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Utilization of *Citrus limetta* Peels Waste to Incorporate UV Protective Properties into Cotton Fabric : A Sustainable Approach for Preventing UV Induced Skin Problems

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Abstract Various renowned organizations has warned about the harmful effect of UV radiation and advised to take precaution against these UV rays. Hence there is need to search out a preventive measure which can prevent these harmful effect of UV radiation from the Sun. Clothing which covers the most of the part of the skin can also act as a protective measure but not all clothing available in the market can provide protection form these UV rays. There is need to incorporate the UV protection properties in to the fabric. In the present study *Citrus limetta* were utilized to incorporate UV protection properties into the fabric. It was found in the present study that the extract of *Citrus limetta* peels can be utilized to incorporate UV protection properties in to the fabric and further helpful to prevent UV induced skin problems.

Keywords Peel waste, *Citrus limetta,* UV protective properties, UV induced skin problems.

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Introduction

UV radiation has many beneficial effects but too exposure to these rays can be proved harmful to the human skin. 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 rays [1]. The United Nations Environmental Protection Agency has also been estimated that ozone depletion will lead to between 3 and 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 earth [2]. Indian Institute of Tropical Meteorology has also warned about the high UV index cases in India especially in summer season [3]. Awareness about the harmful effects and the use of UV protective measures can help to combat this problem. Many renowned organizations and dermatological institutions of the world have been working in this area for minimizing 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 presense of perspiration. Some evidences have also been found about the accumulation of chemical sunscreen in body and leads to hor-

monal imbalances, cancer and other allergic reaction [5]. These chemicals affect phytoplankton of marine environment in an adverse way [5].

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 utilized in summers. The 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.

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Materials and Methods

Collection and preparation of plant material

Citrus limetta peels were collected from juice corners. The collected peels were washed properly to remove dirt and other particles. The washed peels were dried in shade. After drying, the peels were grinded using mortar and pestle as well as domestic electric grinder.

Extraction process

Ten gram powder of *Citrus limetta* peels was extracted through Soxhlet apparatus with 80% of the methanol for 24 h at 40^0C. Extract was filtered using filter paper. Application of *Citrus limetta* peels extract on cotton fabric using microwave method

Table 1. Experimental design matrix for application of *Citrus limetta* extract on cotton fabric using Box – Behnken experimental design.

Experiment No.	Concentration of extract (%)	Microwave power (Watt)	Treatment time (Minutes)
1.	5	320	3
2.	5	400	5
3.	5	240	5
4.	5	320	7
5.	8	320	5
6.	8	320	5
7.	8	240	3
8.	8	400	3
9.	8	320	5
10.	8	320	5
11.	8	240	7
12.	8	320	5
13.	8	400	7
14.	11	320	3
15.	11	400	5
16.	11	240	5
17.	11	320	7

Microwave method is carried out in the water bath. Pre-mordanting of fabric was done 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 80^0C 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 *Citrus limetta* peels keeping material to liquor ratio as 1:40. The process parameters for microwave method were optimized using experimental design of Box and Behnken with 3 levels for each three independent variable. The three independent variables included concentration of extract, microwave power and treatment time 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 re-

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

gression 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 factor [6]. 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 analyzer.

The UV protection category was determined by the UPF values described by Australian Standards/ New Zealand AS/NZS 4399 (1996) [7] given in Table 2.

Fabric physical properties

Fabric physical properties like tensile strength and bending 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 fabric [8] whereas bending length of the fabric was assessed using standard test method ASTM D1388-96, 2002 [9].

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 modification [10]. 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 5^{th}, 10^{th}, 15^{th}, 20^{th} wash.

Results and Discussion

The experimental results were analyzed by Response surface methodology (RSM). The design matrix and corresponding results of finishing experiments for

Table 3. Finishing conditions with observed responses for application of *Citrus limetta* extract on cotton fabric.

Factor 1 A : concentration of extract %	Factor 2 B : Microwave time minutes	Factor 3 C : Microwave power degree centigrade	Response 1 UPF	Response 2 tensile strength kg	Response 3 bending length cm
5	320	3	22.9	15.91	1.9
5	400	5	8.2	14.07	2
5	240	5	22.3	16.37	1.6
5	320	7	23.5	15.63	1.7
8	320	5	24.1	15.18	1.8
8	320	5	24.9	15.18	1.8
8	240	3	31.1	16.21	1.8
8	400	3	27.8	14.12	2.1
8	320	5	25	15.18	1.8
8	320	5	24	15.18	1.8
8	240	7	32.9	16.12	1.7
8	320	5	29.3	15.18	1.8
8	400	7	27.1	14.31	2.1
11	320	3	42.9	15.12	1.9
11	400	5	50.2	14.01	2.2
11	240	5	35.7	16.11	1.8
11	320	7	35.5	15.07	1.9

application of *Citrus limetta* peels extract on cotton fabric are shown in Table 3.

Ultraviolet protection factor of cotton fabric treated with *Citrus limetta* peels extract under various experimental conditions is reported in Table 3. The UPF was recorded in the range of 8.2 to 50.2. The maximum value (50.2) of ultra violet protection factor was obtained for experiment number 15 with 11% concentration of extract at the power of 400 watt for 5 minutes. The minimum value (8.2) was recorded in experiment number having 5% concentration of extract at the power of 400 watt for 5 minutes.

The tensile strength was recorded in the range of 14.01 to 16.37. The maximum value (16.37) of tensile was obtained for experiment number 3 with 5% concentration of extract at the microwave power of 240 watt for 5 minutes. The minimum value (14.01) was recorded in experiment number 15 having 11% concentration of extract, at the power of 400 watt for 5 minutes.

Bending length of cotton fabric treated with *Citrus limetta* extract under various experimental conditions is reported in Table 3. The bending length was recorded in the range of 1.6 to 2.2. The maximum value (2.2) of bending length was obtained for experiment number 15 with 11% concentration of extract at the power of 400 watt for 5 minutes. The minimum value (1.6) was recorded in experiment number having 5% concentration of extract at the power of 240 watt for 5 minutes.

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, treatment time, microwave power 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 independents variables itself by the software. UPF response were given (+++++) importance while all other the responses were given equal (++++) importance.

Table 4. Optimized conditions of treated cotton fabric.

Finishing variable	Coded value	Actual value
Concentration of extract (%)	+1	8.414
Microwave power (watt)	0	317.912
Treatment time (minutes)	-1	6.751

A total of 3 optimization solutions were generated by design expert software, out of which, the one with the maximum desirability was selected. The coded and actual value of selected optimized finishing conditions has been shown in Table 4. Best results of finishing were achieved with 8.414% concentration of *Citrus limetta* peels extract, 317.912 watt, and a treatment time of 6.751 minutes.

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 *Citrus limetta* 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.

It can be concluded from the results that the applied model was sufficient therefore, optimized value

Table 5. Predicted and experimental values of the treated cotton fabric with optimum finishing conditions.

Sl. No.	Response	Predicted value	Experimental value
1.	UPF	28.608	50.2
2.	Tensile strength (kg)	15.276	12.09
3.	Bending length (cm)	1.807	1.6

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

of concentration of extract (A), microwave power (B) and treatment time (C) predicted by the numerical optimization i.e. 8.414% of *Citrus limetta* peels extract concentration at 317.912 watt for 6.751 minutes was selected as optimum conditions for UV protective finishing of cotton fabric with *Citrus limetta* peels extract using microwave 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 *Citrus limetta* extract adds the UV protection properties to the cotton fabric which can remain on the fabric even after 15 wash cycles. Utilization 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 utilizing the plant waste in economic terms.

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