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EFFECT OF CHITOSAN ON COMFORT AND FUNCTIONAL PROPERTIES OF SYNTHETIC DYED COTTON FABRIC

A. Poornima[1], D. Anitha[2], Sadhana D Kulloli[3]

[1]Dept. of Apparel and Textiles, College of Community Science, ANGRAU, India;

[2]Dept. of Apparel and Textiles, College of Community Science, ANGRAU, India

[3]Department of Textile and Apparel Designing, College of Community Science, UAS, India

ABSTRACT

Cotton is one of the fabrics available in the market that is accepted all over the globe for apparel purpose because of its versatility and comfort properties. Treating cotton with cationizing agents like chitosan in volume by volume concentration has caused modification of fabric surface characteristics and the treatment has enhanced the physical and functional properties of the treated fabric. Treated fabrics are dyed in 2% blue reactive dye. Improved dye uptake and fastness properties to washing, crocking (dry and wet) and perspiration (alkaline and acidic) compared to control sample. Other properties like fabric wicking, air permeability, water repellency has decreased than control. Further decrease in effluent load was observed in terms of BOD and COD. In addition to other properties, treated fabric has showed antimicrobial activity against E.coli, S. aureus and A.niger. Therefore, chitosan application on cotton fibre is a possible approach to get a fabric with enhanced properties to utilise for apparel use.

Keywords: Chitosan, reactive dye, comfort properties, antibacterial properties, BOD and COD

1. INTRODUCTION:

Cotton is the most important natural cellulosic fibre among the textile fibres which is widely used in the apparel industry for its properties like absorbency, softness and breathability (Bhuiyan et al., 2017). It is an eco-friendly fibre with natural comfort and biodegradability. It is relatively hydrophilic in nature which has imparted comfort property by absorbing sweat from the human body and readily evaporates it. Besides the comfort properties, cotton fibres also possess some limitations by its nature such as shrinkage, formation of wrinkles, low exhaustion of dyes and bacterial degradation. To overcome these limitations, various processes were developed and one among the processes developed is through surface modification of fabric using cationizing agents. Many cationizing agents were in use and over the last decade, chitin has attracted many researches to overcome the limitations mentioned.

Chitin and chitosan is a polysaccharide and biodegradable polymer with various molecular weights, purities and crystallinities which has the similar structure as cellulose. Chitin is a white, hard, inelastic, nitrogenous polysaccharide that exists naturally in number of sources ranging from cell walls of fungi, mushrooms, exoskeleton of arthropods etc. The inherent properties of chitosan such as nontoxicity, biodegradable, antibacterial, antifungal, biocompatible with plant and animal tissues, viscoelastic behaviour and formation of film has made its place for various applications (Chattopadhyay and Inamdar, 2012). Chitosan is the product after deacetylation of chitin that is utilized for various applications which has been extensively used in the textile industry for dyeing and multifunctional finishing of textiles (Arash et al., 2021)

Chitosan treatment has resulted in formation of crosslink with cellulose polymer (Haji et al., 2016) and improvement of cationic sites (Abeer et al., 2015). An effective way of enhancing dye absorption of a fabric is by introducing of cationic sites (Bhuiyan et al., 2013) and other properties that made cotton fabric the most comfortable garments (Abeer et al., 2015). Keeping in view of the properties of chitosan, the present study was carried out to study the impact of chitosan on cotton in enhancing the properties of treated fabric.

2. EXPERIMENTAL SECTION:

2.1 Selection of materials and chemicals:

Bleached and mercerised cotton fabric with fabric count 98 x 76; thickness of 0.22 mm and GSM 80.5 g/m^2 was used for the experiments. Chitosan flakes that are 75% deacetylated were procured from M/S Loba Chemie Pvt. Ltd. Mumbai. Analytical grade chemicals and dyeing auxiliaries were used for dissolving chitosan and dyeing of fabric with reactive dyes.

2.2 Preparation of sample for dyeing:

Chitosan solutions of four different concentrations 0.5,%, 1.0%, 1.5% and 2.0% were prepared in 2% (v/v) aqueous acetic acid solution. To study the effect of chitosan treatment on the fabric, along with pretreatment (PrT), Pretreatment + Solar radiation (PrT+S), Solar radiation+Pretreatment (S+PrT) and Post treatment (PsT) were selected. Fabrics were immersed and treated in the chitosan solution for 1 hr at 60° temperature with constant stirring. Excess solution is removed from the fabric and utilised for dyeing. Chitosan treated fabrics were dyed with 2% reactive dye measured on weight of fabric. The dyeing was carried out without using salt using exhaust method of dyeing and the recipe is given in the table 1. Fabric treatment method was selected based on the colour strength.

Table 1. Dye recipe for dyeing chitosan treated fabrics

S.no	Particulars	Recommended quantity
1.	Percent shade	2%
2.	Sodium carbonate (g/l)	10
3.	Progression time	60 min
4.	Material liquor ratio	1:10
5.	Temperature	80°C

2.3 Analysis of dyed samples:

2.3.1 Colour analysis:

The depth of colour absorbed by samples treated with chitosan was analyzed by colour spectrophotometer with reference to colour strength (K/S values), colour change (CC) and colour stain (CS) of samples. The colour strength of the dyed samples was calculated using Kubelka-Munk equation:

$$K/S = \frac{(1 - R)^2}{2R}$$

Where, R= Reflectance of an incident light from the material; K= Absorption Coefficient of the material and S= Scattering Coefficient of the material.

Colourfastness to washing, crocking and perspiration were analyzed as per IS 687-1979, IS 766-1956 and IS 971 – 1956.

2.3.2 Comfort properties:

Chitosan treated fabrics are analysed for different comfort properties like fabric wicking, water repellency and air permeability following standard test procedures JIS L1907 -1994, IS 390-1975 and IS 11056-1984 respectively.

2.3.3 Antibacterial properties:

Bacterial activity was evaluated by a modified qualitative AATCC 147 test method for the growth inhibition of *E. Coli, A.niger and S. Aureus.*

2.3.4 Estimation of effluent load:

BOD and COD were estimated in the dye liquor after dyeing following the standard procedures IS 3025, 1993 and IS 5220 – B respectively. The permissible levels of oxygen demand of effluent discharge standards from textile industries at end of pipeline are; COD is 156-400(mg/L) and BOD is 80-250mg/L (Dey and Islam, 2015).

3. RESULTS AND DISCUSSIONS:

3.1 Selection of fabric treatment method:

Fabric treated and dyed in 2% reactive dye is analyzed for K/S values and are furnished in the table 2. Among the four fabric treatment methods with chitosan, S+PrT methods yielded higher K/S values than control in all chitosan concentration. Hence, the sample treated with S+PrT method was selected for further evaluation of comfort and antibacterial properties.

Table : 2 Colour strength of 2% Reactive Dyed samples in various treatment methods

Method of treatment		Chitosan conc. (%)			
	Control	**0.5**	**1.0**	**1.5**	**2.0**
Control	0.92	-	-	-	-
PrT	-	0.93	0.96	0.98	0.90
PrT + S	-	0.88	0.90	0.92	0.87
S+PrT	-	0.95	0.96	1.01	1.04
PsT	-	0.65	0.69	0.73	0.64

3.2 Colour fastness properties:

Chitosan treated and dyed samples were caused to undergo three colour fastness tests such as washing, crocking (dry and wet) and perspiration (acidic and alkaline). Evaluation of colour fastness of the samples was evaluated with regard to staining and colour change on silk fabric and the results of the dyed samples are given in table 3.

Table : 3 Colourfastness properties of 2% Reactive Dyed samples

Per cent of Chitosan treatment (%)	Washing		Crocking				Perspiration			
			Dry		Wet		Alkaline		Acidic	
	CC	CS	CC	CS	CC	CS	CC	CS	CC	CS

Control – untreated	2-3	2-3	3	2-3	2-3	2-3	2	2-3	2-3	2-3
1.5	4	3	4	5	4	3	4	3	3	3
2.0	3	2-3	4	4-5	3	3	3-4	3	4	3

The fastness grades of treated fabrics and control were presented in table 3. It was found that both control and chitosan treated samples have exhibited almost similar fastness to all serviceable conditions. Fastness to dry conditions was very good where as wet fastness has shown less fastness rating. Significant colour change and staining was observed in the fabrics subjected to perspiration fastness and the ratings found to vary from good to very good.

The reason for slightly lower fastness ratings may be because of decrease in bonding between dye and fibre due to the presence of chitosan on the fabric surface and unavailability of bonding sites. The unfixed dye present on the fabric surface has removed due to which colour change and staining was observed. Similar results were observed to be parallel with study carried out Chatha et al., (2016).

3.3 Evaluation of comfort properties of dyed fabrics

3.3.1 Fabric wicking:

The wicking property of dyed samples is determined as rate of absorbency after treatment with chitosan. It was found that the wicking capacity of dyed fabrics decreased after dyeing over control (Figure 1). Wickability in weft direction was found to be lesser than in warp direction.

The results were identical with the study carried out by Souza et al., (2019) who reported that higher chitosan concentrations has shown considerable reduction in water uptake due to the interaction of hydrogen bond between cellulose and chitosan because of which there is reduction in porosity and non-availability of hydrophilic groups.

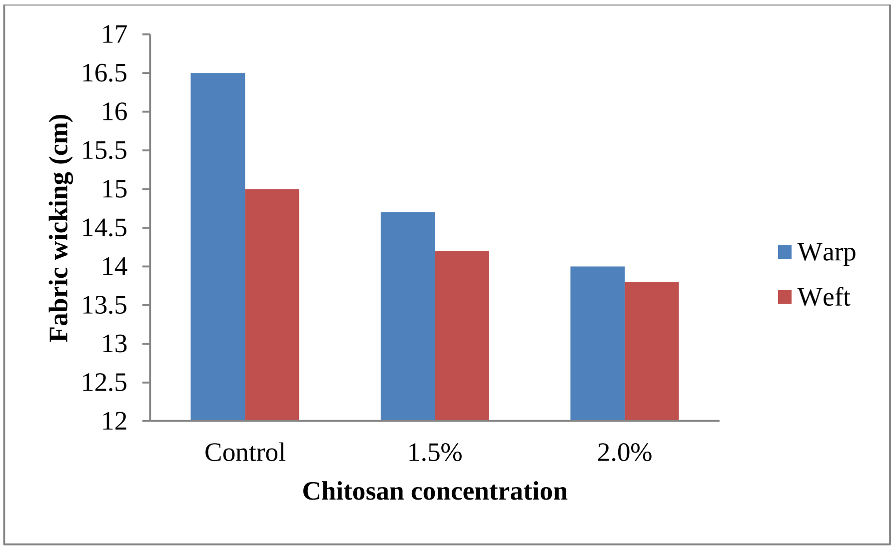

Figure 1: Fabric wicking after chitosan treatment

3.3.2 Water repellency:

Water repellency of the treated fabrics was determined by spray test. The results were represented in figure 2. As per the readings it was observed that all the chitosan fabrics exhibited similar results. The control sample has '0' rating which indicated that the fabric has completely got wet after spraying of water. Fabric treated with chitosan and dyed has not completely resisted water absorption of water but delayed the time of absorption. The repellent property of the fabric has increased with increase in chitosan concentration. Absorption of chitosan by the fabric and formation of insignificant film had made the fabric to lower the absorption of water. As reported by Shin et al., (2016), the chitosan treatment makes the fabric stiffer and more water repellent.

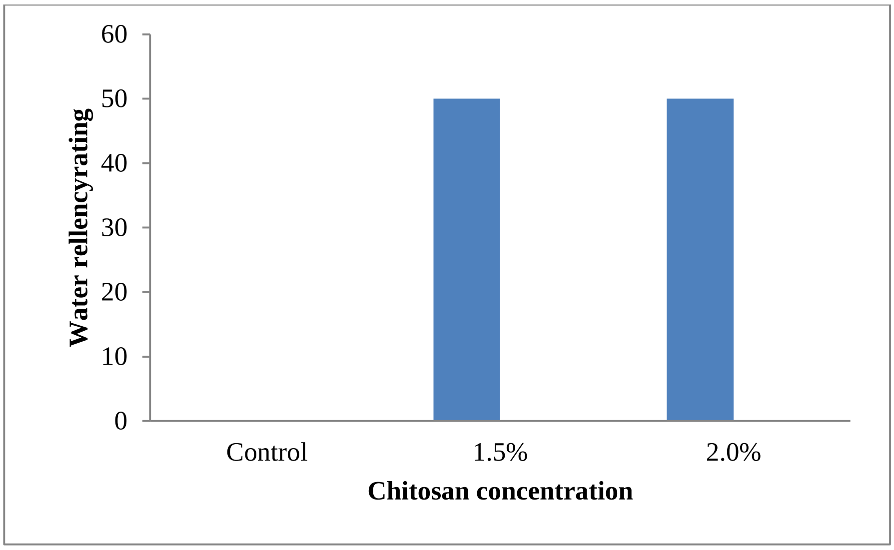

Figure 2: Water repellent property of fabric after chitosan treatment

3.3.3 Air permeability:

Chitosan treated and dyed fabrics were tested for air permeability and the results are presented in figure 3. Decrease in air permeability was observed when compared with control fabric and has increased with increase in chitosan concentration. Even though, chitosan treatment was given by volume by volume concentration, chitosan filled the spaces partially between warp and weft and has resulted in decrease in passage of air through the fabric without compromising the breathability of the fabrics. The findings are in line with Benltoufa et al., (2020) that a significant decrease in air permeability was observed with chitosan treatment when compared to control samples.

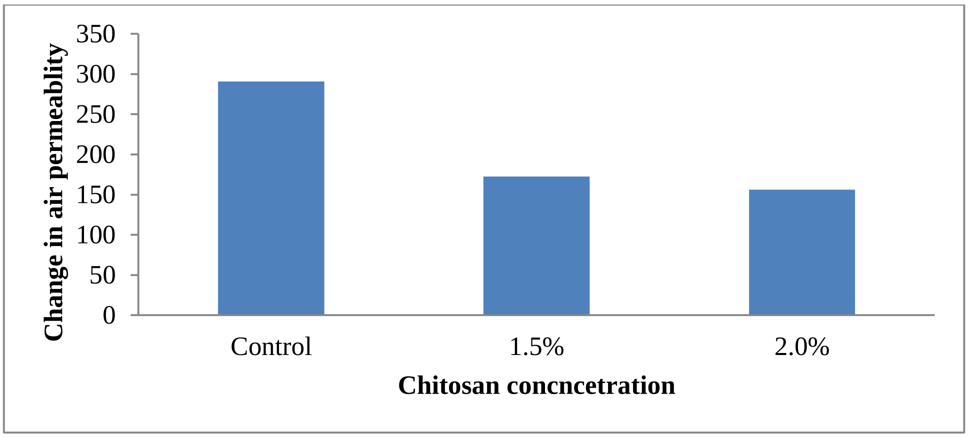

Figure 3: Air permeability property of fabric after chitosan treatment

3.3.4 Antibacterial properties:

Chitosan is being used widely as an antimicrobial agent on different fabrics. Impact of treatment on the dyed fabric was studied for its activity against *E.coli, A. niger* and *S. aureus* at different chitosan concentrations. Antimicrobial activity was given as zone of inhibition (zoi) and the readings were measured in mm.

It is clear from figure 4 that antimicrobial activity was visible at highest concentration 2% to all the strains whereas no activity was observed at 1.5% treated fabric samples which are similar to control and dyed fabrics.

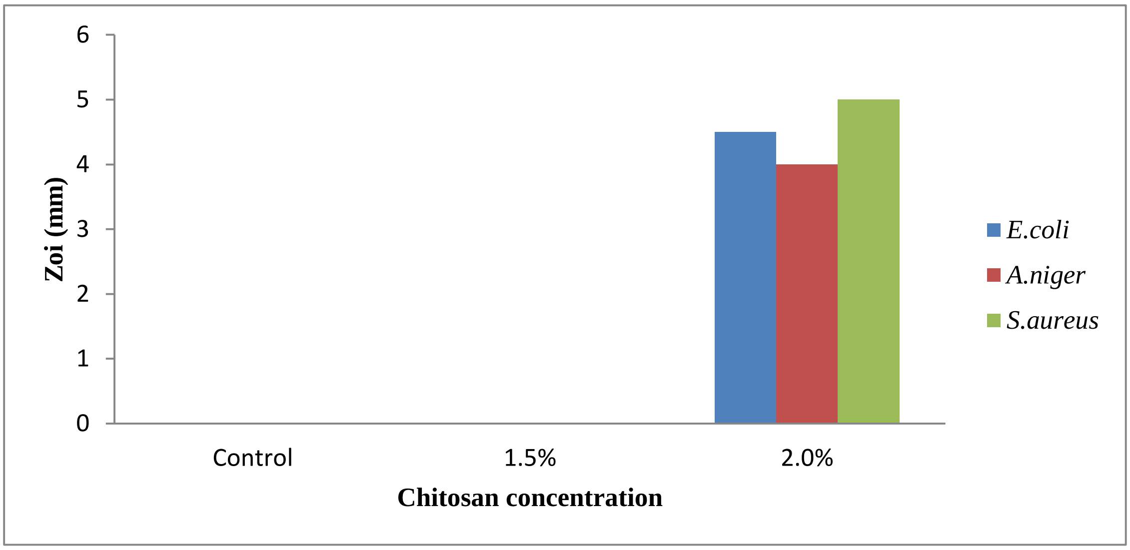

Figure 4: Antibacterial activity on chitosan treated fabric

The reason for the antimicrobial activity may be assumed as the electrostatic interaction between the positively charged chitosan groups and negatively charged sites on the microbial cell. The results arrived are in agreement with Ranganath and Sarkar (2014) where the fabric treated with chitosan has shown maximum efficiency against *E.coli and S. aureus.*

3.3.5 Estimation of BOD and COD:

The dye liquor was estimated for BOD and COD and the results are represented in figure 5. Standards for permissible levels of oxygen demand of effluent discharge from textile industries are; COD is 156-400(mg/L) and BOD is 80-250mg/L (Dey and Islam, 2015). Dye effluent load of chitosan treated and dyed samples are lower than the dye liquor of control.

From the observations it is clear that even though the effluent load has reduced with chitosan treatment, the effluents discharged from the textile industries still need to be treated after dyeing.

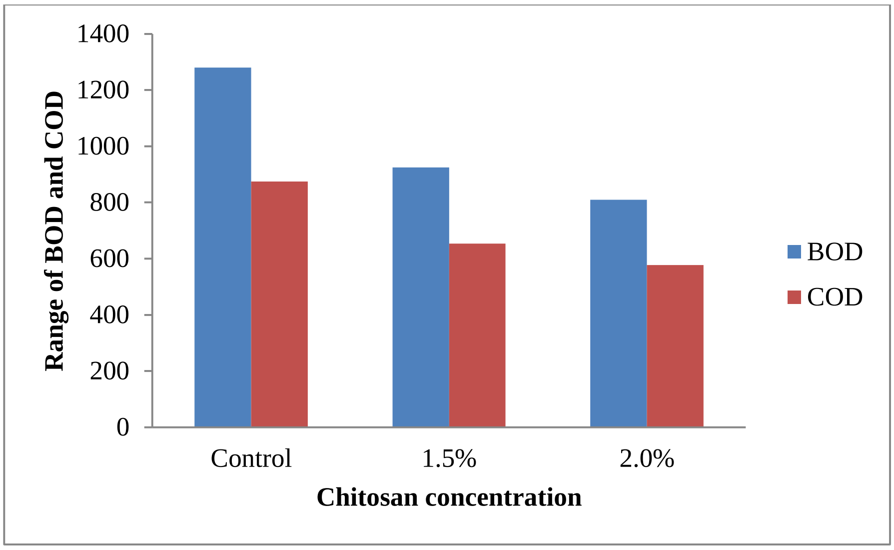

Figure 5: Estimation of BOD nd COD from the dye effluent

4. CONCLUSION:

The present study was undertaken to study the impact of chitosan treatment on cotton fabric treated in volume by volume concentration. Among the four different fabric treatments, solar radiation and pre-treatment has improved the colour strength than the other methods. Comfort and antibacterial properties of the dyed fabric were further analysed. Chitosan treatment has yielded a flexible fabric without significant stiffness. The reason for less stiffness is formation of partial film in between the yarn spaces. Colourfastness properties of reactive dyed fabric have yielded similar properties as control fabric. The water repellent property of the treated and dyed fabrics possessed similar rating in both the concentrations with delay in time of absorption. Chitosan treatment has reduced the air permeability without compromising the breathability of fabrics. Antibacterial activity was improved when compared to control fabric. Decrease in BOD and COD levels was observed with chitosan treatment in the dye effluent. Thus the findings of the study suggest a possible fabric treatment with chitosan for apparel use with increased antibacterial property, colour strength and decrease in effluent load producing an eco-friendly product.

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