

Direct Application of *Vitisvinifera* (grape) Leaves Extract on Cotton Fabric: A Potential to Prevent UV Induced Skin Problems

DEEPTI PARGAI* and SHAHNAZ JAHAN

Department of Clothing and Textiles, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India.

Abstract

UV radiation causes various skin problems starting from reddening of skin to the change in the shape of DNA which further leads to the skin cancer. Considering harmful effect of UV radiation present study was designed to develop an environmental friendly UV protective finish for cotton fabric using *Vitisvinifera* leaves. Process parameters of the study were optimized using response surface methodology for getting maximum UV protection while maintaining other physical properties of the fabric. It was found that 9.038 %concentration of extract with 60 minutes of exhaustion time at 40.909 °C exhaustion temperature were selected as optimum conditions for application of *Vitisvinifera* extract on cotton fabric. It can be concluded that application of *Vitisvinifera* extract on cotton fabric incorporates UV protection properties on cotton fabric which can be helpful to prevent various UV induced skin problems.



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Introduction

Various programmes for creating the awareness about the harmful effect of UV radiation are being organised in different parts of the world by various environmental and health organisations. Besides tanning, various skin problems and even skin cancer are being diagnosed due to UV radiation. It has been estimated by WHO that up to sixty thousand deaths a year are caused by too much exposure to sun rays¹. The United Nations Environmental Protection Agency has also been estimated that

ozone depletion will lead to between 3 to 15 million new cases of skin cancer in the United States by the year 2075 as ozone depletion leads to the more penetration of UV radiation on the earth². Indian Institute of Tropical Meteorology has also warned about the high UV Index cases in India especially in summer season³. Awareness about the harmful effects and the use of UV protective measures can help to combat this problem. Many renowned organisations and dermatological institutions of the world have been working in this area for minimising

CONTACT Deepti Pargai  pargai.deepti16@gmail.com  Department of Clothing and Textiles, G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India.

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harmful effect of the UV radiation. Several measures are being created to combat this problem.

Sunscreen is a widely used measure for UV protection which is available in the market, it works well for protection against UV rays but many limitations are also associated with it while using it. It works only to limited areas on which it is applied. It requires reapplication after some time and also loses its efficiency in the presence of perspiration. Some evidences have also been found about the accumulation of chemical sunscreen in body and leads to hormonal imbalances, cancer and other allergic reactions⁴. These chemicals affect phytoplankton of marine environment in an adverse way⁵.

Besides sunscreen clothing are also being used as a protective measure against UV radiation as it covers most of the part of the skin. The degree of ultraviolet radiation protection of textile material is measured by the Ultraviolet Protection Factor (UPF). The UPF is the measure of ultraviolet (UV) radiation blocked by the fabrics. Higher UPF value is indicative of more blocking of UV radiation. Clothing made from woven and knitted fabrics can provide convenient personal protection, but there are numerous factors which affect the ultraviolet protection properties of fabric, however very few clothing available in the market can offer sufficient UV protection. The majority of apparel grade textiles available in the market show a UPF value < 10 (i.e. no protection). Hence there is a need to enhance UV protection property of fabric that could be comfortably utilised in summers. As UV protection is mostly requires in summers and cotton fabric is most preferred fabric for summers for providing comfort hence the cotton fabric was selected for the present study. Main aim of the present study was to develop a suitable process to enhance anti UV properties of the cotton fabric which are friendly to environment, economic, durable, as well as could also maintain the other properties of the cotton fabric.

Material and Methods

Collection and Preparation of Plant Material

Vitisvinifera leaves were collected from the campus of G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India. The collected leaves were washed properly to remove dirt and other

particles. The washed leaves were dried in shade. After drying, the leaves were grinded using domestic electric grinder as per the requirement.

Extraction Process

Ten gram powder of *Vitisvinifera* leaves was extracted through Soxhlet apparatus with 80 percent of the methanol for 24 hour at 40 °C. Extract was filtered using filter paper. Whatman filter paper no. 1 was used for the filtration.

Application of *Vitisvinifera* Leaves Extract on Cotton Fabric Using Exhaustion Method

Exhaustion method is carried out in the water bath. Pre-mordanting of fabric was done using the powder of lemon peels to enhance the absorbency and wash fastness of the cotton samples. Mordant solution was prepared by taking 2 g powder of lemon peel in 50 ml of distilled water, allowed to soak overnight, then boiled for 15-20 minutes and filtered. Cotton fabric samples were treated in the prepared mordant solution at 80 °C for 30 minutes in water bath. The pre mordanted samples just removed from the mordant bath, were slightly squeezed and dipped into the extract of *Vitisvinifera* leaves keeping material to liquor ratio as 1:40. The process parameters for exhaustion method were optimised using experimental design of Box and Behnken with 3 levels for each three independent variable. The three independent variables included concentration of extract, exhaustion time and exhaustion temperature which was taken as independent variables is designated as A, B, C respectively. The application of each selected plant extract was done as per the experimental design matrix which is given in the Table 1.

17 samples were produced for application of each plant extract. Least square method and multiple regression analysis were used in the present study for getting optimum conditions.

UV Protection Property Assessment

Standard test method AATCC-183: 2004 was used for calculating Ultraviolet protection factor⁶. Ultraviolet Protection Factor (UPF) indicates the UV protection properties of the fabric. UPF of the treated fabric samples was determined by using "Lab-sphere's UV transmittance analyser".

The UV protection category was determined by the UPF values described by Australian Standards / New Zealand AS/NZS 4399 (1996) given in Table 2.

Fabric Physical Properties

Fabric physical properties like tensile strength and bending length were also assessed with UV protection properties as these are also important parameters in case of application of finish on to the fabric. Tensile strength of the treated fabric sample was calculated using Innolab's tensile strength tester. Standard test method IS 1969-1, 2009 was used to assess tensile strength of the fabric⁹ whereas bending

length of the fabric was assessed using standard test method ASTM D1388-96, 2002⁹.

Washing Durability Test

Durability of the finish is the one of the most important parameter to test the quality of the finish. To assess the durability of the finish, the washing fastness test AATCC method 61(1996) test no. 2A were used using launder-O-Meter of Metrex Scientific Instrument Pvt Ltd with some modification¹⁰. The washed samples were tested for the retention of UV protective finish for 20 laundry washes. The UPF of the treated fabric samples were evaluated after 5th, 10th, 15th, 20th wash.

Table 1: Experimental design matrix for application of *Vitisvinifera* extract on cotton fabric using Box – Behnken experimental design

Experiment No.	Concentration of extract (%)	Exhaustion Time (Minutes)	Exhaustion Temperature (°C)
1.	8	60	40
2.	8	30	40
3.	11	45	40
4.	5	45	40
5.	8	45	60
6.	8	45	60
7.	8	45	60
8.	5	60	60
9.	8	45	60
10.	5	30	60
11.	11	60	60
12.	8	45	60
13.	11	30	60
14.	5	45	80
15.	11	45	80
16.	8	30	80
17.	8	60	80

Table 2: UPF Classification system(AS/NZS 4399:1996)

UPF Rating	UVR Protection	Effective UVR transmission (%)	UPF labelling
15-24	Good protection	6.7-4.2	15, 20
25-39	Very good protection	4.1-2.6	25,30,35
40-50,50+	Excellent protection	≤ 2.5	40,45,50,50

Results and Discussion

The experimental results were analysed by Response surface methodology (RSM). The design matrix and corresponding results of finishing experiments for application of *Vitisvinifera* extract on cotton fabric are shown in Table 3.

Ultra violet protection factor of cotton fabric treated with *Vitisvinifera* extract under various experimental conditions is reported in Table 3. The UPF was recorded in the range of 22.1 to 61.1. The maximum value (61.1) of Ultra violet protection factor was obtained for experiment number 3 with 11% concentration of extract at the temperature of

60 °C for 60 minutes. The minimum value (22.1) was recorded in experiment number 11 having 5% concentration of extract, at the temperature of 80 °C for 45 minutes. It is clear from the results that as the concentration of the extract was increased, the UPF value was found to be increased. Higher concentration of plant extract indicates the more attachment of tannin molecules. The attachment of more tannin sites on the fabric may be the reason of higher UPF value because tannin is considered as a good UV absorber¹¹. Other parameters such as time and temperature have no significant effect on the UPF value of the fabric sample.

Table 3: Finishing conditions with observed responses for application of *Vitisvinifera* extract on cotton fabric

Factor 1	Factor 2	Factor 3	Response 1	Response 2	Response 3
A: Concentration of extract	B: Exhaustion time	C: Exhaustion temperature	UPF	Tensile strength	Bending length
%	minutes	degree centigrade	-	kg	cm
8	45	60	45.7	18.24	1.6
11	30	60	54.7	17.53	1.6
11	60	60	61.1	16.89	1.6
5	30	60	25.4	17.63	1.4
8	45	40	36.9	18.92	1.6
5	60	60	23.7	18.11	1.5
8	45	60	32.3	17.01	1.6
5	45	40	25.2	20.01	1.5
8	60	80	36.3	15.98	1.7
8	30	60	31.5	18.01	1.6
5	45	80	22.1	16.34	1.6
11	45	40	54.1	18.98	1.7
8	30	80	32.4	16.23	1.7
11	45	80	47.5	16.01	1.8
8	30	40	30.7	19.57	1.5
8	45	60	31.7	17.03	1.6
8	45	60	31.5	17.86	1.6

Tensile strength of cotton fabric treated with *Vitisvinifera* extract under various experimental conditions is reported in Table 3. The tensile strength was recorded in the range of 15.98 to 20.01. The maximum value (20.01) of tensile strength was obtained for experiment number 8 with 5% concentration of extract at the temperature of

40 °C for 45 minutes. The minimum value (15.98) was recorded in experiment number 9 having 8% concentration of extract, at the temperature of 80 °C for 60 minutes.

The analysis of the Table 3 reveals that minimum tensile strength was obtained due to the combined

effect of higher level of concentration of extract with maximum level of exhaustion time. It also reveals that a decrease was observed in tensile strength values, as the exhaustion temperature was increased. Based on regression model for predicting the tensile strength, it can be concluded that only exhaustion temperature at linear level was the predictor for tensile strength.

Bending length of cotton fabric treated with *Vitisvinifera* extract under various experimental conditions is reported in Table 3. The Bending length was recorded in the range of 1.4 to 1.8. The maximum value (1.8) of Bending length was obtained for experiment number 11 with 11% concentration of extract at the temperature of 80 °C for 45 minutes. The minimum value (1.4) was recorded in experiment number 4 having 5% concentration of extract at 60 °C temperatures for 30 minutes. The analysis of Table 3 explains that the highest bending length was observed at the interaction of higher level of concentration of extract with maximum level of temperature. A slight increment was observed in bending length with an increase of concentration of plant extract which indicates the slight increment in stiffness of the fabric. Based on regression model for predicting the bending length, it can be concluded that the concentration at linear level whereas exhaustion temperature at linear level as well as at quadratic level were the best predictors for bending length.

Regression analysis was performed using design expert software it was found model was adequate to predict the each response. It was also implied from the regression analysis that the equations for each response were also adequate for correlating the experimental results.

Optimized Finishing Conditions of Treated Cotton Fabric

The goal fixed for independent variables i.e. concentration of extract, exhaustion time, exhaustion temperature was in range. The goal that were fixed for these experimental conditions included maximum UPF, maximum tensile strength and minimum bending length so as obtain the highest desirability factor. The importance was selected (+++) for the independent variables itself by the software. UPF response were given (+++++) importance while

all other the responses were given equal (++++) importance.

A total of 45 optimization solutions were generated by design expert software, out of which, the one with the maximum desirability was selected. The optimized finishing conditions have been shown in Table 4. Best results of finishing were achieved with 9.038% concentration of *Vitisvinifera* leaves extract, at 40.909 °C of exhaustion temperature for 60 minutes of exhaustion time.

Table 4: Optimized conditions of treated cotton fabric

Finishing variable	Optimized conditions
Concentration of extract (%)	9.038
Exhaustion Time(minutes)	60
Exhaustion Temperature (°C)	40.909

To determine the validity of the optimized conditions, set of experiments were conducted according to the conditions that were optimized by the model. The experiments were run in triplicates and average value was calculated. The predicted results obtained from the equation for application of *Vitisvinifera* extract on cotton fabric using the optimized conditions are shown in Table 5. The average value of the experiment was compared with the predicted values obtained. The results indicate that the experimental results were quite close to the predicted theoretical values.

Table 5: Predicted and experimental values of *Vitisvinifera* treated cotton fabric with optimum finishing conditions

S. No.	Response	Predicted value	Experimental value
1.	UPF	47.816	64.7
2.	K/S	14.753	16.89
3.	Lightness value	68.618	57
4.	Tensile strength(kg)	18.763	18.67
5.	Bending length(cm)	1.647	1.545
6.	Crease recovery angle (degree)	78.118	76.90

Table 6: Washing durability of treated samples

No. of wash cycle	UV protection property	
	UPF	Category
0	64.7	Excellent
5	43.2	Very good
10	36.1	Very good
15	16.8	Good
20	12.7	No protection

It can be concluded from the results that the applied model was sufficient. Therefore, the optimized value of concentration of *Vitisvinifera* leaves extract (A), exhaustion time (B) and temperature (C) predicted by the numerical optimization i.e. 9.038% concentration of *Vitisvinifera* leaves extract at 40.909 °C for 60 minutes were selected as optimum conditions for UV protective finishing of cotton fabric with *Vitisvinifera* leaves extract using exhaust method.

Washing Durability of Treated Fabric Samples at Optimum Conditions

Table 6 represents that the excellent UV protection properties was observed to be remained in case of

each finished fabric samples even after 15 wash cycles.

Conclusion

It can be concluded from the present study that application of *Vitisvinifera* extract adds the UV protection properties to the cotton fabric which can remain on the fabric even after 15 wash cycles. Utilisation of plant waste to incorporate UV protection properties to the cotton fabric will not only provide UV protective properties but also maintains the environment in the aspect of sustainability. Further research has been extended to make the finish more durable. The present study may not only beneficial to provide UV protection properties but also help in utilising the plant waste in economic terms.

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