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RESEARCH PAPER

Effect of natural antioxidants on colour strength and colour coordinates of reactive dyed cotton fabric

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Abstract: Natural antioxidants are the substance that aims to delay the oxidative stress of the product and to make its conditions optimal for a longer period of time. They are the chain breaking antioxidants which react with lipid radicals and convert them into more stable products which are mainly phenolic in structures. Vetiver and chebula are the abundantly available natural resources which possessed good amount of natural antioxidants. Three primary coloured (red, blue and yellow) vinyl sulphone (cold brand) plain woven reactive dyed cotton fabrics were used for the study. The variables used for optimization of plant extracts were media of extraction (aqueous and ethanol) and application of heat (heated and unheated) subjected to colour spectrophotometer to know about the colour strength and transmittance of the plant extracts. The optimized extracts were selected for finishing of reactive dyed cotton fabric with varied concentrations (5, 10 and 15%) at different temperatures (30°- 40° and 60°-70°) through zigger machine by exhaust method and later assessed for colour strength and colour coordinates of reactive dyed cotton fabric. Irrespective of source and method of extraction the colour strength was found to be greater in vetiver heated aqueous solution and chebula unheated aqueous solution compared to the ethanolic solvent. It was observed that all the treated samples showed significant increase in colour strength with lesser reflectance values. The colour strength was found to be greater in red coloured fabric of both the plant extracts with varied concentrations (5, 10 and 15 %) and temperatures (30°-40° and 60°-70°) followed by blue and yellow coloured treated fabrics. The chebula treated blue coloured fabric exhibited greater colour difference on contrary with vetiver treated reactive dyed cotton fabric. As colour strength is very important parameter for dyeing, it was found that the natural antioxidant treated fabrics exhibited greater colour with lesser colour difference values.

Key words : Colour coordinates, Colour strength, Natural antioxidants, Vetiver

Introduction

Reactive dyes are coloured compounds that contain functional groups capable of forming covalent bonds with active sites in fibres. Reactive dyes basically belong to two classes, *viz.,* substitutive and additive. Substitutive dyes include mono and dichlorotriazines. Dichlorotriazine dyes possess two reactive chlorine atoms and are applied at room temperature, called cold brand or M dyes. Additive types include mainly vinyl sulphone dyes (ramazol dyes) possessing a general formula $DSO_2CH=CH_2$. These dyes do not possess any by-product during reaction with cotton or water, follows a neucleophilic addition mechanism. Finishing of fabrics with herbs and plant extracts that are of great medicinal value is incredibly gaining high popularity (Khushboo, 2015). In recent years, substantial attention has been given to plant source for textile colouration and finishing because of their newly found properties such as insect repellence, antioxidant, antibacterial activity and sun protection. In general, garments and clothing are exposed to light, heat, excessive friction *etc.,* or treated with different washing chemicals and detergents, resulting in slow colour fading of selective dyes. Photo-fading of textile dyes is the most intricate phenomenon and need more investigation to establish the facts for improvement of colour fastness properties.

Textiles containing antioxidants can function as a reservoir system gradually delivering antioxidants to the skin. When in contact with skin, such textiles have the ability to scavenge free radicals caused by skin degeneration, and protect skin tissues from oxidative stress and damage (Li *et al*., 2019). Natural antioxidants, often referred to as inhibitors of oxidation, are organic compounds applied to oxidizable organic materials to hinder auto-oxidation and to extend the functional life of substrates. Antioxidants describe the process by which they function, are known as either radical trapping or decomposing peroxide. The two plant sources (vetiver and chebula) were selected for the finishing of reactive dyed cotton fabrics and these identified sources are well known antioxidants in Ayurveda.

Vetiveria zizanioides is an aromatic herb and one of the most useful natural resources for human well-being. Vetiver is the most efficient grass with tremendous potential properties that are also beneficial to human health and clothing. Vetiver extract has multi functional properties *viz.*, antioxidant, antifungal and aromatic and act as a natural reagent for wet processing. Based on the research studies it was proved that the source was found to be most useful for improvising the mechanical and functional properties of cellulosic textiles (Sannapapamma *et al*., 2019). *Terminalia chebula* belongs to the Combretaceae family and is one of the most important medicinal plants for ayurveda, siddha, unani and homoeopathic medicines. It exhibits excellent antioxidant, antibacterial, antifungal, antiviral, antimutagenic properties and also used as mordant for natural dyeing since time immemorial (Chattopadhyay and Bhattacharya, 2007). In addition to defending against environmental threats, the use of these bio

resources helps in protecting the atmosphere, minimize the dye effluent load and encourages eco-friendly textiles. The use of such products also offers health benefits for both the user as well as the community. Hence, the aim of present research was to study the effect of natural antioxidants on colour strength and colour coordinates of reactive dyed cotton fabric.

Material and methods

The present investigation entitled effect of natural antioxidants on colour strength and colour coordinates of reactive dyed cotton fabric was carried out during the year 2018 – 2020 at College of Community Science, UAS, Dharwad. Red, blue and yellow vinyl sulphone (cold brand) reactive dyed (plain woven) unfinished (without commercial dye fixing agent) and finished (commercial dye fixing agent) cotton fabrics were procured from Unirose Textile Processors Pvt. Ltd. - Ichalkaranji, Maharashtra. Two plant source *i.e., Vetiveria zizanioides* roots and *Terminalia chebula* fruit were selected for the study as natural antioxidants. These bio resources were procured from Amrita herbal extracts and research centre, Karwar, Uttara Kannada district, Karnataka. The dried and cleaned *Vetiveria zizanioides* roots and *Terminalia chebula* fruits were crushed into fine powder by traditional pounding method and stored in air tight poly bags to protect from moisture.

The variables used for optimization of plant extracts were, media of extraction and application of heat. Two methods used for extraction of vetiver root and chebula fruit powder through are aqueous and solvent extraction. A required quantity of vetiver root and chebula powder (5 %) was soaked in 95 ml of solvent (aqueous/ethanol) and kept it for overnight. Thereafter, both the stock solutions *viz.,* heated and unheated were centrifuged at 5000 rpm for 20 min and the centrifuged solution was filtered using Whatsmann No. 1 filter paper. Further, the stock solution was subjected to colour spectrophotometer for spectral analysis to know the colour strength and transmittance of the plant extracts.

Colour spectrophotometer measures the spectral transmittance of the plant extracts were assessed through the visible spectrum relative to a particular reference. The prepared extracts (heated and unheated) of vetiver and chebula (aqueous and ethanolic) solutions were subjected to colour spectrophotometer to know analyze the colour strength (K/S), colour coordinates (L*, a*, b*) and colour difference (dE) of plant extracts for optimization.

Vinyl Sulphone (cold brand) reactive dyed, unfinished cotton fabrics of three primary colours (red, blue and yellow) were used for finishing with optimised vetiver and chebula extracts. The finishing conditions *viz.*, extract concentrations (5%, 10%, 15 % owf), MLR, temperature, duration and pH were maintained as per the industrial standards. The required amount of optimized extracts in varied concentrations (5%, 10%, 15 % owf) were added to finishing bath, continued with slow heating which are based on the temperatures (30°- 40°C and 60°- 70°C) and the finishing is continued for 4-6 folds. After 8-10 folds the finish bath is discharged and loaded with fresh water treated samples and are thoroughly washed with two folds for removal of partially hydrolyzed extract. The washed sample is loaded to industrial drying machine for drying with required temperature (80^0-100^{0C}). The dried samples were further used for assessment of colour strength and colour coordinates. Total 36 samples were finished based on the types of extracts, varied concentrations and temperature separately by following the same procedure at Khadi Gramodhyoga Centre, Hubli. The treated fabrics were than assessed for colour strength and colour coordinates through colour spectrophotometer.

Results and discussion

Effect of extraction methods on colour strength and colour coordinates of vetiver and chebula extracts

Irrespective of source and method of extraction, the colour strength was found to be greater in aqueous unheated extract of chebula (2.092) followed by heated ethanol (1.848), unheated ethanol (1.456) and heated aqueous extracts (1.726) (Table 1). However, the extract of vetiver, exhibited greater colour strength in aqueous heated (1.575) as compared to ethanol heated (1.565) extract followed by ethanol unheated (1.556) and aqueous unheated extracts (0.976) due to the application of heat, the electrostatic forces of attraction formed between colouring components yields darker shades (Adeel *et al.,* 2009).

Among the chebula extract, aqueous unheated extract exhibited greater colour strength and lesser transmittance values on contrary with the ethanol unheated extract with more transmittance value. This may be due to the maximum amount of phytochemicals available in unheated extract and application of heat may degrade the total polyphenols in the extract.

Further, as the colour strength of different extracts increases the reflectance value decreases therefore, the reflectance of vetiver (aqueous) heated (2.66) exhibited lesser values as

Table 1. Effect of extraction methods on colour strength and colour coordinates of vetiver and chebula extracts

Colour coordinates	Vetiver				Chebula				S.Em.±	C.D. @5%
	Aqueous		Ethanol		Aqueous		Ethanol			
	Heated	Unheated	Heated	Unheated	Heated	Unheated	Heated	Unheated		
K/S	1.575	0.976	1.565	1.556	1.726	2.092	1.848	1.456	0.014	0.04
Transmittance	2.66	10.57	2.72	3.2	8.32	2.73	1.42	4.68	0.01	0.05
L*	40.38	52.44	47.13	57.06	38.4	39.23	34.42	36.34	0.05	0.19
a*	6.65	-1.67	0.21	-2.4	7.1	3.73	5.36	3.77	0.13	0.45
b*	23.15	6.38	25.38	22.71	25	15.23	21.57	28.35	0.57	1.88
dE	22.59	13.71	17.35	10.38	25.18	8.4	30.55	25.13	0.05	0.19

Indicate details K/S : colour strength L*, a*,b* colour coordinates dE: colour difference

compared to the ethanolic heated extracts (2.72) and chebula (aqueous) unheated possessed lower reflectance (2.73) as compared to the ethanolic unheated extracts (4.68) (Table 1).

Colour coordinates (L*, a*, b*) of both the extracts revealed that, irrespective of media and application of heat, the chebula extracts (39.23,3.73,15.23) exhibited more darker, redder and bluer in shades than the vetiver extract (40.38, 6.65, 23.15) (more lighter, redder and bluer shades). This may be because of greater amount of TPC and DPPH percentage in chebula. Irrespective of source and method of extraction the colour difference of all the extracts were found to be greater *i.e.,* the highest colour difference was found in chebula ethanol heated extract (30.55) followed by ethanol unheated extract (25.13) and aqueous heated extract of chebula (25.18). Moreover, among the extracts of vetiver the greater colour difference was found in aqueous heated (22.59) followed by ethanol heated (17.35), aqueous unheated (13.71) and ethanol unheated extracts (10.38) respectively.

Effect of natural antioxidants on colour strength and colour coordinates of treated reactive dyed cotton fabric (Red, Blue and Yellow)

Colour strength is the most important parameter to test the quality measurement of a sample in terms of depth of the coloured dyed fabrics. It was observed from the table 1, 2, 3 and 4 that irrespective of source (vetiver and chebula), all the treated samples showed significant increase in colour strength compared to the control samples due to the absorption and deep penetration of natural antioxidants in the fabric structure.

Among the fabrics, it was found that, as the concentration 5, 10 and 15 per cent of vetiver extract increases, the colour strength was also increased in both the temperature *i.e.,* 30°- 40°C and 60°- 70°C temperature (27.9,28.5,29.4) and (29.10, 29.60,28.63) of red colour treated fabrics compared to control sample (26.94) (Table 2). Further, the fabric treated with chebula at 5 and 10 per cent concentration showed greater colour strength (27.07, 27.07) compared to 15 per cent concentration (26.34) in lower temperature. However, in 60°-70°C temperature the colour strength was found to be reduced as compared to control in all the concentration. As the colour strength increased, the reflectance value was found to be lesser in all the treated samples. With the increase in the concentration of dye from 0.5 to 15.0 % (owf), an increase in color strength (*K*/*S*) is observed resulting in deeper shades with increase in the dye adsorption. (Shabbir *et al.,* 2016). The colour strength was found to be greater in vetiver treated blue coloured samples in varied concentrations *viz.,* 5, 10 and 15 per cent concentration and temperatures (17.76, 17.24, 17.65 and 17.65, 17.38, 17.60) respectively, compared to the control sample (15.96) (Table 3). However, the chebula treated samples exhibited greater colour strength in 5 per cent (17.11, 16.92) and 15 per cent (16.07, 15.44) concentration in both the temperature (30°-40°C and 60°- 70°C) compared to control sample (15.96), respectively. Among the yellow coloured fabrics chebula treated samples exhibited greater colour strength at 15 per cent concentration (5.03) in 60°-70°C temperature followed by 10 per cent

Table 2. Effect of natural antioxidants on colour strength and colour coordinates of treated reactive dyed cotton fabric (Red Colour)

Colour Coordinates	Vetiver							Chebula						
	Control	30°- 40°C			60°-70°C			Control	30°- 40°C			60°-70°C		
		5%	10%	15%	5%	10%	15%		5%	10%	15%	5%	10%	15%
K/S	26.94	27.90	28.50	29.40	29.19	29.63	28.63	26.94	27.07	27.07	26.34	25.99	25.63	25.36
RFL	2.79	2.74	2.77	2.73	2.83	2.71	2.81	2.79	2.47	2.47	2.59	2.47	2.41	2.45
L*	33.91	33.28	33.02	32.36	32.96	32.77	32.95	33.91	33.40	33.44	33.35	33.48	32.82	33.08
a*	52.86	52.17	51.95	50.88	52.23	52.24	52.23	52.86	52.25	52.27	51.47	51.36	50.68	50.91
b*	26.92	25.80	26.04	25.27	26.16	26.22	26.06	26.92	26.17	25.42	25.57	25.67	24.31	24.54
dE	-	1.47	1.56	3.01	1.37	1.48	1.27	-	1.30	1.68	2.02	2.01	4.16	3.20

	K/S			Rfl			L*			a*			b*			dE			
	F value	S.Em.±	C.D. (5 %)	F value	S.Em.±	C.D. (5 %)	F value	S.Em.±	C.D. (5 %)	F value	S.Em.±	C.D. (5 %)	F value	S.Em.±	C.D. (5 %)	F value	S.Em.±	C.D. (5 %)	
Concentration(A)	0.54 NS	0.053	0.154	2.03 NS	0.005	0.014	11.06*	0.045	0.131	7.74*	0.010	0.029	7.80*	0.054	0.159	0.46NS	0.061	0.179	14.03
Temperature (B)	2.46 NS	0.035	0.103	2.70 NS	0.003	0.010	0.09NS	0.030	0.087	0.14NS	0.007	0.020	0.00NS	0.036	0.106	0.34NS	0.041	0.120	
Source (C)	158.71*	0.035	0.103	189.60*	0.003	0.010	35.60S	0.030	0.087	72.61S	0.007	0.020	85.62*	0.036	0.106	11.64*	0.041	0.120	
AxB	1.88NS	0.053	0.154	3.35NS	0.005	0.014	0.36NS	0.045	0.131	0.96NS	0.010	0.029	1.69NS	0.054	0.159	2.12NS	0.061	0.179	
BxC	15.89NS	0.105	0.308	11.95*	0.010	0.029	0.84NS	0.089	0.262	2.13NS	0.020	0.059	1.56NS	0.109	0.319	3.11NS	0.122	0.359	
AxC	2.43	0.105	0.308	2.48NS	0.010	0.029	2.21NS	0.089	0.262	135.97*	0.020	0.059	28.79*	0.109	0.319	8.13*	0.122	0.359	
AxBxC	3.28	0.210	0.617	1.33NS	0.020	0.058	5.87*	0.179	0.524	1.10NS	0.040	0.117	9.15*	0.217	0.638	9.35*	0.245	0.717	

NS- Non Significant, *Significant @ 5 % level , Figures in parenthesis indicate K/S (ΔE), L*(ΔL), a*(Δa), b*(Δb), K/S- Colour strength, RFL- Reflectance, L-The lightness/darkness co-ordinate, a*- The red/green co-ordinate with +a* indicating red –a* indicating green, b*- The yellow/blue co-ordinate with +b* indicating yellow and –b* indicating blue, dE- Colour difference

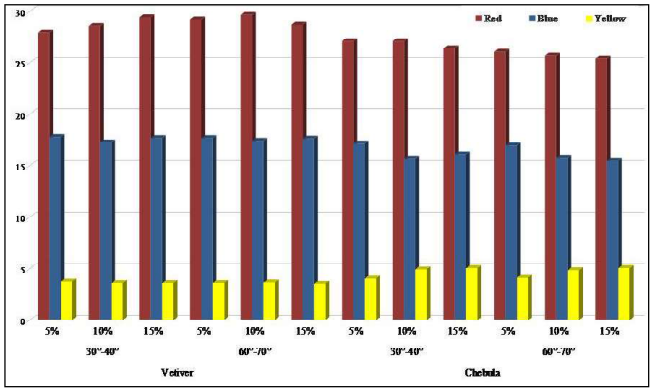

Fig. 1. Effect of natural antioxidants (vetiver and chebula) on colour strength of treated reactive cotton fabric

concentration in 30°- 40°C temperature (4.94) compared to the control samples (3.51) whereas in vetiver at 5 per cent concentration in 30°- 40°C temperature showed highest colour strength (3.71) followed by 10 per cent concentration in 60°- 70°C temperature (3.62) compared to the control sample (3.51) (table 4) due to the presence of greater amount of phenolic compounds and antioxidant activity. In general, the treated samples became slightly darker, greener and bluer than the control sample both in vetiver and chebula. As the colour strength was increased the reflectance values was found to be decreased.

The lightness (L*) of red coloured fabric was found to be slightly reduced in vetiver and chebula extract in both the temperature (30°- 40°C and 60°- 70°C) at 5, 10 and 15 per cent concentration (vetiver: 73.09,73.33,72.44 and 73.62,72.78, 73.72) and (chebula : 73.21, 71.47, 71.48 and 72.37, 72.31, 71.15) compared to the control sample (75.46) indicates the treated samples became more darker. Among the blue coloured fabric of vetiver extract, the lightness (L*) value was found to be lesser (32.67,33.17,32.58 and 32.84,33.08,33.19) at (30°- 40°C and 60°- 70°C) in 5, 10 and 15 per cent concentrations compared to the control sample (35.03) indicated that the treated samples became more darker. Further, the sample treated with chebula was found to be greater in lightness value at 10 and 15 per cent concentration in both the temperature (30°- 40°C and 60°- 70°C) which was 35.61, 35.44 and 35.40, 35.24 indicates the treated samples became more lighter and at 5 per cent treated samples showed lesser hue (33.70 and 33.64) compared to the control sample (35.03). Moreover, in yellow coloured fabric it was found to be slightly reduced in vetiver and chebula extract in both the temperature (30°- 40°C and 60°- 70°C) at 5, 10 and 15 per cent concentration (vetiver: 73.09, 73.33, 72.44 and 73.62,72.78, 73.72) and (chebula : 73.21, 71.47, 71.48 and 72.37, 72.31, 71.15) compared to the control sample (75.46) indicates the treated samples became more darker which may be due to the presence of greater amount of total phenolic content and antioxidant activity of the plant extracts *viz*. vetiver and chebula.

In red/ green coordinates (a*) of red coloured treated samples, exhibited lesser values in both the temperature

Table 3. Effect of natural antioxidants on colour strength and colour coordinates of treated reactive dyed cotton fabric (Blue Colour)

Colour coordinates	Vetiver										Chebula									
	Control	30°- 40°C			60°-70°C						Control	30°- 40°C			60°-70°C					
		5%	10%	15%	5%	10%	15%					5%	10%	15%	5%	10%	15%			
K/S	15.96	17.76	17.24	17.65	17.65	17.38	17.60				15.96	17.11	15.63	16.07	16.92	15.72	15.44			
RFL	17.16	15.10	15.36	14.87	15.23	15.51	15.60				17.16	8.98	9.45	9.52	8.43	8.77	8.93			
L*	35.03	32.67	33.17	32.58	32.84	33.08	33.19				35.03	33.70	35.61	35.40	33.64	35.44	35.24			
a*	1.36	0.70	0.50	0.43	0.53	0.87	0.53				1.36	-7.25	-9.42	-8.86	-8.06	-9.68	-10.29			
b*	-43.26	-40.22	-40.43	-39.70	-40.15	-40.73	-40.75				-43.26	-33.23	-32.39	-33.20	-32.24	-31.98	-30.46			
dE	-	3.93	3.50	4.46	3.91	3.23	3.23				-	13.29	15.33	14.35	14.60	15.82	17.32			
ANOVA	K/S			Rfl			L*			a*			b*			dE				
	F value	S.Em. ±	C.D. (5 %)	F value	S.Em. ±	C.D. (5 %)	F value	S.Em.±	C.D. (5 %)	F value	S.Em.±	C.D. (5 %)	F value	S.Em.±	C.D. (5 %)	F value	S.Em.±	C.D. (5 %)		
Concentration(A)	37.59*	0.021	0.063	0.17^{NS}	0.027	0.080	24.610*	0.033	0.096	24.61	0.033	0.096	0.81^{NS}	0.453	1.329	4.31*	0.064	0.186		
Temperature (B)	2.20^{NS}	0.014	0.042	1.56^{NS}	0.018	0.053	7.97*	0.022	0.064	7.97	0.022	0.064	1.57^{NS}	0.302	0.886	4.57*	0.042	0.124		
Source (C)	266.66*	0.014	0.042	3325.00*	0.018	0.053	27.84*	0.022	0.064	52.84	0.022	0.064	29.64*	0.302	0.886	14.85*	0.042	0.124		
AxB	2.40^{NS}	0.021	0.063	0.25^{NS}	0.027	0.080	2.72^{NS}	0.033	0.096	2.72	0.033	0.096	1.02NS	0.453	1.329	0.78^{NS}	0.064	0.186		
BxC	1.85^{NS}	0.043	0.126	18.80*	0.054	0.159	12.73*	0.066	0.192	12.73	0.066	0.192	2.21^{NS}	0.906	2.659	17.07*	0.127	0.373		
AxC	17.62*	0.043	0.126	2.44^{NS}	0.054	0.159	22.74*	0.066	0.192	22.74	0.066	0.192	0.66^{NS}	0.906	2.659	7.44*	0.127	0.373		
AxBxC	1.06^{NS}	0.086	0.251	4.20*	0.109	0.319	1.31^{NS}	0.131	0.384	1.31	0.131	0.384	0.81^{NS}	1.813	5.317	4.40*	0.254	0.745		

NS- Non Significant, *Significant @ 5 % level , Figures in parenthesis indicate K/S (ΔE), L*(ΔL), a*(Δa), b*(Δb), K/S- Colour strength, RFL- Reflectance, L-The lightness/darkness co-ordinate, a*- The red/green co-ordinate with +a* indicating red –a* indicating green, b*- The yellow/blue co-ordinate with +b* indicating yellow and –b* indicating blue, dE- Colour difference

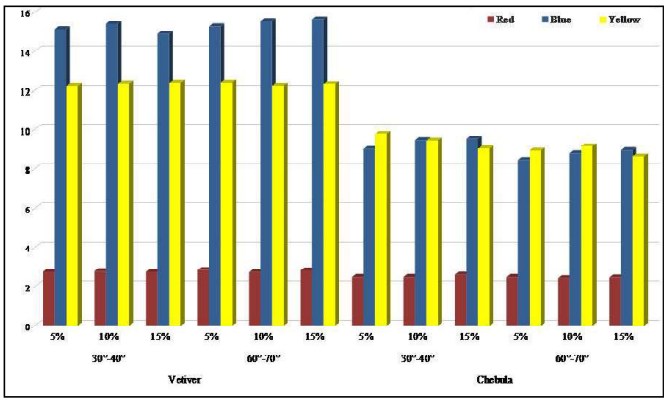

Fig. 2. Effect of natural antioxidants (vetiver and chebula) on reflectance of treated reactive dyed cotton fabric

(30°- 40°C and 60°- 70°C) with varied concentrations treated with vetiver (52.17,51.95,50.88 and 52.23,52.24,52.23) and chebula (52.25,52.27,51.47 and 51.36,50.68,50.91) compared to the control samples (52.86) which indicates that the treated samples became more greener (less redder). Yellow/blue coordinates (b*) explained similar results indicates that the treated samples became more bluer and less yellower. The colour difference was found to be more in chebula at 60°-70°C in 10 per cent and 15 per cent concentration (4.16 and 3.20) than vetiver (1.48 and 1.27). Among the red/green coordinates (a*) of vetiver blue coloured, treated samples became more greener and less redder in both the temperature (30°- 40°C and 60°- 70°C) (0.70, 0.50,0.43 and 0.53,0.87,0.53) compared to the control sample (1.36). However, chebula exhibited more greener shade in both the temperature and in concentration 5, 10 and 15 per cent (-7.25, -9.42, -8.86 and -8.06, -9.68, -10.29) respectively.

Further in (b*) coordinate , the treated samples were found to be more bluer in shade in both the temperature (30°- 40° and 60°- 70°C) and concentration 5, 10 and 15 per cent for both the extracts (vetiver: -40.22, -40.43, -39.70 and -40.15, -40.73, -40.75) and (chebula : -33.23,-32.39, - 33.20 and -32.24, -31.98, - 30.46) respectively. The colour difference was found to be more in chebula in 10 and 15 per cent with 60°- 70° temperature (15.82 and 17.32) compared to vetiver extract (3.23 and 3.23). Irrespective of source, finishing conditions and treatment concentration, the colour difference (dE) was found to be more in higher temperature (60°-70°C) specially in blue colour fabric may be due to darker shades which are more sensitive to temperature and random heating will cause unlevel dyeing (Atul, 2009).

Among the colour coordinates of yellow coloured treated fabric the red/green coordinates (a*) of 5 and 10 per cent of chebula treated samples at 30°- 40°C was found to be slightly reduced (7.34 and 7.81) compared to the control sample (8.04). Similarly, at 5 per cent in 60°- 70°C temperature treated samples was decreased in red/green coordinates (7.37) compared to the control sample. Further, in 15 per cent at 30°- 40° and 60°- 70°C temperature treated samples was slightly increased a* coordinate (8.36 and 8.33) compared to the control sample (8.04) which indicates that the treated samples became more greener and less redder whereas in vetiver treated samples the (a*)

Table 4. Effect of natural antioxidants on colour strength and colour coordinates of treated reactive dyed cotton fabric (yellow Colour)

Colour Coordinates	Vetiver										Chebula									
	Control	30°- 40°C			60°-70°C						Control	30°- 40°C			60°-70°C					
		5%	10%	15%	5%	10%	15%					5%	10%	15%	5%	10%	15%			
K/S	3.51	3.71	3.57	3.58	3.59	3.62	3.52				3.51	4.02	4.94	5.03	4.09	4.83	5.03			
RFL	12.71	12.23	12.34	12.38	12.40	12.25	12.33				12.71	9.79	9.45	9.01	8.93	9.14	8.63			
L*	75.46	73.09	73.33	72.44	73.62	72.78	73.12				75.46	73.21	71.47	71.48	72.37	72.31	71.15			
a*	8.04	8.61	8.14	7.96	8.53	8.10	7.95				8.04	7.34	7.81	8.36	7.37	8.04	8.33			
b*	56.45	51.89	51.65	50.07	51.94	50.77	51.76				56.45	52.13	53.72	54.61	51.06	54.81	53.83			
dE	-	5.18	5.56	7.06	4.91	6.29	4.88				-	4.92	4.85	4.24	6.26	3.56	5.06			
	K/S			Rfl			L*			a*			b*			dE				
	F value	S.Em.±	C.D. (5 %)	F value	S.Em.±	C.D. (5 %)	F value	S.Em.±	C.D. (5 %)	F value	S.Em.±	C.D. (5 %)	F value	S.Em.±	C.D. (5 %)	F value	S.Em.±	C.D. (5 %)		
Concentration(A)	68.35*	0.008	0.025	3.44*	0.009	0.028	11.06*	0.045	0.131	7.74*	0.010	0.029	7.80*	0.054	0.159	0.46^{NS}	0.061	0.179		
Temperature (B)	0.81^{NS}	0.006	0.016	4.30*	0.006	0.019	0.09^{NS}	0.030	0.087	0.14^{NS}	0.007	0.020	0.00^{NS}	0.036	0.106	0.34^{NS}	0.041	0.120		
Source (C)	998.29*	0.006	0.016	4.30*	0.006	0.019	35.60 *	0.030	0.087	72.61S	0.007	0.020	85.62*	0.036	0.106	11.64 *	0.041	0.120		
AxB	0.00^{NS}	0.008	0.025	3.44*	0.009	0.028	0.36^{NS}	0.045	0.131	0.96^{NS}	0.010	0.029	1.69^{NS}	0.054	0.159	2.12^{NS}	0.061	0.179		
BxC	0.21^{NS}	0.017	0.049	4.30*	0.019	0.056	0.84^{NS}	0.089	0.262	2.13^{NS}	0.020	0.059	1.56^{NS}	0.109	0.319	3.11^{NS}	0.122	0.359		
AxC	97.20*	0.017	0.049	3.44*	0.019	0.056	2.21^{NS}	0.089	0.262	135.97*	0.020	0.059	28.79*	0.109	0.319	8.13*	0.122	0.359		
AxBxC	2.28^{NS}	0.034	0.098	3.44*	0.038	0.111	5.87*	0.179	0.524	1.10^{NS}	0.040	0.117	9.15*	0.217	0.638	9.35*	0.245	0.717		

NS- Non Significant, *Significant @ 5 % level , Figures in parenthesis indicate K/S (ΔE), L*(ΔL), a*(Δa), b*(Δb), K/S- Colour strength, RFL- Reflectance, L-The lightness/darkness co-ordinate, a*- The red/green co-ordinate with +a* indicating green, b*- The yellow/blue co-ordinate with +b* indicating yellow and –b* indicating blue, dE- Colour difference

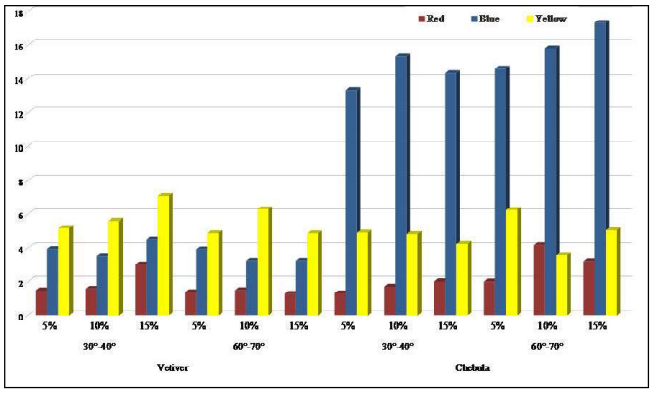

Fig. 3. Effect of natural antioxidants (vetiver and chebula) on colour difference of treated reactive dyed cotton fabric

value was found to be greater at both the temperatures (30°- 40°C and 60°- 70°C) in 5 and 10 per cent (8.61 and 8.14) , (8.53 and 8.10) compared to the control sample (8.04). On contrary at 15 per cent, a* values was found to be reduced (7.96 and 7.95) compared to the control sample (8.04) which indicates that the treated samples became more redder and less greener. This may be due to the partial hydrolysis of dye molecules at higher temperature which may result into change in hue. The colour difference was found to be more in chebula treated samples, this may be due to the greater changes in colour coordinates (L*, a*, b*) values under different conditions and treatment concentrations which may effects the hue of the treated sample resulting into greater colour difference.

Conclusion

All the colours can be characterised by hue, saturation, and lightness. Hue indicates the colour or saturation – *i.e*, the shade determined by how much colour of any hue is present and by lightness *i.e*, the degree of lightness and darkness of a particular colour. The colour strength was significantly increased with the reduction in reflectance value of treated reactive dyed cotton fabric. The lightness (*L**) values of all the treated samples was found to be slightly changed compared to control in both vetiver and chebula extract. The colour coordinates (L*, a*, b*) of treated samples exhibited darker shades with more redder and bluer in vetiver extract of red and yellow coloured fabric compared to the chebula which exhibited more darker, greener and bluer shades. Irrespective of source, finishing conditions and treatment concentration, the colour difference (dE) was found to be more in higher temperature (60°-70°C) in blue colour fabric than the red and yellow coloured fabric.

From the above study it was found these fabrics treated with natural antioxidants (vetiver and chebula extracts) were beneficial in reducing skin diseases and prevents photo – degradation of the textile substrate which leads to protection from sun rays, can be replaced with commercial dye fixing agents to improve the colour fastness properties of reactive dyed cellulosic's with minimum effluent load.

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