

## HERBAL EXTRACTS – WASHING AGENTS FOR COLOURED FABRICS?

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**Abstract:** Selection of saponins as natural detergents for washing of textiles contributes to the promotion of green chemistry in textile applications. Herbs such as European Ivy, wild chestnut, soapwort and soap nut shell are sources of saponins with specific hydrophilic and oleophilic character able to provide detergency properties. The objective of this research is to study the washing performance of saponins from European Ivy (*Hedera helix*) and soap nut shells (*Sapindus mukorossi*) in comparison to standard detergents and commercial products. The primary criterion is a colour preservation of pastel and dark shaded cotton and wool fabrics in washing at 40°C. The second criterion is UPF enhancement. Washing performance of applied agents was evaluated through optical and protective characteristics of fabrics based on colour difference and Ultraviolet Protection Factor (UPF). The results confirmed a multifunctional ability of saponins from herbal extracts for colour protection and enhanced UPF of washed cotton and wool fabrics.

**Keywords:** washing agent, saponin, colour, Ultraviolet Protection Factor (UPF), herbal extracts

### 1. Introduction

Since the ancient time, when the laundry detergent didn't exist, people have tried to achieve cleanliness with assistance from the nature. They used wood ash as a source of alkali and observed that some plants, soaked in water, create foam which showed a good washing ability. The source of foam from plants is saponins.

This paper deals with natural sources of saponins, European Ivy (*Hedera helix*) (Fig. 1a) and soap nut shells (*Sapindus mukorossi*) (Fig. 1b). European Ivy is a plant that belongs to the *Araliaceae* family and is able to give a host of bioactive compounds (mainly saponins) of important biological activities, like spasmolytic, secretolytic, anti-inflammatory, antimicrobial, analgesic, anthelmintic, antitumor, antimutagenic and antibacterial activities [1,2]. Recent studies have demonstrated that the European Ivy has also UV protective abilities, thus making them suitable and ideal for sunscreens and cosmetic fillers [3,4]. While European Ivy naturally grows in the Western, Central, and Southern Europe, the Soap nut shells, which is a deciduous tree, widely grows in tropical and sub-tropical regions of Asia at altitudes from 200 m to 1500 m [2,5,6]. Soap nut shell belongs to the group of *Sapindaceae* family and commonly is known as soapnut, soapberry or washnut. Due to the presence of saponins, soap nut is well known as an agent with detergency and insecticidal properties. Since ancient times soap nut shell has been used as a detergent for wool and silk fabrics [5,6].



a.



b.

**Figure 1.** Herbal sources of saponins: a. European Ivy, b. Soap nut shell

Saponins are glycosidic compounds present in many plants. The presence of saponins has been reported in more than 100 plants, including in a few marine sources . such as sea cucumber and star fish [Red orbit]. They are structurally composed of a lipid-soluble aglycone consisting of either a sterol or triterpenoid and water-soluble sugar residues differing in type and amount of sugars. Because of their amphiphilic (dual) nature they are highly surface-active [7,8]. It is well documented in the research literature that the presence of saponin in aqueous soap nut extract significantly lowers the surface tension of water from 72 up to 40 mN/m upon addition of soap nut to water [9,10].

The aim of a research is to study the washing performance of saponins from two natural herbs, European Ivy (*Hedera helix*) and soap nut shells (*Sapindus mukorossi*). Selection of saponins as natural detergents for washing of textiles contributes to the promotion of green chemistry in textile applications. Washing performance of applied agents was evaluated through optical and protective characteristics. The results were compared to the washing effects of standard reference detergent and commercial detergents intended for special application.

## 2. Materials and methods

### 2.1 Materials

Washing performance was tested on a pastel shaded cotton, silk and wool fabrics, and black shaded wool fabric, as well. The main characteristics of tested fabrics are shown in Tab. 1.

**Table 1.** Technical characteristics of tested fabrics

Fabric's sample	Type of tested fabric	Fiber content, w (%)	Mass per unit area, Q (g/m <sup>2</sup> )	Colour/shade
Cotton	Knitted	100	195.0	Yellow/ Pastel
Silk			78.5	Red/ Pastel
Wool			379.6	Pale yellow/ Pastel
Wool	Woven		198.8	Black

European Ivy (EI) and soap nut shells (SN) were applied as a natural detergents rich with saponins. Comparatively, the fabrics were washed with special mild detergent for delicate cloth (I), commercial detergents for wool and silk (C), and standard ECE reference detergent without optical brighteners (ECE).

### 2.2 Washing

European Ivy washing was prepared on the old fashioned Croatian procedure [11]: 100 of fresh and clean leaves of European Ivy (55,526 g) were boiled for 15 minutes in a 2 litres of water. After that the leaves are chopped, returned to the water and left it to soak for 24 hours.

The soap nut shell bath was prepared as follows: 2 dried soap nut shells (4,646 g) were boiled for 15 minutes in a 2 litres of water and allowed to soak for 24 hours in a bath. After 24 hours both prepared baths were decanted and tested in washing at 40 °C.

Other washing agents were dosed according to the manufacturer recommendation (Tab. 2), with bath ratio 1:20. For all experiments was used distilled water. Water (W) was used as a control washing medium for all fabrics.

**Table 2.** Washing agents, labelling and dosing

Washing agent	Label	Dosing
European Ivy	EI	100 leaves (55,526 g)
Soap nut shell	SN	2 pieces (4,646 g)
Liquid detergent for special purpose	I	10 ml/l
Commercial liquid detergent for wool and silk	C	8 ml/l
ECE reference detergent	ECE	5 g/l

The samples were washed in laboratory apparatus Polymat, Mathis, at 40 °C through 30 minutes (15 minutes of rising temperature and 15 minutes of washing at the set temperature). The washed samples were rinsed four times and dried at ambient temperature.

### 2.3 Methods

Different methods were used in order to provide the objective assessment of the washing performance. The pH value was measured using pH-meter MA 5736, Metrel (Tab. 4). The content of surface active substances (SAS) was determined by the extraction in 99.8 % ethanol.

The washing performance was evaluated through changes in colour before and after washing, using Datascolor Spectraflash SF 300 spectrophotometer, with the aperture size of 20 mm, under standard illumination D<sub>65</sub> with the measuring range of 360-700 nm. The results were expressed as mean values of three individual measurements.

UPF was determined using the UV/VIS spectrophotometer Varian-Cary 50/Solascreen by method *in vitro*, in accordance with the AS/NZS 4399:1996 . Sun Protective Clothing . Evaluation and Classification, with four scans per sample. This instrument measures sunlight transmission in the range from 280 to 400 nm. According to AS/NZS 4399:1996, the UPF is the ratio of the average effective ultraviolet radiation (UVR) irradiance calculated for unprotected skin to the average effective UV-radiation irradiance calculated for skin protected by the test fabric [12]. The results obtained indicate the degree of protection offered by the fabric when worn directly to the skin [12,13,14] and, according to the standards, excellent protection is when the UPF is higher than 40 (Tab. 3).

**Table 3.** UPF classification according to AS/NZS 4399:1996

UPF rating	UV-R protection category	UV-R blocking [%]
0, 5, 10	non-rateable	<93.3
15, 20	good	93.3-95.8
25, 30, 35	very good	95.9-97.4
40, 45, 50, 50+	excellent	> 97.5

### 3. Results

Washing performance of natural and synthetic detergents was evaluated on a pastel and dark shaded cotton, wool and silk fabrics (Tabs.4-6 and Fig. 2.) The pH values and content of surface active substances (SAS) was analysed in detergent used, Tab. 4.

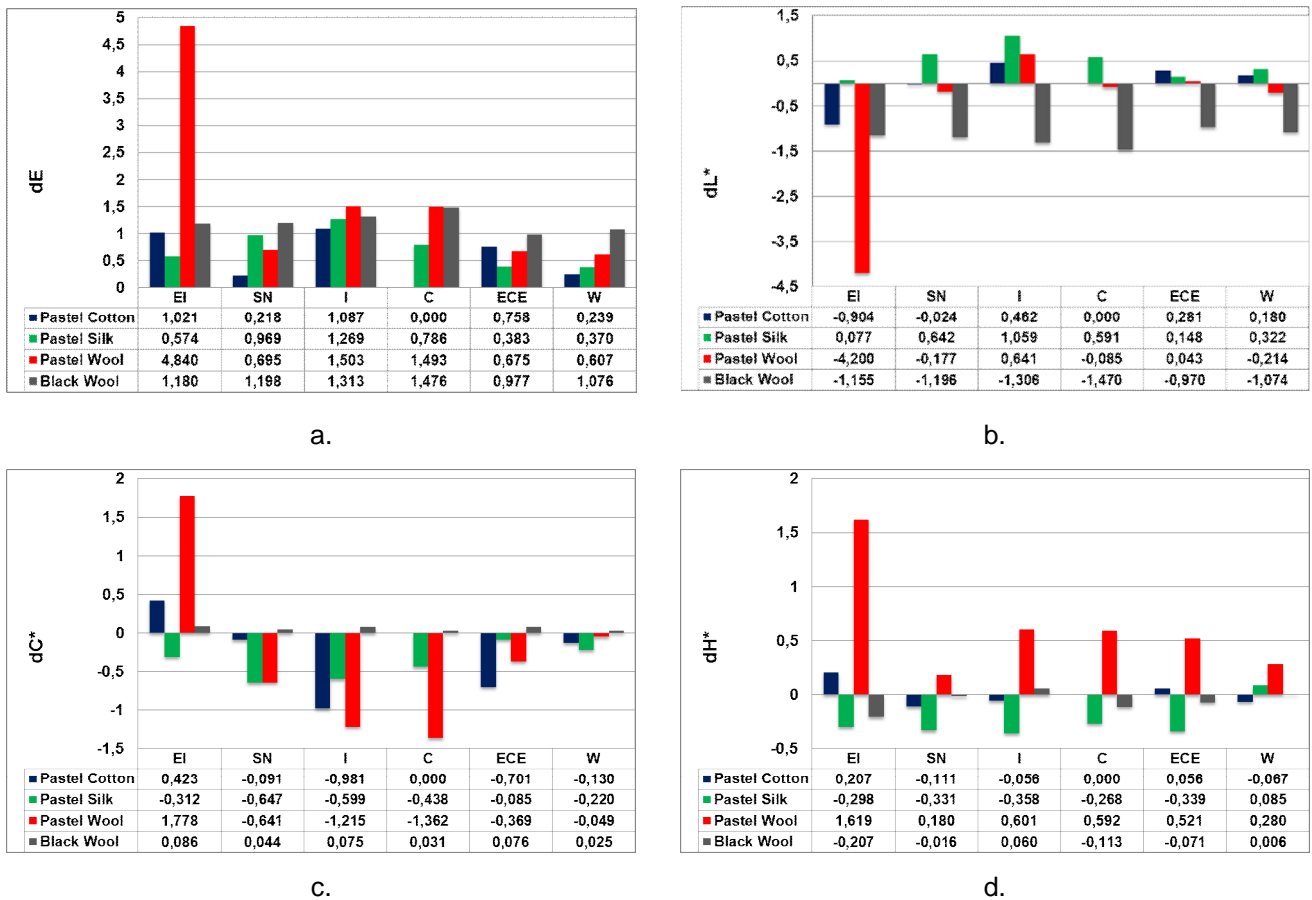
**Table 4.** pH and the content of surface active substances (SAS)

Washing agents	pH	T (°C)	SAS (%)
EI	3.83	22.9	7.07
SN	4.87	20.3	25.70
I	6.43	22.7	24.03
C	7.13	22.3	11.81
ECE	10.05	23.0	14.88

The values obtained showed that in almost all products was present surface active substances (tab. 4). It was found that the content of SAS in a soap nut is the highest (25.70%). The lowest content of the SAS was found in European Ivy (7.07%) which is in compliance with literature data found [15].

The water extracted solution of European Ivy and soap nut shell show acidic character, pH less than 5. Industrial detergent intended for special purposes and detergent for wool and silk are neutral, while reference ECE detergent solution show alkalinity (pH~10). Some recent investigations have also shown that soap nuts comprises alkyl polyglycosides and, despite their aqueous bath acidity, the primary effect of washing naturally soiled fabrics was satisfactory [10].

Change in shade washed fabrics was controlled according to next parameters: lightness ( $dL^*$ ), chromaticity ( $dC^*$ ), hue ( $dH^*$ ), and total difference in colour ( $dE$ ) (Figs. 2a-d).



**Figure 2.** Colour difference of washed fabrics: a. total difference in colour, b. change in lightness, c. chromaticity, d. hue

The results in Fig 2 show that the most prominent changes in colour of pastel woollen fabric were achieved in washing with European Ivy (EI). It is confirmed by all presented colour characteristics ( $dE$ ,  $dL^*$ ,  $dC^*$  and  $dH^*$ ). According our opinion it is influenced by green colour of EI extract in synergy with low pH (3.83). It is well known that wool textiles are dyed mostly in acidic conditions [16]. The negative value of lightness indicates that the washed fabric is, in the most cases, darker than unwashed one. That can be seen on a black woollen fabric, as well as on pastel wool washed with European Ivy, soap nut shells and detergents for wool and silk.

Objective evaluation of change in colour was done by grey scale rating (tab. 5). Results confirmed that the noticeable change in colour of pastel and black wool fabrics was observed. The strongest impact on the change in colour of the pastel shaded wool is caused by a washing with European Ivy. It can be affected by chlorophyll, well known natural green pigment from plants. In both cases detergent for wool and silk had significant impact on these fabrics (colour change according to ISO 105-A05 is 4). That is surprising because of his main purpose - to wash delicate fabrics - wool and silk.

**Table 5.** Change in colour according to ISO 105-A05:1996 [17]

Fabric's sample	ISO A04					
	EI	SN	I	C	ECE	W
Pastel Cotton	4-5	5	4-5	-	4-5	5
Pastel Silk	5	4-5	4-5	4-5	5	5
Pastel Wool	2-3	4-5	4	4	4-5	4-5
Black Wool	4-5	4-5	4	4	4-5	4-5

The impact of chosen detergents on the UV protective properties was monitored by the UV-A and UV-B transmission and UPF (Tab. 6).

**Table 6.** Mean UPF, UV-A and UV-B transmission and UV protection rating of washed fabrics in accordance to AS/NZS 4399:1996

Fabric's sample	Washing agents	Mean UPF	$\tau_{UVA}$	$\tau_{UVB}$	SD	CV (%)	UPF rating	
Pastel Cotton	Unwashed	29.515	2.596	5.616	0.493	1.67	25	Very good
	EI	341.627	0.230	0.253	26.510	7.76	50+	Excellent
	SN	34.011	2.161	5.021	0.756	2.22	30	Very good
	I	34.300	2.099	5.139	0.661	1.93	30	Very good
	ECE	35.921	2.004	4.972	0.728	2.03	35	Very good
	W	32.457	2.343	4.934	0.405	1.25	30	Very good
Pastel Silk	Unwashed	12.838	7.507	8.188	0.381	2.97	10	Non-rateable
	EI	26.130	3.597	4.247	0.379	1.45	25	Very good
	SN	22.009	4.311	4.915	0.879	3.99	20	Good
	I	24.591	3.845	4.485	1.224	4.98	20	Good
	C	20.419	4.810	5.429	3.892	19.06	15	Good
	ECE	19.241	5.037	5.742	3.319	17.25	15	Good
	W	20.524	4.679	5.072	0.743	3.62	15	Good
Pastel Wool	Unwashed	978.542	0.100	0.126	3.966	0.41	50+	Excellent
	EI	1000.000	0.100	0.100	0.000	0.00	50+	Excellent
	SN	1000.000	0.100	0.100	0.000	0.00	50+	Excellent
	I	998.569	0.100	0.102	1.698	0.17	50+	Excellent
	C	1000.000	0.100	0.100	0.000	0.00	50+	Excellent
	ECE	998.990	0.100	0.101	1.903	0.19	50+	Excellent
	W	1000.000	0.100	0.100	0.000	0.00	50+	Excellent
Black Wool	Unwashed	285.752	0.314	0.351	15.279	5.35	50+	Excellent
	EI	157.590	0.599	0.587	10.862	6.89	50+	Excellent
	SN	975.638	0.101	0.108	29.818	3.06	50+	Excellent
	I	994.074	0.100	0.104	7.241	0.73	50+	Excellent
	C	1000.000	0.100	0.100	0.000	0.00	50+	Excellent
	ECE	1000.000	0.100	0.100	0.000	0.00	50+	Excellent
	W	1000.000	0.100	0.100	0.000	0.00	50+	Excellent

Wool fabric is natural good UV protector, therefore initial UPF value is much higher than in the case of cotton and silk fabrics. Due to initial excellent UPF protection, it is not reasonable evaluate enhancement of UPF in washing with selected agents. It is also known that pastel shaded cotton possesses some protective properties [18]. On the other hand, silk fabric is non-rateable for UV protection (UPF is 12.838), Tab. 6.

Obtained results were confirmed earlier studies about UV protective abilities of European Ivy. That is especially noticeable on a pastel shaded cotton. After one washing, the UPF reached 50+ (excellent protective properties). It can be seen lower transmission values in both regions (UV-A and UV-B), thus making them ideal for UV protection. It was also noticed significant increasing of protective properties of silk fabrics (from 12.838 which is non-rateable to 26.130 with very good UV protection). Soap nut shells (SN) gave satisfactory protection after one washing. It can be assumed that UPF would be further increased by multiple washing. Industrial detergent (I) and detergent for wool and silk (C) act like a soap nut shell as regards the UV protection.

#### 4. Conclusions

European Ivy and soap nut shells, as natural detergents with saponins, were tested in washing at 40 °C. The detergency of this natural herbs was analysed through the colour difference and Ultraviolet Protection Factor (UPF) on pastel shaded cotton, silk and wool fabrics, including dark shaded wool fabric.



It was confirmed that European Ivy contain less amount of saponins (7.07%) and enhanced UPF of washed fabrics. Soap nut shell contain the highest amount of surface active substances, have a good ability for preservation of colours and UV protective properties.

The results of this study showed that the European Ivy and soap nut shell offer some benefits for washing of coloured textiles. Further research will be oriented to the stain removal tests and colour preservation of naturally dyed textiles.

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