

# SIGNIFICANCE OF MOISTURE MANAGEMENT IN TEXTILES

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**Abstract:** Comfort is one of the most important aspects of all clothing. In this research an attempt has been made to finish the fabric with various softeners. Four different types of bleached fabrics like cotton, heavy cotton, P/ V blend, P/C blend were used for the study. These fabrics were treated with softeners like Anionic, Nonionic, PE Emulsion, Amino Silicone, Micro Amino Silicone, Reactive Softener, Glycerin, Micro Silicone and hydrophilic silicones like Silkofeel HP 678, Silkofeel HP 387 to improve the comfort properties of fabrics. The softener concentrations were varied as 10 gpl, 20 gpl, 30 gpl and 40 gpl. The results have shown that the fabrics treated with Silkofeel HP 678 had significant improvement in all comfort properties like wicking, water absorbency, air permeability, bending length.

**Keywords:** Moisture management, Comfort, Wetting, Wicking, Moisture Vapour Transmission

## I. INTRODUCTION

Around the world rapid changes are calling for a different look and a newer feel in both fashion and fabric. Whether it is woven or knitted, the demand is for something new and different in the world of high fashion. As the worldwide business gears to tackle the challenges, product diversification has become the key to global opportunities. The main factors affecting consumers when selecting garments are aesthetic, appearance and fashion. Besides these factors, comfort properties of garments during usage are important. Now-a-days, consumers have become much more demanding when it comes to the properties of clothing, particularly those of leisure and sportswear. One of the textile properties that have steadily gained importance among increasingly well-informed consumers are breathability of the material, because this property seems to be directly linked to comfortable wear of the garment. To be comfortable and to maintain the state of comfort, clothing must be designed to allow the body's heat balance to be maintained under a wide range of environmental conditions and body activity. It should fulfill this function without inhibiting the evaporation of humidity caused by perspiration (good moisture management), and thus not interfering with the temperature regulation of the body.

Moisture management is one of the key performance criteria in today's apparel industry, which decides the comfort level of that fabric. Wearing garments that transport moisture and evaporate it quickly actually enhance your body's ability to cool itself. Moisture management can be defined as the controlled movement of water vapour and liquid water (perspiration) from the surface of the skin to the atmosphere through the fabric. This action prevents perspiration from remaining next to the skin. When your body can cool itself more effectively you actually perspire less as a result. With reduced perspiration your body requires less dehydration, and maintains maximum performance for an extended period of time. Top athletes, emergency personnel and even the military have realized that proper moisture management optimizes physical performance and endurance.

The main aim of development of moisture management fabrics is:

- a) To transport the humidity to the atmosphere as fast as possible
- b) To evaporate the humidity as early as possible
- c) To make the skin feel dry

Moisture management can include the use of microfiber technology or the application of various softening finishes like silicones at the molecular level to enhance both hydrophobic and hydrophilic properties of a fabric. Hydrophilic fabrics or waterproof breathable fabrics are some advances in the field of moisture management in textiles. Water-resistant and moisture-permeable materials may be divided into three main categories - high-density fabrics, resin-coated materials and film-laminated materials which are selected by manufacturers according to finished garment requirements in casual, athletic, ski or outdoor apparel.

One of the ways of improving moisture management property of a fabric is by applying softener finishing on it. A softener is defined as an auxiliary that when applied to textile material improves its handle with more pleasing touch. Fabric softeners have been used to impart good softening characteristics of various fibres to get desired handle, wherein they help as fibre lubricants, overcome the harshness imparted by natural oils during scouring and also overcome the rigidity imparted by resin finishing.

Several studies have been made to measure the effect of fabric constructions or finishes on changes in hand and correlations were generally good between these mechanical properties and sensory hand response. The present article is

the outcome of an investigation carried out with the objectives of studying the moisture management properties of cotton and blended fabrics finished with various types of softeners.

## II. MATERIALS AND METHODS

### 2.1 Materials

#### 2.1.1 Fabrics

A total number of four different types of scoured and bleached fabrics- 133GSM cotton(warp count -32 Ne<sup>s</sup>, weft count- 29 Ne<sup>s</sup>, 104 ends/inch, 68 picks/inch, plain weave), 263 GSM cotton(warp count -19 Ne<sup>s</sup>, weft count- 10 Ne<sup>s</sup>, 112 ends/inch, 52 picks/inch, twill weave) and blended fabrics like 100 GSM polyester/viscose(warp count - 49 Ne<sup>s</sup>, weft count- 56 Ne<sup>s</sup>, 100 ends/inch, 84 picks/inch, plain weave), 63 GSM polyester/cotton(warp count -74 Ne<sup>s</sup>, weft count- 59 Ne<sup>s</sup>, 96 ends/inch, 72 picks/inch, plain weave) blended fabrics were selected for the study.

#### 2.1.2 Chemicals

Different softeners like anionic, non- ionic, reactive, reactive softener + glycerin, amino silicone, amino silicone + glycerin, micro amino silicone, micro silicone softener, Silkofeel HP 387 (hydrophilic silicone), Silkofeel HP 678(hydrophilic silicone) and PE emulsion softener were used. All softeners were of industrial grade.

### 2.2 Methods

#### Softening Treatment

The softening treatment was given using pad- dry- cure method. The concentrations of all softeners were varied from 10 gpl, 20 gpl, 30 gpl and 40 gpl. The pH of the solution was maintained at 5.5 using small quantity of acetic acid. The treated samples were padded at constant pressure to achieve 60 % expression. The curing temperature for reactive softener was maintained at 160°C for 60 Sec while remaining softeners were dry cum cured at 80 °C for 60 Sec.

## III. TESTING

All the finished fabrics were tested for the various moisture managing properties in standard atmospheric condition of 65±2% RH and 25±2 °C temperature. The properties tested were as follows

### 3.1 Air Permeability

Air permeability of treated fabrics was measured in terms of cm<sup>3</sup>/cm<sup>2</sup>/s, using Air Permeability Tester using ASTM D 737 test standard. The specimen was clamped over the test head opening by pressing down the clamping arm which automatically started the vacuum pump. The pre- selected test pressure was automatically maintained and after a few seconds the air permeability of the test specimen was digitally displayed on the screen. This air permeability was measured at different positions for each specimen.

### 3.2 Wickability Test

Vertical wicking is one of the most widely used test method for describing the wickability of fabric. The strip test is employed to measure the wickability of fabrics using DIN 53925 test standard. In which a sample of 20 cm x 2.5 cm was suspended vertically with its lower end immersed in a reservoir of distilled water containing red dye. Water is transported by the immersed fabric and travels vertically against gravity. The height achieved by water in particular time is recorded at specified intervals.

### 3.3 Drop Test

A drop of water is allowed to fall from a fixed height onto the taut surface of a test specimen. The time required for the specular reflection of the water drop to disappear is measured and recorded as water absorbency time. It was measured by the standard method AATCC 79-2000.

### 3.4 Moisture Regain/ Moisture Content

The moisture content and moisture regain of each sample is measured in standard atmospheric condition using ASTM D 2495 test standard.

### 3.5 Perspiration Fastness

Fabric samples were evaluated for perspiration fastness for both acidic and alkaline perspiration using ISO 105- E04 1994 Standard method.

### 3.6 Whiteness Index

Fabric samples were evaluated for Whiteness Index by using Computer Colour Matching (CCM) system as per the ASTM D1925 method.

IV. RESULT AND DISCUSSION

The untreated and finished fabrics were subjected to various tests to analyse the comfort and handle properties and the results are discussed below

Table 4.1: Effect of various Softeners on Air Permeability of 133 GSM Cotton substrate

Sr. No.	Softener	Air Permeability(cm <sup>3</sup> /cm <sup>2</sup> /sec)				
		Control Sample	Softener Concentration (gpl)			
			10	20	30	40
		4.03				
1	Anionic Softener	-	3.82	3.48	3.426	3.38
2	Non-ionic Softener	-	3.438	3.400	3.254	3.460
3	PE Emulsion Softener	-	3.80	3.764	3.676	3.086
4	Silkofeel HP678 Softener	-	3.49	3.38	3.126	3.010
5	Silkofeel HP387 Softener	-	3.502	3.461	3.32	3.16
6	Reactive Softener	-	3.632	3.558	3.518	3.418
7	Reactive Softener + Glycerin	-	3.75	3.40	2.94	2.93
8	Amino Silicone	-	3.906	3.81	3.648	3.497
9	Amino Silicone + Glycerin	-	3.81	3.708	3.679	3.390
10	Micro Amino Silicone	-	3.91	3.81	3.70	3.62
11	Micro Silicone Softener	-	3.97	3.86	3.73	3.622

Results of table 4.1 indicate that for 133 GSM cotton fabrics treated with various softeners, the value of air permeability decreases as the softener concentration increases from 10 gpl to 40 gpl. The anionic softener shows that there is decrease in air permeability value from 3.82 to 3.38cm<sup>3</sup>/cm<sup>2</sup>/sec. The Silkofeel HP678 softener shows the same trend as 3.49 to 3.01cm<sup>3</sup>/cm<sup>2</sup>/sec. The minimum value of air permeability was found to be 3.01cm<sup>3</sup>/cm<sup>2</sup>/Sec at 40 gpl concentrations of Silkofeel HP678 softener.

The other softeners have shown more values of air permeability as compared with that of Silkofeel HP678. The reason behind this may be the swelling of fibres due to hydrophilic silicone group present in Silkofeel HP678 softener which the air spaces between fibres resulting in decrease in air permeability.

Table 4.2: Effect of various Softeners on Air Permeability of 263 GSM Cotton substrate

Sr. No.	Softener	Air Permeability(cm <sup>3</sup> /cm <sup>2</sup> /sec)				
		Control Sample	Softener Concentration (gpl)			
			10	20	30	40
		1.158				
1	Anionic Softener	-	1.120	1.072	1.110	0.994
2	Nonionic Softener	-	1.114	1.110	1.07	1.058
3	PE Emulsion Softener	-	1.13	1.12	1.1	1.08
4	Silkofeel HP678 Softener	-	1.140	1.087	1.072	1.044
5	Silkofeel HP387 Softener	-	1.14	1.09	1.086	1.054
6	Reactive Softener	-	1.15	1.14	1.12	1.14
7	Reactive Softener + Glycerin	-	1.14	1.12	1.10	1.06
8	Amino Silicone	-	1.142	1.136	1.112	1.107
9	Amino Silicone + Glycerin	-	1.136	1.1052	1.076	1.056
10	Micro Amino Silicone	-	1.146	1.14	1.136	1.13
11	Micro Silicone Softener	-	1.148	1.14	1.133	1.13

Results of table 4.2 indicate that for 263 GSM cotton fabrics treated with various softeners, the value of air permeability decreases as the softener concentration increases from 10 gpl to 40 gpl. The anionic softener shows that there is decrease in air permeability value from 1.12 to 0.994cm<sup>3</sup>/cm<sup>2</sup>/sec. The Silkofeel HP678 softener shows the same trend as 1.14 to 1.044cm<sup>3</sup>/cm<sup>2</sup>/sec. The minimum value of air permeability was found to be 1.044cm<sup>3</sup>/cm<sup>2</sup>/sec at 40 gpl concentration of Silkofeel HP678 softener. The other softeners have shown more values of air permeability as compared with that of Silkofeel HP678.

The reason behind this may be the swelling of fibres due to hydrophilic silicone group present in Silkofeel HP678 softener which the air spaces between fibres resulting in decrease in air permeability.

Table 4.3: Effect of various Softeners on Air Permeability of Polyester/Viscose Blend substrate

Sr. No.	Softener	Air Permeability(cm <sup>3</sup> /cm <sup>2</sup> /sec)				
		Control Sample	Softener Concentration (gpl)			
			10	20	30	40
		27.325				
1	Anionic Softener	-	26.622	26.387	26.40	26.058
2	Non-ionic Softener	-	25.798	25.576	24.942	24.074
3	PE Emulsion Softener	-	26.512	26.140	23.850	21.034
4	Silkofeel HP678 Softener	-	24.048	23.79	21.616	20.928
5	Silkofeel HP387 Softener	-	24.083	24.79	23.616	20.928
6	Reactive Softener	-	25.50	24.666	23.432	21.344
7	Reactive Softener + Glycerin	-	25.20	25.00	24.18	23.29
8	Amino Silicone	-	26.222	26.054	26.00	25.090
9	Amino Silicone + Glycerin	-	26.00	25.84	25.75	25.50
10	Micro Amino Silicone	-	27.01	26.93	26.892	26.67
11	Micro Silicone Softener	-	27.024	27.00	26.388	26.70

Results of table 4.3 indicate that for 100 GSM cotton fabrics treated with various softeners, the value of air permeability decreases as the softener concentration increases from 10 gpl to 40 gpl. The anionic softener shows that there is a decrease in air permeability value from 26.622 to 26.058 cm<sup>3</sup>/cm<sup>2</sup>/Sec. The Silkofeel HP678 softener shows the same trend as 24.048 to 20.928cm<sup>3</sup>/cm<sup>2</sup>/sec. The minimum value of air permeability was found to be 20.928cm<sup>3</sup>/cm<sup>2</sup>/sec at 40 gpl concentration of Silkofeel HP678 softener. The other softeners have shown more values of air permeability as compared with that of Silkofeel HP678.

The reason behind this may be the swelling of fibres due to hydrophilic silicone group present in Silkofeel HP678 softener which the air spaces between fibres resulting in decrease in air permeability.

Table 4.4: Effect of various Softeners on Air Permeability of Polyester/Cotton Blend substrate

Sr. No.	Softener	Air Permeability(cm <sup>3</sup> /cm <sup>2</sup> /sec)				
		Control Sample	Softener Concentration (gpl)			
			10	20	30	40
		104.398				
1	Anionic Softener	-	102.84	101.24	101.068	100.840
2	Non-ionic Softener	-	105.360	105.582	105.95	106.154
3	PE Emulsion Softener	-	106.580	106.398	105.314	105.192
4	Silkofeel HP678 Softener	-	100.17	98.95	93.51	91.78
5	Silkofeel HP387 Softener	-	101.52	100.83	98.272	93.78
6	Reactive Softener	-	104.512	103.168	102.532	100.226
7	Reactive Softener + Glycerin	-	100.75	100.68	100.12	98.4
8	Amino Silicone	-	103.810	103.56	102.244	100.712
9	Amino Silicone + Glycerin	-	101.574	100.40	100.058	99.320
10	Micro Amino Silicone	-	104.208	103.810	103.268	102.668
11	Micro Silicone Softener	-	103.62	103.55	102.276	102.154

Results of table 4.4 indicate that for 133 GSM cotton fabrics treated with various softeners, the value of air permeability decreases as the softener concentration increases from 10 gpl to 40 gpl. The anionic softener shows that there is a decrease in air permeability value from 3.82 to 3.38cm<sup>3</sup>/cm<sup>2</sup>/Sec. The Silkofeel HP678 softener shows the same trend as 3.49 to 3.01cm<sup>3</sup>/cm<sup>2</sup>/sec. The minimum value of air permeability was found to be 3.01cm<sup>3</sup>/cm<sup>2</sup>/Sec at 40 gpl concentrations of Silkofeel HP678 softener. The other softeners have shown more values of air permeability as compared with that of Silkofeel HP678.

The reason behind this may be the swelling of fibres due to hydrophilic silicone group present in Silkofeel HP678 softener which the air spaces between fibres resulting in decrease in air permeability.

Table 4.5: Effect of various Softeners on Water Absorbency of 133 GSM Cotton substrate

Sr. No.	Softener	Water Absorption time(sec)				
		Control Sample	Softener Concentration (gpl)			
			10	20	30	40
		2.09				
1	Anionic Softener	-	2.60	2.69	2.74	2.85
2	Non-ionic Softener	-	2.75	2.86	2.98	3.12
3	PE Emulsion Softener	-	2.59	2.65	2.78	2.89
4	Silkofeel HP678 Softener	-	1.16	1.06	0.962	0.842
5	Silkofeel HP387 Softener	-	1.31	1.107	1.100	1.092
6	Reactive Softener	-	2.91	2.96	3.05	3.18
7	Reactive Softener + Glycerin	-	2.16	1.84	1.72	1.45
8	Amino Silicone	-	4.66	4.73	4.88	4.98
9	Amino Silicone + Glycerin	-	3.02	2.94	2.81	2.75
10	Micro Amino Silicone	-	7.70	8.03	8.37	8.42
11	Micro Silicone Softener	-	5.00	5.2	5.32	5.43

Results of table 4.5 indicate the values of time required to make the drop of water disappear from the surface of cotton fabric treated with various softeners, at different softener concentrations from 10 gpl to 40 gpl. The Micro Amino Silicone softener shows the highest values of water absorption time as 7.70 sec, 8.03 sec, 8.37 sec and 8.42 sec for concentrations 10 gpl, 20 gpl, 30 gpl and 40 gpl respectively. The reason for this may be the increase in the hydrophobic nature of cotton fabric due to application of Micro Amino Silicone softener.

The Silkofeel HP678 softener shows the lowest values of water absorption time as 1.16 sec, 1.06 sec, 0.962 sec and 0.842 sec for concentrations 10 gpl, 20 gpl, 30 gpl and 40 gpl respectively among all the softeners. This might be due to the increase in the hydrophilicity of cotton fabric by the hydrophilic group present in Silkofeel HP678 softener.

Table 4.6: Effect of various Softeners on Water Absorbency of 263 GSM Cotton substrate

Sr. No.	Softener	Water Absorption Time(sec)				
		Control Sample	Softener Concentration (gpl)			
			10	20	30	40
		2.91				
1	Anionic Softener	-	2.98	3.16	3.32	3.40
2	Nonionic Softener	-	3.04	3.18	3.24	3.49
3	PE Emulsion Softener	-	2.99	3.2	3.35	3.45
4	Silkofeel HP678 Softener	-	2.14	2.084	2.060	2.044
5	Silkofeel HP387 Softener	-	2.180	2.089	2.074	2.066
6	Reactive Softener	-	3.32	4.38	4.76	5.68
7	Reactive Softener + Glycerin	-	3.08	2.94	2.81	2.76
8	Amino Silicone	-	5.09	5.17	5.22	5.4
9	Amino Silicone + Glycerin	-	4.99	4.87	4.82	4.72
10	Micro Amino Silicone	-	7.89	7.93	8.05	8.14
11	Micro Silicone Softener	-	5.04	5.16	5.27	5.32

Results of table 4.6 indicate the values of time required to make the drop of water disappear from the surface of cotton fabric treated with various softeners, at different softener concentrations from 10 gpl to 40 gpl. The Micro Amino Silicone softener shows the highest values of water absorption time as 7.89 sec, 7.93 sec, 8.05 sec and 8.14 sec for concentrations 10 gpl, 20 gpl, 30 gpl and 40 gpl respectively. The reason for this may be the increase in the hydrophobic nature of cotton fabric due to application of Micro Amino Silicone softener. The Silkofeel HP678 softener shows the lowest values of water absorption time as 2.14 sec, 2.084 sec, 2.060 sec and 2.044 sec for concentrations 10 gpl, 20 gpl, 30 gpl and 40 gpl respectively among all the softeners. This might be due to the increase in the hydrophilicity of cotton fabric by the hydrophilic group present in Silkofeel HP678 softener.

Table 4.7: Effect of various Softeners on Water Absorbency of Polyester/Viscose Blend substrate

S r. N o	Softener	Water Absorption Time(sec)				
		Control Sample	Softener Concentration (gpl)			
			10	20	30	40
		2.15				
1	Anionic Softener	-	2.46	2.57	2.69	2.83
2	Nonionic Softener	-	2.56	2.68	2.75	2.99
3	PE Emulsion Softener	-	2.49	2.60	2.71	2.87
4	Silkofeel HP678 Softener	-	1.852	1.512	1.454	1.094
5	Silkofeel HP387 Softener	-	1.950	1.83	1.78	1.514
6	Reactive Softener	-	2.47	2.58	2.67	2.80
7	Reactive Softener + Glycerin	-	2.32	2.21	2.11	2.01
8	Amino Silicone	-	4.79	4.88	4.91	5.03
9	Amino Silicone + Glycerin	-	3.11	3.22	3.36	3.40
1	Micro Amino Silicone	-	7.82	7.93	7.99	8.07
1	Micro Silicone Softener	-	5.12	5.23	5.37	5.44

Results of table 4.7 indicate the values of time required to make the drop of water disappear from the surface of cotton fabric treated with various softeners, at different softener concentrations from 10 gpl to 40 gpl. The Micro Amino Silicone softener shows the highest values of water absorption time as 7.82 sec, 7.893 sec, 7.99 sec and 8.07 sec for concentrations 10 gpl, 20 gpl, 30 gpl and 40 gpl respectively. The reason for this may be the increase in the hydrophobic nature of cotton fabric due to application of Micro Amino Silicone softener. The Silkofeel HP678 softener shows the lowest values of water absorption time as 1.852 sec, 1.512 sec, 1.454 sec and 1.094 sec for concentrations 10 gpl, 20 gpl, 30 gpl and 40 gpl respectively among all the softeners. This might be due to the increase in the hydrophilicity of cotton fabric by the hydrophilic group present in Silkofeel HP678 softener.

Table 4.8: Effect of various Softeners on Water Absorbency of Polyester/Cotton Blend substrate

Sr. No.	Softener	Water Absorption Time(sec)				
		Control Sample	Softener Concentration (gpl)			
			10	20	30	40
		3.58				
1	Anionic Softener	-	3.85	3.96	4.16	4.22
2	Nonionic Softener	-	3.90	3.99	4.27	4.36
3	PE Emulsion Softener	-	3.80	3.97	4.2	4.25
4	Silkofeel HP678 Softener	-	3.102	3.100	2.96	2.738
5	Silkofeel HP387 Softener	-	3.20	3.116	2.108	2.822
6	Reactive Softener	-	3.91	3.99	4.28	4.34
7	Reactive Softener + Glycerin	-	3.60	3.52	3.43	3.34
8	Amino Silicone	-	5.04	5.14	5.55	5.68
9	Amino Silicone + Glycerin	-	4.97	4.91	4.82	4.76
10	Micro Amino Silicone	-	7.89	8.08	8.15	8.22
11	Micro Silicone Softener	-	5.32	5.46	5.55	5.69

Results of table 4.8 indicate the values of time required to make the drop of water disappear from the surface of cotton fabric treated with various softeners, at different softener concentrations from 10 gpl to 40 gpl. The Anionic softener shows the highest values of water absorption time as 7.70 sec, 8.03 sec, 8.37 sec and 8.42 sec for concentrations 10 gpl, 20 gpl, 30 gpl and 40 gpl respectively. The reason for this may be the increase in the hydrophobic nature of cotton fabric due to application of Micro Amino Silicone softener.

The Silkofeel HP678 softener shows the lowest values of water absorption time as 1.16 sec, 1.06 sec, 0.962 sec and 0.842 sec for concentrations 10 gpl, 20 gpl, 30 gpl and 40 gpl respectively among all the softeners. This might be due to the increase in the hydrophilicity of cotton fabric by the hydrophilic group present in Silkofeel HP678 softener.

Table 4.9: Effect of various Softeners on Moisture Regain of 133 GSM Cotton substrate

Sr. No.	Softener	Moisture Regain (%)				
		Control Sample	Softener Concentration (gpl)			
			10	20	30	40
		6.729				
1	Anionic Softener	-	6.75	6.68	6.6	6.57
2	Nonionic Softener	-	6.76	6.69	6.59	6.54
3	PE Emulsion Softener	-	6.76	6.62	6.6	6.55
4	Silkofeel HP678 Softener	-	7.018	7.122	7.168	7.24
5	Silkofeel HP387 Softener	-	6.914	6.946	6.982	7.16
6	Reactive Softener	-	6.642	6.59	6.52	6.50
7	Reactive Softener + Glycerin	-	6.8	6.82	6.86	6.9
8	Amino Silicone	-	6.62	6.6	6.54	6.43
9	Amino Silicone + Glycerin	-	6.71	6.73	6.74	6.76
10	Micro Amino Silicone	-	6.5	6.47	6.42	6.39
11	Micro Silicone Softener	-	6.6	6.62	6.68	6.7

Results of table 4.9 indicate the moisture regain values of 133 GSM cotton fabrics treated with various softeners at various softener concentrations from 10 gpl to 40 gpl. Micro Amino Silicone softener shows the lowest values of moisture regain as 6.5%, 6.47 %, 6.42% and 6.39% for concentrations 10 gpl, 20 gpl, 30 gpl and 40 gpl respectively. The possible reason for this may be the increase in the hydrophobicity of the fabric due to the hydrophobic group present in this softener.

Silkofeel HP678 softener shows the highest values of moisture regains as 7.018%, 7.12%, 7.16% and 7.24% for concentrations 10 gpl, 20 gpl, 30 gpl and 40 gpl respectively. The reason behind this may be the increase in the hydrophilicity of the fabric due to the hydrophilic group present in Silkofeel HP678 softener which allows the moisture to absorb. Nearly similar results are shown by Silkofeel HP 387 softener.

Table 4.10: Effect of various Softeners on Moisture Regain of 263 GSM Cotton substrate

Sr. No.	Softener	Moisture Regain (%)				
		Control Sample	Softener Concentration (gpl)			
			10	20	30	40
		6.154				
1	Anionic Softener	-	6.17	6.169	6.166	6.152
2	Nonionic Softener	-	6.19	6.181	6.16	6.15
3	PE Emulsion Softener	-	6.17	6.161	6.158	6.15
4	Silkofeel HP678 Softener	-	6.32	6.34	6.36	6.420
5	Silkofeel HP387 Softener	-	6.30	6.312	6.32	6.4
6	Reactive Softener	-	6.142	6.32	6.29	6.22
7	Reactive Softener + Glycerin	-	6.182	6.208	6.239	6.24
8	Amino Silicone	-	6.148	6.147	6.152	6.162
9	Amino Silicone + Glycerin	-	6.136	6.148	6.154	6.20
10	Micro Amino Silicone	-	6.126	6.124	6.12	6.11
11	Micro Silicone Softener	-	6.32	6.13	6.128	6.121

Results of table 4.10 indicate the moisture regain values of 263 GSM cotton fabrics treated with various softeners at various softener concentrations from 10 gpl to 40 gpl. Micro amino silicone softener shows the lowest values of moisture regain as 6.126%, 6.124%, 6.12% and 6.11% for concentrations 10 gpl, 20 gpl, 30 gpl and 40 gpl respectively. The possible reason for this may be the increase in the hydrophobicity of the fabric due to the hydrophobic group present in this softener.

Silkofeel HP678 softener shows the highest values of moisture regains as 6.32%, 6.34%, 6.36% and 6.42% for concentrations 10 gpl, 20 gpl, 30 gpl and 40 gpl respectively. The reason behind this may be the increase in the hydrophilicity of the fabric due to the hydrophilic group present in Silkofeel HP678 softener which allows the moisture to absorb. Nearly similar results are shown by Silkofeel HP 387 softener.

Table 4.11: Effect of various Softeners on Moisture Regain of Polyester/ Viscose Blend substrate

Sr. No.	Softener	Moisture Regain (%)				
		Control Sample	Softener Concentration (gpl)			
			10	20	30	40
		6.578				
1	Anionic Softener	-	6.601	6.62	6.68	6.703
2	Nonionic Softener	-	6.689	6.69	6.71	6.74
3	PE Emulsion Softener	-	6.69	6.705	6.72	6.63
4	Silkofeel HP678 Softener	-	6.734	6.789	6.804	6.93
5	Silkofeel HP387 Softener	-	6.707	6.76	6.846	6.97
6	Reactive Softener	-	6.31	6.29	6.25	6.2
7	Reactive Softener + Glycerin	-	6.59	6.6	6.62	6.63
8	Amino Silicone	-	6.3	6.27	6.23	6.2
9	Amino Silicone + Glycerin	-	6.5	6.59	6.6	6.62
10	Micro Amino Silicone	-	6.4	6.38	6.31	6.2
11	Micro Silicone Softener	-	6.45	6.41	6.37	6.35

Results of table 4.11 indicate the moisture regain values of 100 GSM polyester/cotton blend fabrics treated with various softeners at various softener concentrations from 10 gpl to 40 gpl. Micro amino silicone softener shows the lowest values of moisture regain as 6.4%, 6.38 %, 6.31% and 6.2% for concentrations 10 gpl, 20 gpl, 30 gpl and 40 gpl respectively. The possible reason for this may be the increase in the hydrophobicity of the fabric due to the hydrophobic group present in this softener.

Silkofeel HP678 softener shows the highest values of moisture regains as 6.734%, 6.78%, 6.80% and 6.93% for concentrations 10 gpl, 20 gpl, 30 gpl and 40 gpl respectively. The reason behind this may be the increase in the hydrophilicity of the fabric due to the hydrophilic group present in Silkofeel HP678 softener which allows the moisture to absorb. Nearly similar results are shown by Silkofeel HP 387 softener.

Table 4.12: Effect of various Softeners on Moisture Regain of Polyester/Cotton Blend

Sr. No.	Softener	Moisture Regain (%)				
		Control Sample	Softener Concentration (gpl)			
			10	20	30	40
		5.641				
1	Anionic Softener	-	5.29	5.26	5.2	5.17
2	Nonionic Softener	-	5.30	5.29	5.23	5.19
3	PE Emulsion Softener	-	5.28	5.27	5.2	5.17
4	Silkofeel HP678 Softener	-	5.666	5.688	5.719	5.80
5	Silkofeel HP387 Softener	-	5.643	5.666	5.68	5.79
6	Reactive Softener	-	5.38	5.32	5.22	5.2
7	Reactive Softener + Glycerin	-	5.48	5.59	5.68	5.79
8	Amino Silicone	-	5.32	5.3	5.26	5.21
9	Amino Silicone + Glycerin	-	5.39	5.46	5.5	5.57
10	Micro Amino Silicone	-	5.26	5.20	5.16	5.12
11	Micro Silicone Softener	-	5.28	5.24	5.21	5.1

Results of table 4.12 indicate the moisture regain values of 63 GSM polyester/cotton fabrics treated with various softeners at various softener concentrations from 10 gpl to 40 gpl. Micro amino silicone softener shows the lowest values of moisture regain as 5.26%, 5.20 %, 5.16% and 5.12% for concentrations 10 gpl, 20 gpl, 30 gpl and 40 gpl respectively. The possible reason for this may be the increase in the hydrophobicity of the fabric due to the hydrophobic group present in this softener.

Silkofeel HP678 softener shows the highest values of moisture regains as 5.66%, 6.68%, 5.71% and 5.80% for concentrations 10 gpl, 20 gpl, 30 gpl and 40 gpl respectively. The reason behind this may be the increase in the hydrophilicity of the fabric due to the hydrophilic group present in Silkofeel HP678 softener which allows the moisture to absorb. Nearly similar results are shown by Silkofeel HP 387 softener.



Table 4.13: Effect of Perspiration on the Whiteness Index of 133 GSM Cotton Substrate Treated with various Softeners

Sr. No.	Softener	Whiteness Index		
		Cotton Fabric(GSM 133)		
		Standard	Acidic	Alkaline
1	Anionic Softener	78.918	72.395	68.407
2	Nonionic Softener	76.869	72.743	69.113
3	PE Emulsion Softener	75.989	71.808	68.652
4	Silkofeel HP678 Softener	87.460	86.929	85.762
5	Silkofeel HP387 Softener	85.322	83.948	81.102
6	Reactive Softener	79.102	75.538	72.186
7	Reactive Softener + Glycerin	78.587	75.786	73.071
8	Amino Silicone	79.806	76.079	73.125
9	Amino Silicone + Glycerin	79.206	76.270	73.462
10	Micro Amino Silicone	80.656	77.696	74.254
11	Micro Silicone Softener	78.619	75.539	72.321

Results of table 4.13 indicate the effect of perspiration on the whiteness index of 133GSM cotton substrate treated with various softeners. For Anionic softener the values of whiteness index are 78.918, 72.395, and 68.407 for standard, acidic and alkaline perspiration solutions respectively. For Silkofeel HP 678 softener the values of whiteness index are 87.460, 86.929, and 85.762 for standard, acidic and alkaline perspiration solutions respectively.

The reason for this may be the decrease in the whiteness of fabric after softener treatment. For acidic perspiration there is less reduction in whiteness of fabric as compared to alkaline perspiration. More prominent results are shown by Silkofeel HP 678 softener where the reduction in whiteness index is less for both acidic and alkaline conditions as compared to all other softeners.

Table 4.14: Effect of Perspiration on the Whiteness Index of 263 GSM Cotton Substrate treated with various Softeners

Sr. No.	Softener	Whiteness Index		
		Cotton Fabric(GSM 263)		
		Standard	Acidic	Alkaline
1	Anionic Softener	78.505	76.668	74.065
2	Nonionic Softener	76.774	74.772	71.119
3	PE Emulsion Softener	76.648	74.894	74.924
4	Silkofeel HP678 Softener	79.622	77.006	75.235
5	Silkofeel HP387 Softener	78.824	75.262	73.876
6	Reactive Softener	75.417	68.072	71.665
7	Reactive Softener + Glycerin	77.418	76.799	73.744
8	Amino Silicone	76.926	62.550	67.704
9	Amino Silicone + Glycerin	68.655	65.308	67.787
10	Micro Amino Silicone	77.013	76.772	73.222
11	Micro Silicone Softener	69.195	68.417	67.389

Results of table 4.14 indicate the effect of perspiration on the whiteness index of 263GSM cotton substrate treated with various softeners. For Anionic softener the values of whiteness index are 78.505, 76.668 and 74.065 for standard, acidic and alkaline perspiration solutions respectively. For Silkofeel HP 678 softener the values of whiteness index are 79.622, 77.006 and 75.235 for standard, acidic and alkaline perspiration solutions respectively.

The reason for this may be the decrease in the whiteness of fabric after softener treatment. For acidic perspiration there is less reduction in whiteness of fabric as compared to alkaline perspiration. More prominent results are shown by Silkofeel HP 678 softener where the reduction in whiteness index is less for both acidic and alkaline conditions as compared to all other softeners.

Table 4.15: Effect of Perspiration on the Whiteness Index of Polyester/Viscose Blend Substrate treated with various softeners

Sr. No.	Softener	Whiteness Index		
		P/V Blend Fabric		
		Standard	Acidic	Alkaline
1	Anionic Softener	69.877	65.708	64.399
2	Nonionic Softener	71.474	69.616	65.283
3	PE Emulsion Softener	72.754	68.090	70.494
4	Silkofeel HP678 Softener	76.172	75.129	74.009
5	Silkofeel HP387 Softener	74.805	72.484	71.087
6	Reactive Softener	68.983	66.775	66.705
7	Reactive Softener + Glycerin	72.757	70.212	67.073
8	Amino Silicone	65.643	65.184	64.744
9	Amino Silicone + Glycerin	68.413	45.371	60.334
10	Micro Amino Silicone	72.894	69.444	68.327
11	Micro Silicone Softener	63.057	62.556	57.675

Results of table 4.15 indicate the effect of perspiration on the whiteness index of 100 GSM polyester/viscose blend substrate treated with various softeners. For Anionic softener the values of whiteness index are 69.877, 65.708, 64.399 for standard, acidic and alkaline perspiration solutions respectively. For Silkofeel HP 678 softener the values of whiteness index are 76.172, 75.129, and 74.009 for standard, acidic and alkaline perspiration solutions respectively. The reason for this may be the decrease in the whiteness of fabric after softener treatment. For acidic perspiration there is less reduction in whiteness of fabric as compared to alkaline perspiration. More prominent results are shown by Silkofeel HP 678 softener where the reduction in whiteness index is less for both acidic and alkaline conditions as compared to all other softeners.

Table 4.16: Effect of Perspiration on the Whiteness Index of Polyester/Cotton Blend Substrate treated with various softeners

Sr. No.	Softener	Whiteness Index		
		Polyester/Cotton Fabric(GSM 63)		
		Standard	Acidic	Alkaline
1	Anionic Softener	62.874	55.075	53.404
2	Nonionic Softener	60.848	58.559	50.872
3	PE Emulsion Softener	64.530	60.757	59.492
4	Silkofeel HP678 Softener	67.926	59.487	57.028
5	Silkofeel HP387 Softener	62.244	59.792	55.478
6	Reactive Softener	58.473	55.810	57.550
7	Reactive Softener + Glycerin	65.506	60.578	58.232
8	Amino Silicone	57.957	52.291	51.116
9	Amino Silicone + Glycerin	56.573	53.331	48.784
10	Micro Amino Silicone	60.447	59.962	55.942
11	Micro Silicone Softener	54.066	52.299	47.038

Results of table 4.16 indicate the effect of perspiration on the whiteness index of 63GSM polyester/cotton blend substrate treated with various softeners. For Anionic softener the values of whiteness index are 62.874, 55.075, 53.404 for standard, acidic and alkaline perspiration solutions respectively. For Silkofeel HP 678 softener the values of whiteness index are 67.926, 57.028, and 59.487 for standard, acidic and alkaline perspiration solutions respectively. The reason for this may be the decrease in the whiteness of fabric after softener treatment. For acidic perspiration there is less reduction in whiteness of fabric as compared to alkaline perspiration. More prominent results are shown by Silkofeel HP 678 softener where the reduction in whiteness index is less for both acidic and alkaline conditions as compared to all other softeners.

## V. CONCLUSION

From the results it is evident that variation in the softeners and softener concentration affects the moisture management properties of fabrics. The findings are summarized as follows:

- a) Silkofeel HP 678 softener shows a better performance in all comfort properties like reduced air permeability, lesser water absorption time, good moisture regain and lesser effect of perspiration on the whiteness index of fabric.
- b) 133 GSM Cotton substrate shows highest moisture management properties followed by Polyester/viscose Blend, 263 GSM Cotton and Polyester/cotton Blend fabrics.

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