Alternatives to Urea in Wool Printing
Part 2
Zero Urea in Printing Wool Fabrics with Reactive Dyes

Prof. Dr Yasser El Hamaky, Prof. Dr Sherief Hassan, Dr Eman Nasef, Eng. Nermin Atef

Abstract: ***In part (1) wool was printed using 50g/kg urea instead of 200g/kg with combination of 20g/kg yeast enzyme and 150g/kg ethylene glycol. In this paper a completely elimination of urea from the printing paste was achieved. The sponge printing film which was formed on the surface of the wool fabrics, contained reactive dye, yeast enzyme, two different types of wetting agents and formic acid.The K/S of the printed samples was increasedby about 60.55% for red dye and 55.34% for blue dye which were applied, when comparing with those printed with the traditional printing paste that containing 200g/kg urea.***

1. Introduction

Urea plays an important role in increasing water content in wool fabrics and helps in dissolving reactive dyes in printing paste(1) and swelling both of printing film and wool fabrics during fixation process (2), besides decrease the aggregation of dye molecules, thus leads to increase the dye ability to diffusion and transfer quickly and easily to wool fabrics(3).

Despite the important role of urea in wool printing, urea is one of the sources of environmental pollution. With increasing awareness towards environmental protection, the present paper reviews an attempt to completely remove urea from the printing paste and replace it with other components that don't affect the color depth of the prints.

2. Experimental

2.1 Materials

100% 2/2 twill wool fabric of 210g/m^2 produced by Ghazl el Mahala Company, Egypt was used throughout this study. Reactive dyes Bezaktiv Red Go and Bezaktiv Blue Go as well as sodium alginate (Sera Print M-AHV 4) whichwere kindly supplied by Dystar and locust bean gum supplied by Special Ingredientswere selected in the present work. Brewer's yeast enzyme used throughout this work was supplied from the Egyptian Starch, Yeast & Detergents Company.Sera-Wash M-RK and Sera-Fast CDR, manufactured by Dystar, Germany. Foryl WAN - Anionic wetting agent supplied by Newtrac trading, GB detergent SRM conc. - nonionic wetting agent supplied by GB chem and TanatergeAdance - nonionic wetting agent supplied by Tanatex Chemicals.

All other chemicals used during this study were laboratory commercial grades.

2. 2 Technical Procedures

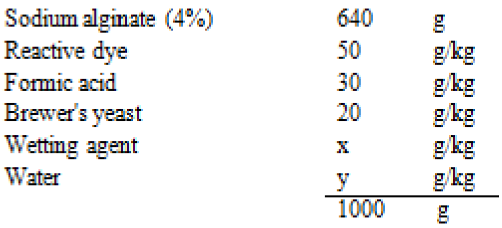
2.2.1 Chlorination of wool fabrics

Wool fabrics were firstly washed withNon-ionic detergent (Sera-Wash M-RK)at room temperature for 10 minutes then rinsed with cold water. Then, the wool was treated with 3ml/L sodium hypochlorite and 6ml/Lglacial acetic acidin a diluted bath for 15 minutes at room temperature.After that, the fabrics were treated with 3g/l sodium bisulfite for 15 minutes at room temperature then rinsing well with cold water.

2.2.2 Printing of wool fabrics

Chlorinated wool fabrics were printed with reactive dyes using flat silk screen (37 meshes/ inch) method. The optimum conditions of using yeast enzyme as mentioned in part (1) was applied which was 20g/kg with fermentation for an hour. The printing paste was prepared by dissolving the thickener (sodium alginate 4%) in water, then the previously dissolved yeast enzyme was added and left for an hour in a warm place or warm bath at 45°C for fermentation, then dissolved dye and all other chemicals were added to the paste after fermentation time while stirring continuously.

The chlorinated wool samples were printed using the following recipe:



Sodium alginate (4%)	640	g
Reactive dye	50	g/kg
Formic acid	30	g/kg
Brewer's yeast	20	g/kg
Wetting agent	x	g/kg
Water	y	g/kg
	1000	g

After printing, the wool fabrics were dried using the dryer at temperature 100ºC for 1 minute.

Fixation:

The printed dried samples were subjected to fixation by steaming at 100ºC for 30 minutes. The steamer manufactured by "Harish Textile Engineers LTD" Umbergaon, Gujarat, India, Machine No: L.S.255, Year: Oct.1996, Type: H.L: 300/250 was used in this step.

Washing off:

The wool samples were rinsed with running cold water, then they were washed with 6ml/l non-ionic detergent, Sera-Wash M-RK at 60ºC for 10 minutes. Finally, the samples were rinsed with cold water and dried at room temperature.(4)

2.3 Measurements

Determination of the color strength (K/S):
Color strength (K/S) of the printswas carried out in the Laboratory of National Research Center (NRC - Cairo, Egypt) (using a Hunter Lab Spectro - Photometer apparatus, model UltraScan PRO made by USA).

Microscope:
The microscope shoots were taken by Video Camera SDL at National Institute of Standards [NIS-Egypt].

Evaluation of color fastness properties:
Color fastness to washing, rubbing whether dry or wet, perspiration and light of the printed samples were measuredaccording to [ISO 105 / C05-1984], [ISO 105-1987], [ISO 105 / E04 - 1978], [ISO l05 / B02 - 1984] respectively.

3. Results and Discussion

3.1 Effect of sodium alginate as a thickener

3.1.1 Effect of anionic wetting agent (Foryl WAN)

The effect of anionic wetting agent was studied to eliminateurea from the printing paste. So different concentrations of "Foryl WAN" which were 0, 10, 20, 30, 40, 50, 60 & 70g/kg were applied with adding 20g/kg yeast enzyme without urea.

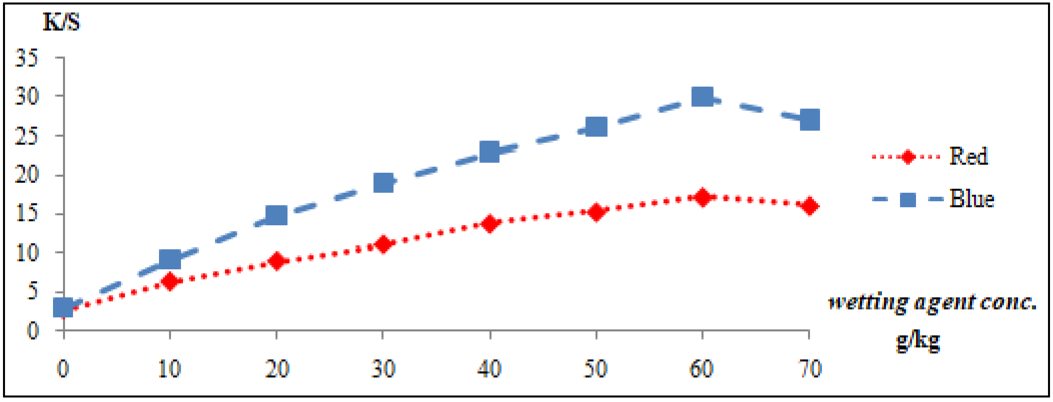


Figure 1: Effect of different conc. of Foryl WAN on K/S

It was found from figure (1) that the maximum K/S value for the red and blue color was at concentration 60g/kg of the anionic wetting agent which were (K/S=17.27& 29.93) respectively.

3.1.2 Effect of nonionic wetting agent (GB detergent SRM conc.):

The chlorinated wool fabrics were printed with different concentrations of nonionic wetting agent which were: 0, 10, 20, 30, 40, 50, 60&70g/kg with adding 20g/kg yeast enzymein order to eliminateurea from the printing paste.

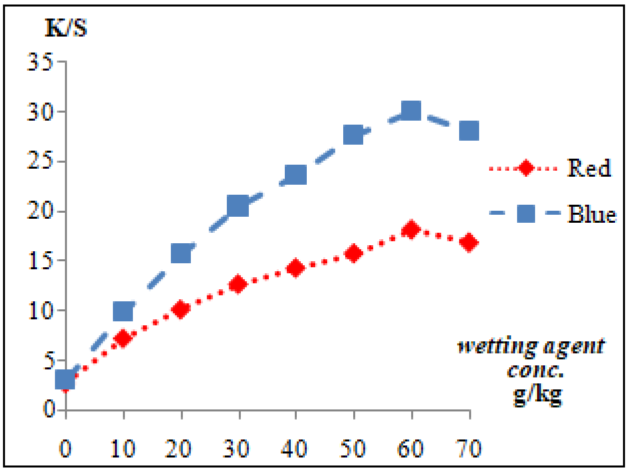


Figure 2: Effect of different conc. of GB detergent SRM conc. on K/S

It is clear from figure (2) that the K/S value is increased by increasing the nonionic wetting agent concentration without adding urea till it reaches its maximum at 60g/kg where (K/S =18.22) for red dyecolor and (K/S =30.11) for blue dye color and this is a high value of K/S to reach without urea.

3.1.3 Effect of nonionic wetting agent (Tanaterge Advance)

The effect of "Tanaterge Advance" was studied by using different concentrations which were 0, 10, 20, 30, 40, 50, 60 & 70g/kg with adding 20g/kg yeast enzyme without urea.

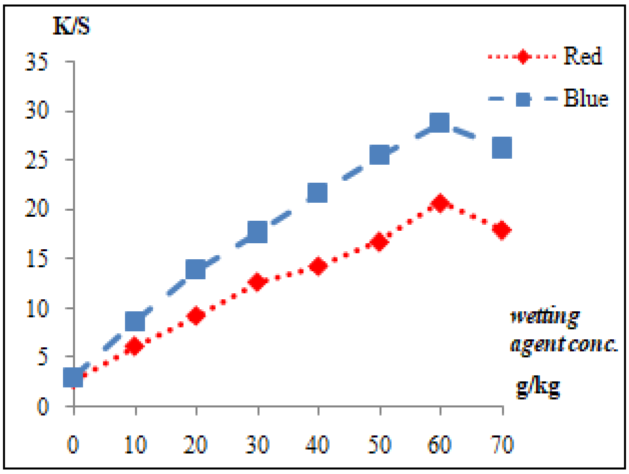


Figure 3: Effect of different conc. of "Tanaterge Advance" on K/S

It was found from figure (3) that the maximum K/S value for the red and blue color was at concentration 60ml/kg of the nonionic wetting agent which were (K/S=20.79&28.86) respectively.

3.1.4 Effect of mixing different types of wetting agents:

The effect of mixing different wetting agents with different concentrations was studied with adding 20g/kg yeast enzyme without urea. The chlorinated wool fabrics were printed with three different wetting agents which were:

a) Foryl WAN - Anionic wetting agent
b) GB detergent SRM conc. - Nonionic wetting agent
c) Tanaterge Advance- Nonionic wetting agent

Where three samples were printed with 60g/kg of each wetting agent and another three samples were printed with mixture of the three wetting agent as follows: (50% a + 50% b), (50% a + 50% c) & (50% b + 50% c) inorder to reach the maximum K/S.

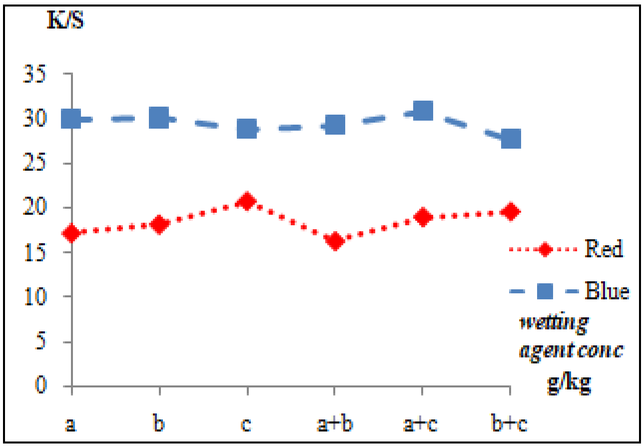


Figure 4: Effect of different types of wetting agents on K/S

From figure (4) it can be noticed that the maximum K/S value (20.79) for the red color is at concentration 60ml/kg of “Tanaterge Advance” only, whereas the maximum K/S (30.87) of the blue color can be observedwhen mixing 50% of “Foryl WAN” + 50% of “TanatergeAdance”.

By comparing the previous results with the K/S values of samples printed with normal printing paste which contains 200g/kg urea, it was found that the K/S values increased by about (15.3%) for the red dye color and (51.32%) for the blue dye color.

The major role of wetting agent is reducing the surface tension between two surfaces(5), the same effect could be happened when using wetting agent in the printing paste of wool fabrics as itdecreases the surface tension between wool fabrics and water which is increased in the printing film during steaming process, where the sponge printing film absorbs a big quantity of water under the action of water condensation on the surface of the printed fabrics and the presence of wetting agent causing a decrease in the surface tension between the printed film and the water which leads to increasing both the solubility of the reactive dye and the wool absorption.

The K/S values which were achieved indicate that the sponge film is able to absorb enough amount of water (as incase of traditional urea printing 200g/kg) to complete the printing process achievement in an excellent way. It is clear that the presence of wetting agent facilitatesand providesa maximum solubility of reactive dye and absorption of wool.

3.1.5 Effect of steaming temperature

After printing the samples using20g/kg yeast enzyme, 30g/kg anionic wetting agent “Foryl WAN” and 30g/kg nonionic wetting agent “Tanaterge Advance”, the samples were dried at100ºC for 1 minute. Then the printed samples were steamed at different temperatures 90, 95, 100, 105 and 110ºC for 30 minutes.

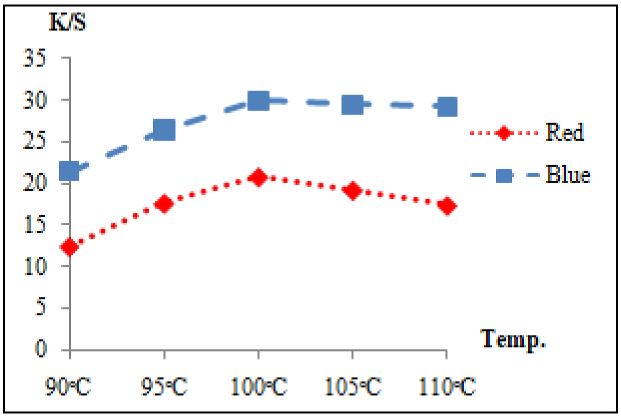


Figure 5: Effect of steaming temperature on K/S

A similar behavior for the two applied reactive dyes under the action of elevating the steaming temperature was observed as it is shown in figure (5), where maximum dye fixation was achieved at a temperature of 100°C for the two colors.

By elevating the temperature of steaming from 90ºC up to 100ºC, K/S was found to increase by about 67.38%for red dye and 39.47% for blue dye.

3.1.6 Effect of steaming time

To determine the suitable steaming duration within which complete reaction and maximum dye fixation may be attained, the printed wool samples were subjected to steaming at 100ºC for different durations as follows : 20, 25, 30, 35 and 40 minutes.

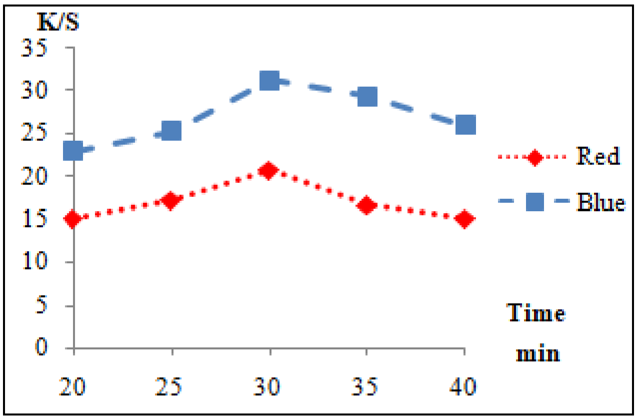


Figure 6: Effect of steaming time on K/S

From figure (6), it is well observed that by increasing the duration of steaming, the dye fixation gradually increased till it reaches its maximum value after 30 minutes for the two applied reactive dyes.

The dye fixation was increased by about 37.28%for the red dye and 35.97% for the blue dye as a result of increasing the steaming time from 20 minutes to 30minutes. Lasting the duration of steaming for more than 30 minutes resulting in decreasing in dye fixation which may be attributed to increasing rate of hydrolysis reaction, as it is well known that prolonged steaming time will increase dye hydrolysis.

3.2 Effect of locust bean gum as a thickener

3.2.1 Effect of pH

The chlorinated wool fabrics were printed with different values of pH which were (3, 4, 5&6) using locust bean gum thickener to bear low pH values when the acidity increase with 20g/kg yeast enzyme, 30g/kg anionic wetting agent “ForylWAN” and 30g/kg nonionic wetting agent “Tanaterge Advance”. When trying to use 60g/kg of nonionic wetting agent “Tanaterge Advance”, the concentration which gave the maximum K/S for the red dye color as shown in figure (4), it was found that the viscosity of the printing paste significantly reduced and became unsuitable for printing.

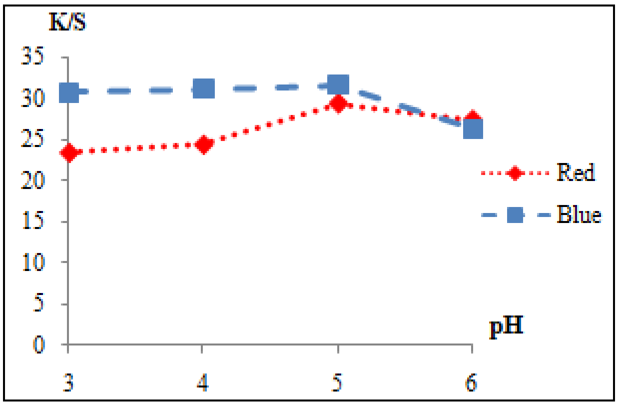


Figure 7: Effect of pH on K/S

It is observed from figure (7) that the increase in color strength (K/S) of the printed samplesis directly proportional to the increase of the pH value until K/S reaches its maximum value at pH=5 for both red and blue dye colors where (K/S=29.43, 31.69) respectively and then started to decrease. By comparing these K/S results with the K/S values of samples printed with normal printing paste which contains 200g/kg urea, it was found that the K/S values increased by about (63.22%) for the red dye color and (55.34%) for the blue dye color.

3.2.2 Effect of steaming temperature

The printed samples were steamed at different temperatures 90, 95, 100, 105 and 110ºC for 30 minutes.

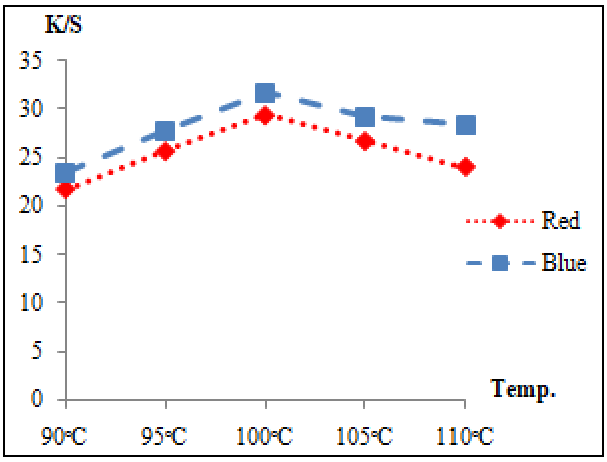


Figure 8: Effect of steaming temperature on K/S

The action of different steaming temperature was observed as it is presented in figure (8), where the highest dye fixation was achieved at a temperature of 100°C for the two colors.

By raising the temperature of steaming from 90ºC up to 100ºC, K/S was increased by about 35.37%for red dye and 35.13% for blue dye.

3.2.3 Effect of steaming time

The printed wool samples were subjected to steaming at 100ºC for different durations as follows: 20, 25, 30, 35 and 40 minutes.

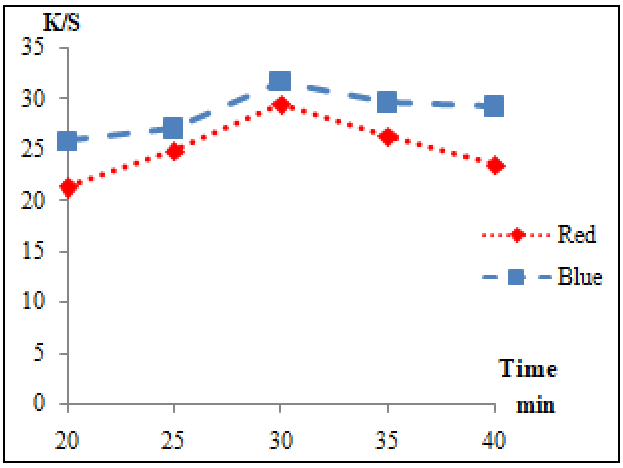


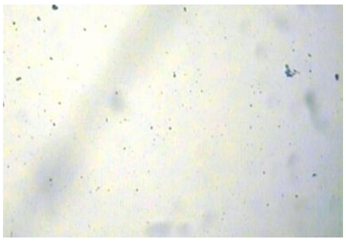
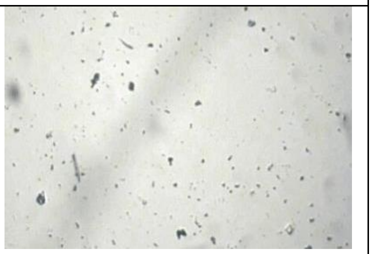
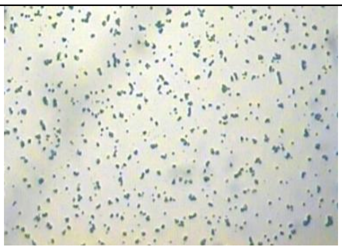
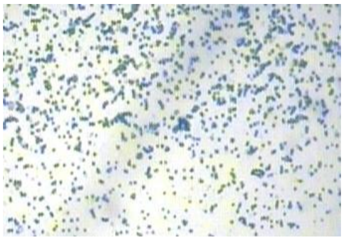
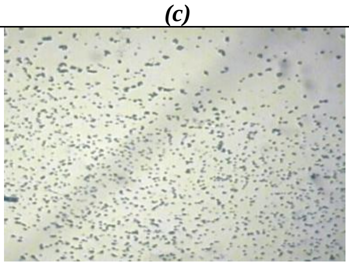
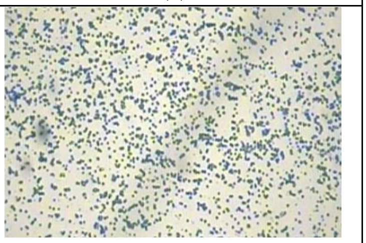
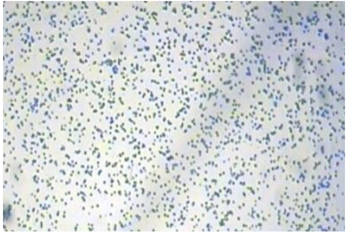
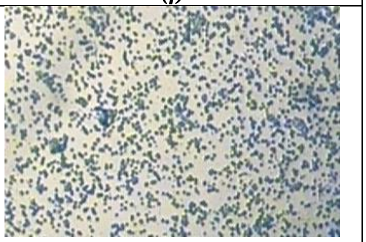
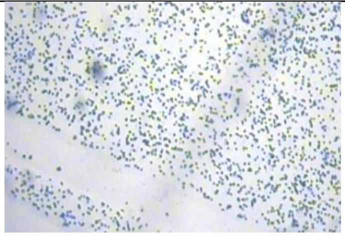
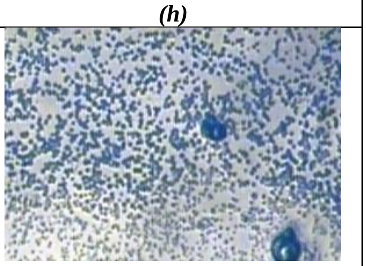
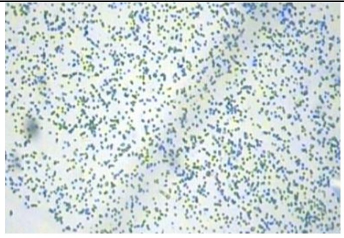
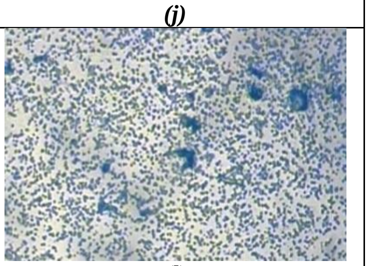
Figure 9: Effect of steaming time on K/S

It is noticed from figure (9) that the maximum K/S value was reached after 30 minutes for the two applied reactive dyes where K/S of the red dye was (K/S=29.43) and K/S of the blue dye was (K/S=31.69), wherethe dye fixation was increased by about 37.91%for the red dye and 22.54% for the blue dye as a result of increasing the steaming time from 20 minutes to 30minutes.

3.3 Microscope shoots for the thickeners

All the shoots was magnified 1000 times the original size.

Table 1: Microscope shoots for sodium alginate and locust bean gum thickener with 20g/kg yeast enzyme after different periods of fermentation time

Fermentation time	*Sodium alginate*	*Locust bean*
Plane	 ***(a)***	 ***(b)***
After 0 min	 ***(c)***	 ***(d)***
After 15 min	 ***(e)***	 ***(f)***
After 30 min	 ***(g)***	 ***(h)***
After 45 min	 ***(i)***	 ***(j)***
After 60 min	 ***(k)***	 ***(l)***

It is clear from table (1) that the yeast enzyme has a great effect on producing air bubbles where carbon dioxide gas is generated during the fermentationand is increased by increasing the duration of fermentation process,(6,7) which could be observed by the naked eye and is clear in the images (c) till (l).By comparing the locust bean gum thickener shoots after adding the yeast enzyme with those of sodium alginate, it is noticed that air bubbles produced in locust bean gum after fermentation is more than those produced in sodium alginate which could be explained the high rise in the K/S of the samples printed with locust bean gum than the samples printed with sodium alginate.

3.4 Color fastness properties

Table 2: Color fastness properties

	Sample	K/S	Rubbing		Washing			Perspiration						Light
			Wet	Dry	Alt	St.1	St.2	Acidic			Alkaline			
								Alt	St.1	St.2	Alt	St.1	St.2	
BezaktivRed Dye	A	18.03	3-4	4-5	4	4-5	4	4-5	4	4	4	4	4	6
	B	20.84	4-5	5	4	4-5	4-5	4-5	4-5	4-5	4	4	4	6
	C	23.83	4-5	5	5	5	4-5	4-5	4-5	4-5	4	4	4	6
BezaktivBlue Dye	A	20.4	3-4	4-5	4	4-5	4	4-5	3-4	3-4	4	4	4	5-6
	B	30	4-5	4-5	4	4-5	4-5	4-5	4-5	4-5	4	4-5	5	6
	C	31.1	4-5	5	5	5	4-5	4-5	4-5	4-5	4	4	4	6

A=Traditional paste
B=Sponge paste with alginate
C=Sponge paste withlocust bean gum
St.1=Staining on cotton
St.2=Staining on wool

Color fastness properties for rubbing, washing, perspiration and light are listed in table (2). In general, all fastness results of the prints with the new pastes were either the same or better than the results of the prints with traditional paste. One can be observed an improvement in wet rubbing fastness for the two applied dyes.Also, there is an enhancement in color alteration of washing fastness for the two dyes in case of locust bean gum.

4. Conclusion

During steaming process, the sponge film formed on wool which has a big surface and empty bubbles becomes very active to absorb steam condensed on its surface.

The components of the new paste including yeast and wetting agenthave the ability to swell both of printed film and wool fabrics during steaming. As a result, more dye solubilization and more dye fixation can be achieved due to the high penetration and rapid transferring of dyes from printing film to wool fabricsleading to decreasing the rate of dye hydrolysis. It can be concluded that it is possible to eliminate urea by replacing it with yeast enzyme and wetting agents in the printing paste. The optimum K/S of the prints was increased by about 60.55% for red dye and 55.34% for blue dye compared with the K/S values of samples printed with 200g/kg urea of traditional paste.

References

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[2] I. Tarakacioglu, A. T. Ozguney, A. Ozerdem and E. Bilgin, "Textile Research journal", Vol. 74, P. (63:67), 2004.
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[5] https://www.himchemindustries.com/pre-treatment.html
[6] https://www.exploratorium.edu/cooking/bread/bread_science.html
[7] http://herbarium.usu.edu/fungi/funfacts/Fermentation.htm