  
**Fabric Stiffness – (Weft) (cm)**



**A - Control sample, B - Conventional sample, C - Ultra sonic atomized sample, D - Nano finished sample**

### A. Crease recovery – (warp)

The results of the samples A, B, C, and D in crease recovery with statistical analysis is presented in Table- XIII and Figure – X

**TABLE – XIII**  
**CREASE RECOVERY (WARP)**

S.No	Samples	Mean $\pm$ SD	Gain / Loss	% of Gain / Loss	T-test (P<0.05)
1	A	120.8° $\pm$ 3.4			0.661**
2	B	119.2° $\pm$ 3.4	-1.6	1.3	2.991*
3	C	115.4° $\pm$ 3.6	-5.4	4.5	5.750*
4	D	113° $\pm$ 2.7	-7.8	6.5	

\*Significant, \*\*- Not significant

It was clear from Table – (XIII) and Figure – (X) that all the finished samples B, C, and D have improvement in crease recovery in warp direction on 1.3, 4.5, and 6.5. Lesser crease recovery angle shows higher the crease recovery.

The statistical analysis also reveals that the samples C and D show significant variation and there is no considerable difference in sample B when compared with its control sample. The nano finished sample (D) shows maximum crease recovery because of effect of finishes and its process.

### B. Crease recovery – (weft)

The Crease recovery of following samples A, B, C, and D, with statistical analysis is presented in Table- XIV and Figure – XI

**TABLE – XIV**  
**CREASE RECOVERY (WEFT)**

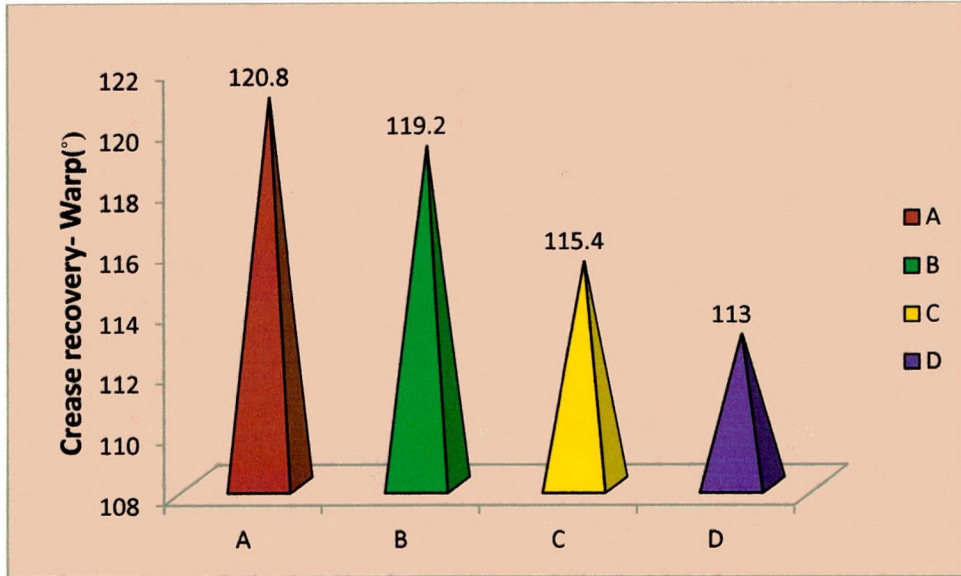
S.No	Samples	Mean $\pm$ SD	Gain / Loss	% of Gain / Loss	T-test (P<0.05)
1	A	123.6° $\pm$ 3.36			
2	B	122.8° $\pm$ 1.92	-0.8	0.7	0.419**
3	C	122.2° $\pm$ 2.38	-1.4	1.2	0.686**
4	D	115.8° $\pm$ 2.64	-7.8	6.3	4.268*

\*Significant, \*\*- Not significant

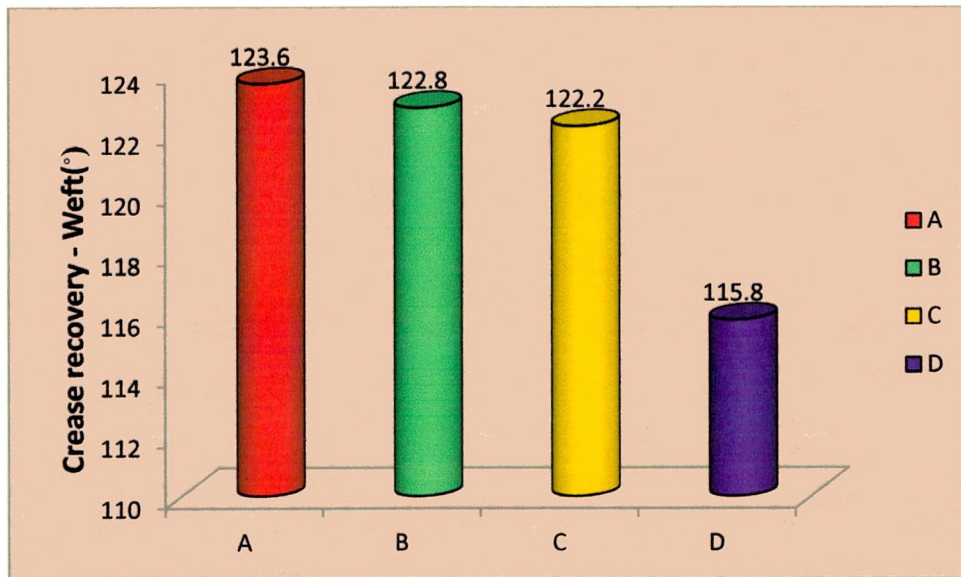
Table – (XIV) and Figure – (XI) shows that all the samples B, C, and D have gained in crease recovery in weft direction on 0.7, 1.2, and 6.3. Lesser crease recovery angle shows higher the crease recovery.

The statistical analysis depicts that the sample D shows significant difference and there is no difference in samples B and C when compared with its control sample. The nano finished sample (D) shows maximum crease recovery when compare with its control sample.

**Figure – X**  
**Crease recovery (Warp)**



**Figure – XI**  
**Crease recovery (Weft)**



**A - Control sample, B - Conventional sample, C - Ultra sonic atomized sample, D - Nano finished sample**

#### 4.1.4.3 Fabric drapability

The Drapability of samples A, B, C, and D, with statistical analysis is presented in Table- XV and Figure – XII

**TABLE – XV**  
**FABRIC DRAPABILITY (grams)**

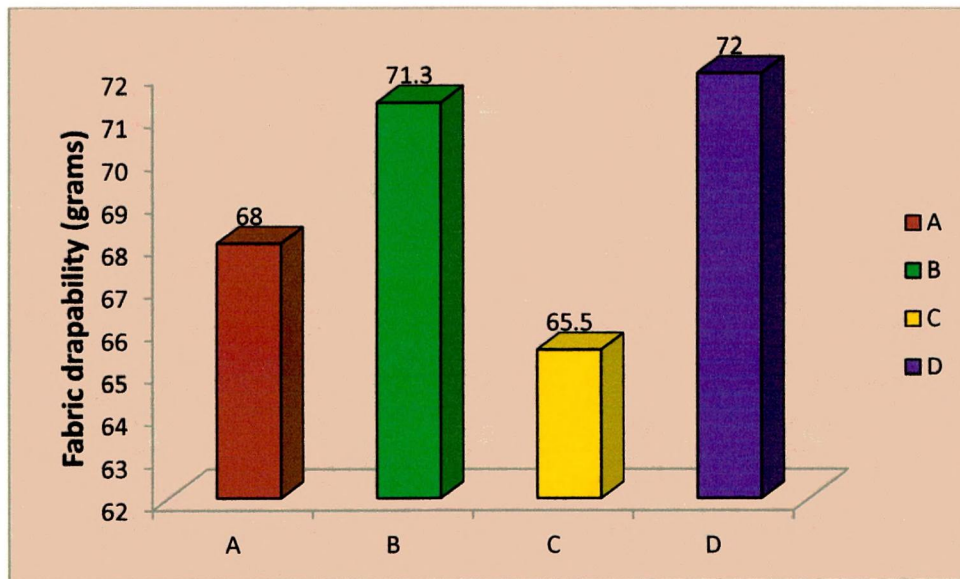
S.No	Samples	Mean $\pm$ SD (grams)	Gain / Loss	% of Gain / Loss	T-test (P<0.05)
1	A	68 $\pm$ 1.7			3.903*
2	B	71.3 $\pm$ 0.54	3.3	4.6	3.748*
3	C	65.5 $\pm$ 0.41	2.5	3.7	6.159*
4	D	72 $\pm$ 0.46	4	5.9	

\*- Significant, \*\*- Not significant

Higher the drape co-efficient value shows lesser the drapability. The Table – (XV) and Figure –(XII) confirm that all the treated samples such as A, B, C, and D are decrease in drapability about 4.6, 3.7, and 5.9 percent respectively because of the finishing increase the stiffness of the fabric.

From the statistical analysis it was clearly evident that all the samples have significant difference in drapability of the fabric

**Figure – XII**  
**Fabric drapability (grams)**



**A - Control sample, B - Conventional sample, C - Ultra sonic atomized sample, D - Nano finished sample**

#### 4.1.6 Absorbency test

**TABLE – XVI**  
**DROP TEST**

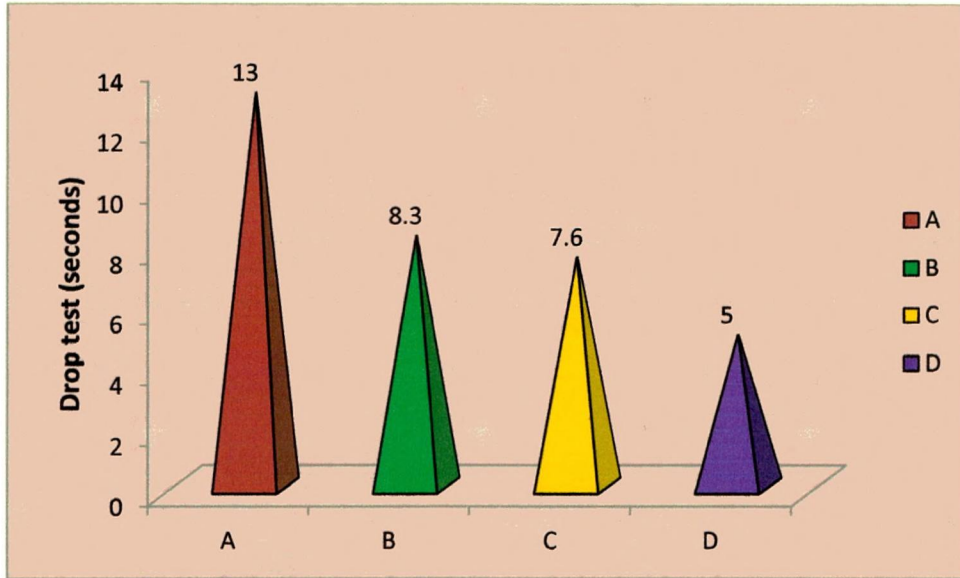
S.No	Samples	Mean	Gain / Loss	% of Gain / Loss
1	A	13	-	-
2	B	8.3	4.7	36
3	C	7.6	5.4	42
4	D	5	8	61.5

The Table – (XIV) and Figure (XIII) depicts that the highest absorbency was found in sample D about 61.5 percent. The sample C and B have increase in absorbency on 42, 36 percent than control sample. All the treated samples show significant improvement in absorbency due to finishing processes.

**TABLE – XVII**  
**SINKING TEST**

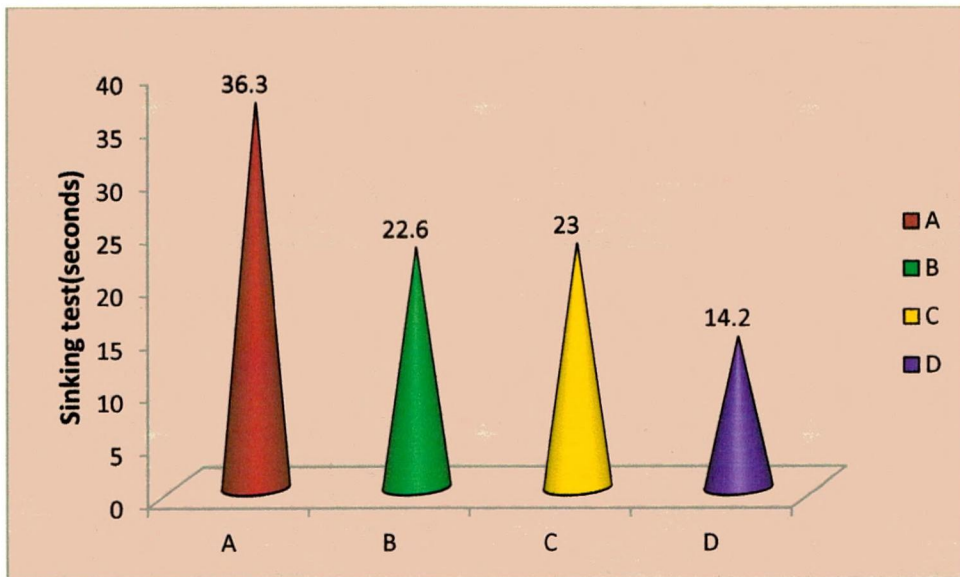
S.No	Samples	Mean	Gain / Loss	% of Gain / Loss
1	A	36.3	-	-
2	B	22.6	13.7	37.7
3	C	23	13.3	36.7
4	D	14.2	22.1	61

**Figure – XIII**  
**Drop test (seconds)**



**A - Control sample, B - Conventional sample, C - Ultra sonic atomized sample, D - Nano finished sample**

**Figure – XIV**  
**Sinking test (seconds)**



**A - Control sample, B - Conventional sample, C - Ultra sonic atomized sample, D - Nano finished sample**

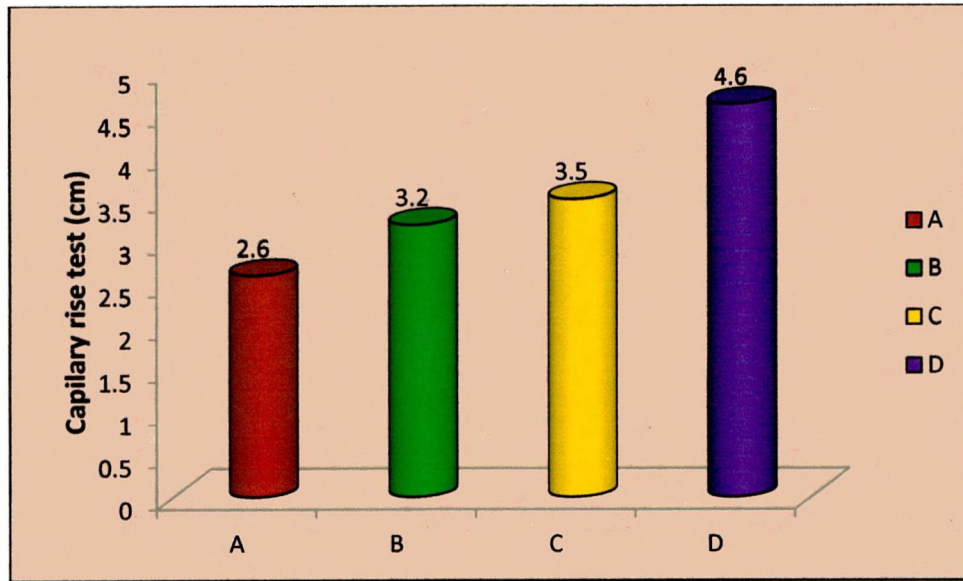
The Table – (XVII) and Figure – (XIV) affirms that all the treated samples have remarkable gain in absorbency. Among the samples the highest absorbency level was achieved by sample D about 61 percent from control sample due to nano finishing. Other samples such as C and B also have improvement on 37.7, 36.7percent from control sample.

**TABLE – XVIII**  
**CAPILARY RISE TEST**

S.No	Samples	Mean	Gain / Loss	% of Gain / Loss
1	A	2.6	-	-
2	B	3.2	0.6	2.3
3	C	3.5	0.9	3.4
4	D	4.6	2.1	7.6

The Table – (XVIII) and Figure – (XV) shows that sample D has maximum absorbency about 7.6 percent than other samples .the sample C and, sample D also gain in absorbency in 3.4, 2.3 percent respectively . It was clear that Nano finishing improves the absorbency of the fabric.

**Figure – XV**  
**Capillary rise test (cm)**



**A - Control sample, B - Conventional sample, C - Ultra sonic atomized sample, D - Nano finished sample**

#### 4.1.6 Assessment of Functional properties

##### 4.1.6.1 Evaluation of antibacterial activity

The antibacterial activity of control and treated samples against Staphylococcus (gram positive) and E.Coli (gram negative) were evaluated by Disc diffusion method. The diameter of incubation zone was presented in Table – XIX.

**TABLE – XIX**  
**ANTIBACTERIAL ACTIVITY (mm)**

SAMPLES	UNWASHED SAMPLES (mm)		WASHED SAMPLES (mm)	
	Staphylococcus	E.Coli	Staphylococcus	E.Coli
<b>A</b>	0	0	0	0
<b>B</b>	15	11	8.7	6.3
<b>C</b>	17.5	13	9.5	8.6
<b>D</b>	20	17	15	12

From the Table –XIX, and Figure - XVI it is clear that the sample D shows maximum diameter of inhibition zone about 20mm and 17mm before washing and 15mm, 12mm after washing against both Staphylococcus (gram positive)(PLATE – XXIII), and E- Coli (gram negative) (PLATE- XXIV). The samples B and C has the zone diameter of 15mm, 11mm and 17.5mm, 13mm in before washing, and 8.7mm, 6.3mm and 9.5mm, 8.6mm zone diameter in after washing.

The major difference between the microbial structure of bacteria Staphylococcus and E-Coli arises from the chemical composition of the cell wall of bacteria, actually the content of lipo polysaccharide contained in the cell wall of gram negative bacteria is much more important than in the gram positive bacteria, then the antibacterial agents have more difficulties to cross the wall of gram negative bacteria.

This was the reason for treated samples have higher inhibition zone against Staphylococcus than E-Coli.

Finally, it was concluded that the nano finishing improved the antibacterial activity of both washed and unwashed samples. The sample D has maximum wash durability due to deep penetration of nano particles.

**PLATE - XXIII**

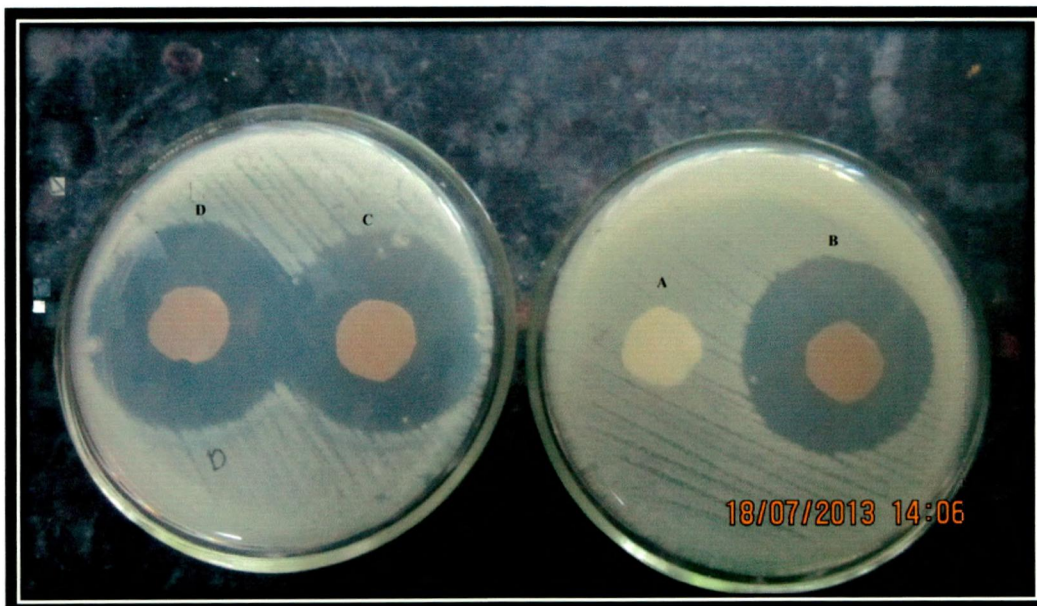
**ANTIBACTERIAL ACTIVITY AGAINST STAPHYLLOCOCCUS**



**A - Control sample, B - Conventional sample, C - Ultra sonic atomized sample, D - Nano finished sampl**

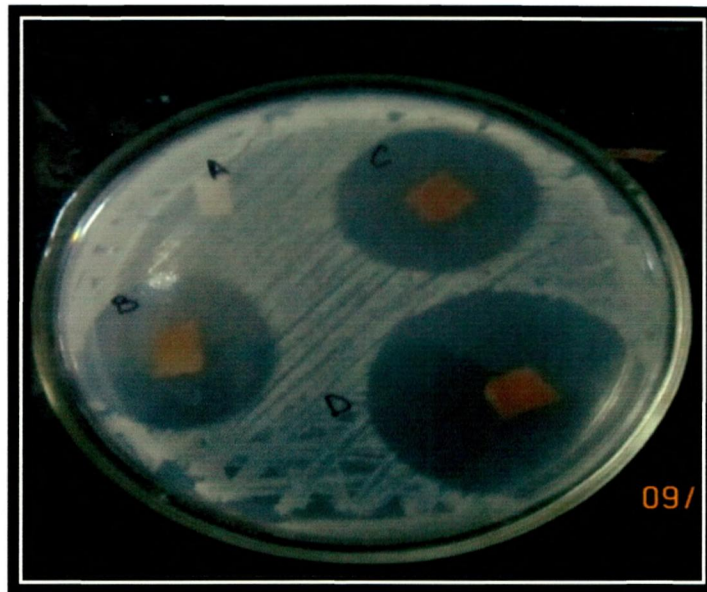
**PLATE - XXIV**

**ANTIBACTERIAL ACTIVITY AGAINST E-COLI**



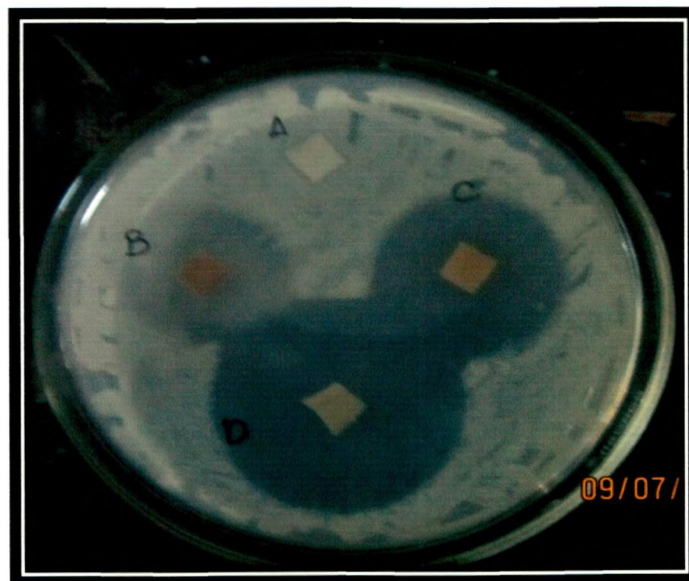
**A - Control sample, B - Conventional sample, C - Ultra sonic atomized sample, D - Nano finished sample**

**PLATE - XXV**  
**ANTIBACTERIAL ACTIVITY AGAINST STAPHYLLOCOCCUS (WASHED SAMPLE)**



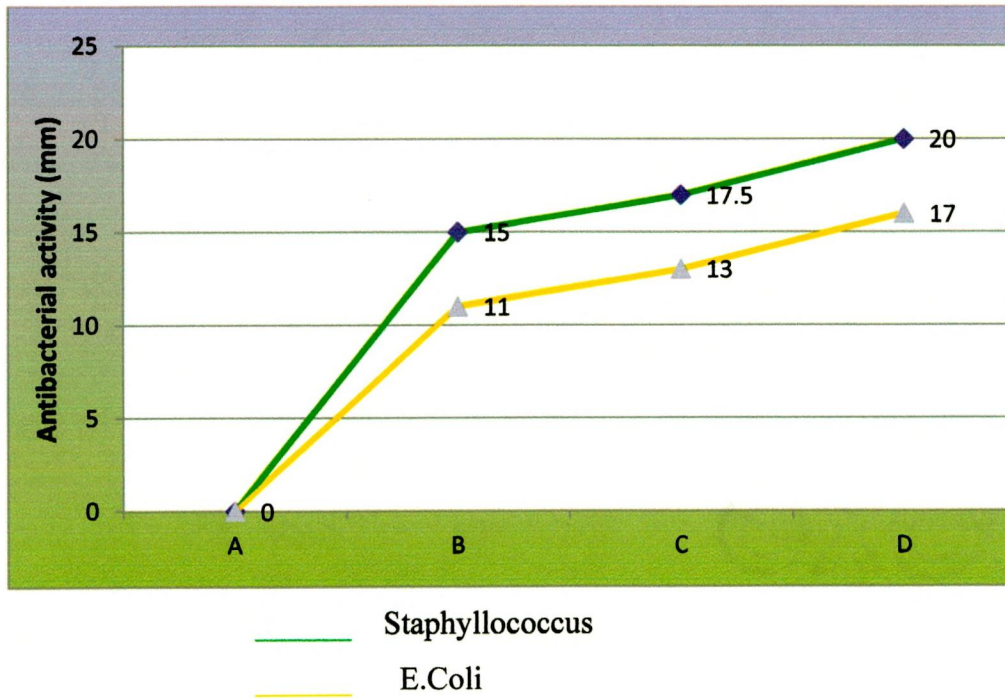
**A - Control sample, B - Conventional sample, C - Ultra sonic atomized sample, D - Nano finished sample**

**PLATE - XXVI**  
**ANTIBACTERIAL ACTIVITY AGAINST E-COLI (WASHED SAMPLE)**



**A - Control sample, B - Conventional sample, C - Ultra sonic atomized D - Nano finished sample**

**Figure – XVI**  
**Antibacterial activity (mm)**



**A - Control sample, B - Conventional sample, C - Ultra sonic atomized sample, D - Nano finished sample**

PLATE – XXVII  
CAGE TEST FOR MOSQUITO REPELLENT



#### 4.1.6.2 Evaluation of Mosquito repellent finishing

The repellency of mosquitoes was evaluated in cage test. The treated and untreated fabrics were placed inside the cage and the mosquitoes were put into the cage. All the mosquitoes were found in untreated fabric. The treated fabric is not affected by mosquitoes because it has good repellency due to finishing agent. (Plate-XXVI)

#### 4.1.6.3 Quantitative evaluation of fragrance finishing

The fragrance deposition and release rate on fabric samples in all the three finished samples such as Conventionally finished sample (B), Ultrasonic atomized sample (C), Nano finished sample (D), were measured using Nano visual spectrometer.

**TABLE - XX**  
**CONCENTRATION OF FRAGRANCE ON THE FABRIC (mm/g)**

<b>SAMPLES</b>	<b>IMMEDIATE</b>	<b>AFTER 8 DAYS</b>
B	0.463	0.242
C	0.904	0.643
D	1.892	1.765

From the Table, it was stated that, sample D shows higher fragrance deposition which has higher readings. Next to it was sample C and then sample B. After Four days, the best result is found in sample D again. Sample D has more fragrance deposition compared to other two samples because the Nano finishing produces the deep penetration of fragrance on fabric.

**TABLE - XXI**

**CONCENTRATION OF FRAGRANCE ON THE WASHED FABRIC (mm/g)**

SAMPLES	IMMEDIATE	AFTER 8 DAYS
<b>B</b>	0.067	0.003
<b>C</b>	0.326	0.087
<b>D</b>	0.957	0.436

The evaluation also done for washed samples to analyze the wash durability of the samples. The Table shows that the maximum concentration was found in sample D after washing. Even after Four days sample D has higher value than other samples due to nano finishing.

**Release rate of fragrance**

The fragrance keeps on releasing day by day depends on certain release rate of fragrance was measured immediately, then after Four days and then after Eight days. The lowest release rate indicates better penetration of finishing in fabric.

**TABLE - XXII**

**RELEASE RATE OF FRAGRANCE (%)**

SAMPLES	AFTER 8 DAYS (%)
<b>B</b>	47.7
<b>C</b>	28.9
<b>D</b>	20.7

The Table depicts that the lowest fragrance release rate was seen in sample D due to deep penetration of Nano particles. The sample C has lesser value then sample B. After Eight days again the best result was found in sample D than other two samples. This indicates that the sample D has best adherence with fabric due to Nano finishing.

**TABLE - XXIII**  
**RELEASE RATE OF FRAGRANCE IN WASHED FABRIC (%)**

SAMPLES	AFTER 8 DAYS (%)
B	95.5
C	73.2
D	54.4

The Table - XXIII confirms that the sample D has minimum release rate of fragrance about 54.4 percent than other samples after eight days. The sample C has 73.2 percent and sample B has 95.5 percent of release rate respectively. The highest release rate was found in sample B that indicates the conventional method has least durability.

The best results were obtained in nano finished sample (D) due to deep penetration of nano particles.

#### **4.1.7 SEM analysis**

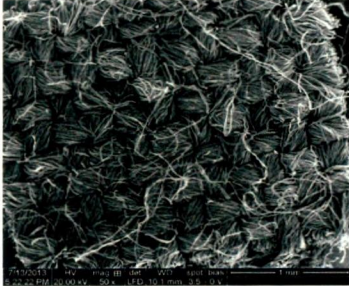
The surface morphology of nanofinished sample was studied using SEM analysis. It was viewed in different magnitude such as 1mm, 500 $\mu$ m, 200 $\mu$ m, 100 $\mu$ m, 50 $\mu$ m, 10 $\mu$ m. it clearly showed adherence of nanoparticles with fabric surface. The sizes of nano particles varied from 30 nm to 65 nm. (Plate – XXVIII)

**PLATE – XXVIII**

**SEM ANALYSIS**

**The nano finished sample was viewed in different magnitude**

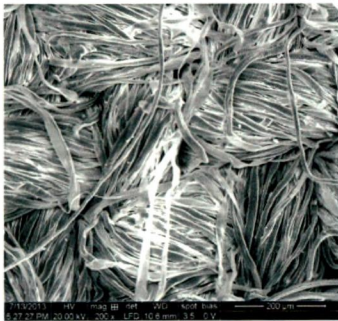
**1mm**



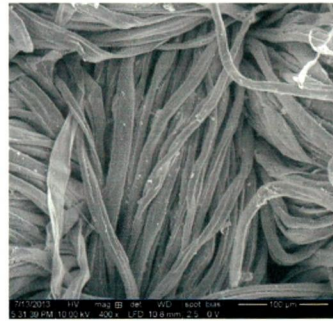
**500  $\mu$ m**



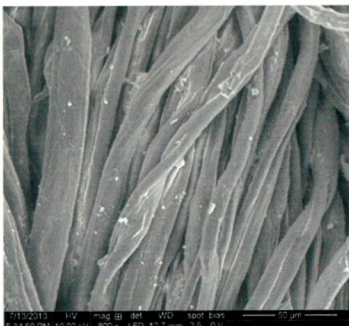
**200  $\mu$ m**



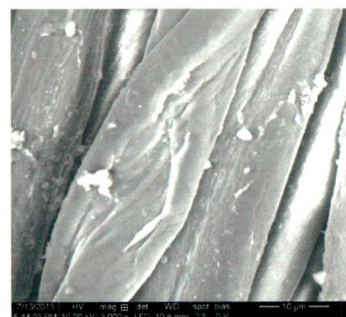
**100  $\mu$ m**

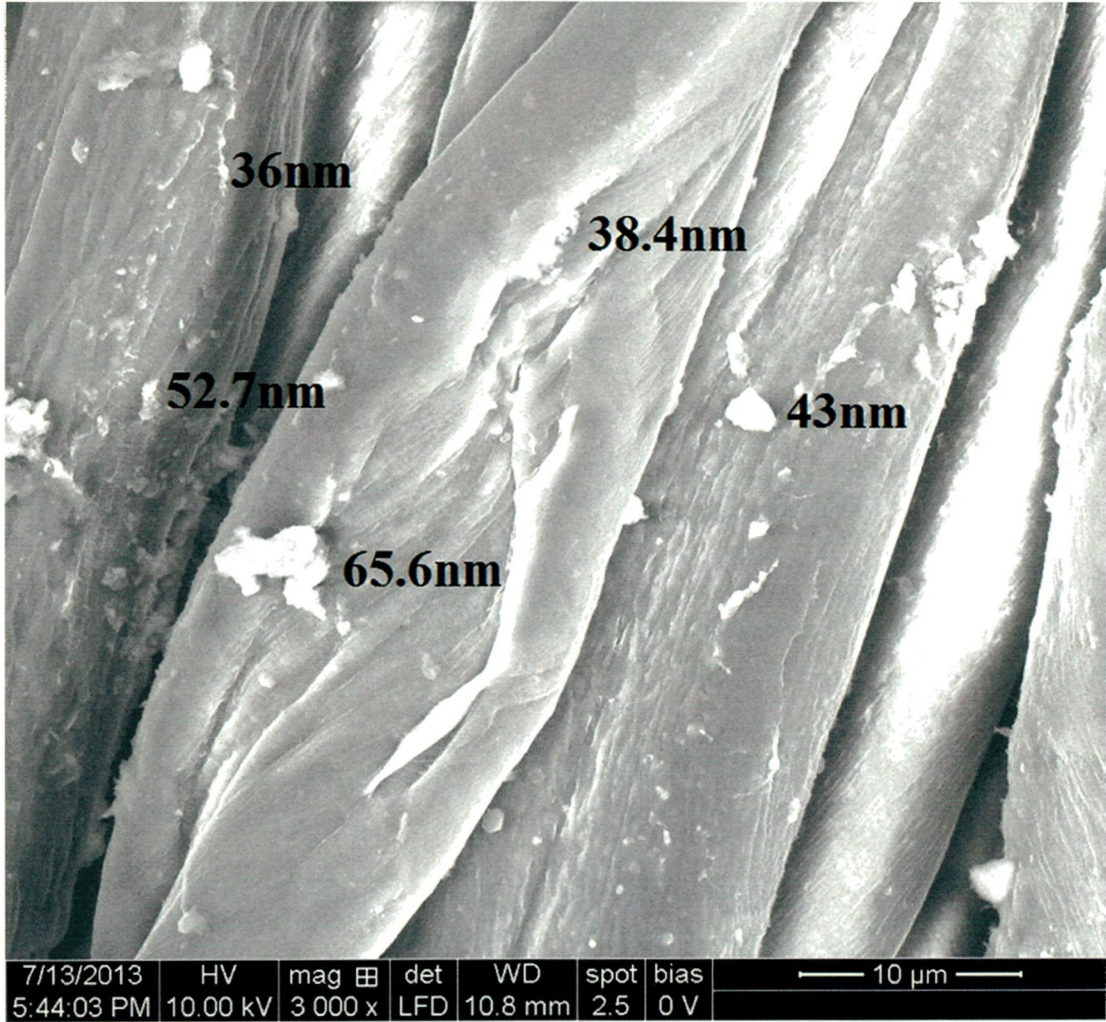


**50  $\mu$ m**



**10  $\mu$ m**





#### **4.1.8 Evaluation of wash durability**

The performance finishes such as antibacterial activity and fragrance finishing were evaluated after washing. The nano finished fabric showed excellent antibacterial activity against both Staphylococcus (Plate – XXV), and E-Coli (Plate – XXVI) about 15mm and 12mm zone diameter respectively after 10 washes. The fragrance of the nanofinished sample was found more durable than other samples after 10 washes.