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ESTIMATION OF COLOUR DIFFERENCES IN THE CASE OF WOOL DYEING WITH NATURAL DYES EXTRACTED FROM GREEN NUTSHELL

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Abstract: *In this paper were experimentally determined the colour differences between two pattern (standard and sample) with CIELAB formula in case of dying with natural dyes extracted from green nutshell. The dyes were made according to an experimental program at different concentration. The obtained dyes were used to estimate the colour differences that are usually a mixture of differences of brightness, saturation and nuance. In order to determine the intensity of the dyeing was measured at spectrophotometer Specord 200 the remission of the dyed samples. With their help were calculated the trichromatic values X, Y, Z and then the rectangular coordinates: L*- lightness coordinate, a* - the chromaticity coordinate for red-green colour area, b* - the chromaticity coordinate for yellow-blue colour area in CIELAB space. From these values derive the cylindrical coordinates: L^*- lightness, C^* -chroma, H* - nuance. The differences in colour ΔE between the samples and the standard sample are represented by distances between respective positions in CIELAB field and were calculated with some standardized relations. This colour differences were decomposed in: ΔL^* - the difference in lightness ΔC^* - the difference in chroma, ΔH^* - the difference in nuance and calculated in CIELAB units. Were also made the diagrams: the position of the colours in CIELAB field, the chromatic diagram a*=f(b*), the lightness position and the colour differences between the samples and the standard sample.*

Keywords: *CIELAB space, remission, colour difference, lightness, chroma, nuance, natural colorant, dyes.*

1. INTRODUCTION

Over time, the determination and assessment of colour differences between two or more colour samples was done visually, being a cheap and fast method but not precise [1].

The objective of measuring the colour consists in numerical characterization of colour sensation, so it is removed the possibility of taking wrong decisions on a full assessing whether the equality of the two colours is proper or improper requirements [1].

The colour is a subjective sensation sent by nervous stimulus to the brain by a light beam that penetrates through the retina in the eye [1].

Correct perception of colour depends on three aspects: light source, the coloured object and colour receiver (human eye) that are quantified and standardized [1], [2].

Colour differences are generally a mixture of differences in brightness, chroma and nuance. In the purpose of calculating the difference of the colour were used several standardized formulas. [1,3,4].

The natural dyes extracted from green nutshell take place in naphthoquinonic dyes class and has a structure like the complexable dyes. From structural point of view naphtochinona has two carbonyl groups and a hydrolytic group and will form chemical bonds salt type with the textile support.

The dye extracted by green nutshell is used for natural fibres dye with or without mordant.

2. EXPERIMENTAL PART

The purpose of this research is to obtain and characterize natural dye extracted from green nutshell, to detect the compounds responsible for the brown colour of the extract, to optimise the dye process of wool with this dye without mordants, to verify the efficiency of the treatment and to calculate the colour differences with CIELAB relation. The wool dying with dye extracted by green nutshell was made in accordance with a central, correlation, rotable, second order compound program with two independent variables. [5, 6, 7, 8]

The variation limits and the code parameters [6,7,8], are presented in table 1.

Table 1: *The variation limits and the code parameters*

Code value /real value	-1.414	-1	0	1	1.414
x-concentration (g plant/g fabric)	0.5	0.7	1	1.3	1.5
y-temperature (^{0}C)	80	84	90	96	100

The central, correlation, rotable, second order compound program with two independent variables was used to set the optimum conditions for dying. [6,7,8].

The dyeing has been lead under the following conditions:

-x - the concentration of the dye (g plant/g fabric); 2% acetic acid; 2% sodium sulphate;

-y - the temperature (^{0}C); ratio 1:100; -M_{fabric} =1 g.

Before dying was made an activation of the wool fibre in the following conditions: 2% glacial acetic acid; ratio 1:100; - t =15 min; - T= 100^{0}C.

3. RESULTS AND DISCUSSIONS

Determination of colour chart of the samples dyed in CIELAB space.

In order to determine the intensity of dying was measured the dyed samples remission at SPECORD 200. With these values were calculated the X,Y, Z values with the following equations [1,2,3,4, 9-13]:

$$X = 0.782 \cdot R_X + 0.198 \cdot R_Z \quad \textbf{(1)}$$

$$Y = R_Y \quad \textbf{(2)}$$

$$Z = 1.181 \cdot R_Z \quad \textbf{(3)}$$

The rectangular coordinates of CIELAB space, L^* a^* b^*, are calculated with the following equations [1,2,3,4, 9-13]:

$$L^* = 116 \cdot \left(\frac{Y}{Y_0}\right)^{\frac{1}{3}} - 16 \quad \textbf{(4)}$$

$$a^* = 500 \cdot \left[\left(\frac{X}{X_0}\right)^{\frac{1}{3}} - \left(\frac{Y}{Y_0}\right)^{\frac{1}{3}}\right] \quad \textbf{(5)}$$

$$b^* = 200 \cdot \left[\left(\frac{Y}{Y_0} \right)^{\frac{1}{3}} - \left(\frac{Z}{Z_0} \right)^{\frac{1}{3}} \right] \quad \textbf{(6)}$$

where:

- X, Y, Z - represents the trichromatic values of the samples
- X_0, Y_0, Z_0 - represents the trichromatic values of illuminant C
- L^* - represents the bright variable named brightness coordinate or luminance. It has (+) value if the sample is lightish, pale and (-) value if the sample is dark. If all the values are (+), the more it is higher the intensity of the dying is smaller.
- a^* - represents the chromaticity coordinates for the red - green space
- b^*- represents the chromaticity coordinates for the yellow - blue space

These equations are applied to:

$$\frac{X}{X_0}; \frac{Y}{Y_0}; \frac{Z}{Z_0} > 0.001 \quad \text{and} \quad X_0=98{,}075;\ Y_0=100{,}0\ ;\ Z_0=118{,}224 \quad \textbf{(7)}$$

Cylindrical coordinates deduced from these expressions have the following forms [1,2,3,4, 9-13]:

$$L^* = 116 \cdot \left(\frac{Y}{Y_0} \right)^{\frac{1}{3}} - 16 \quad \textbf{(8)}$$

$$C^* = (a^{*2} + b^{*2})^{1/2}; \quad \textbf{(9)}$$

$$H^* = arc\ tg\ (b^*/a^*) \quad \textbf{(10)}$$

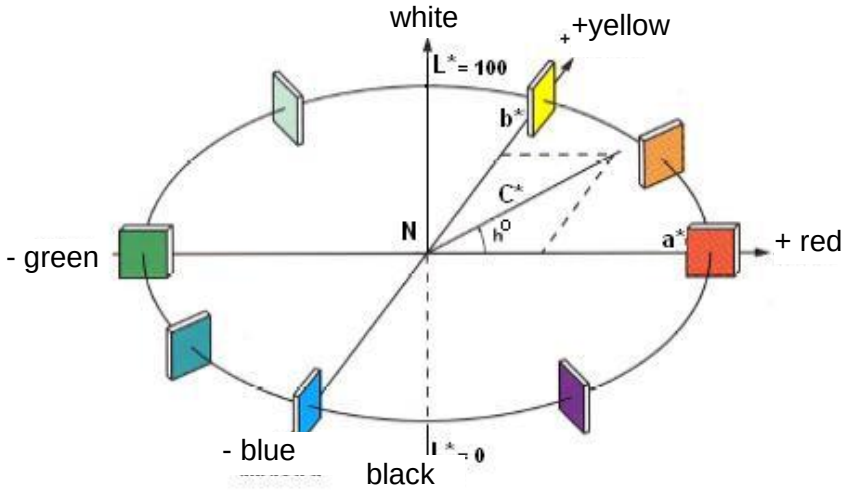

***Fig.1**: The rectangular and cylindrical coordinates of CIELAB space [14]*

H* is expressed in scale 0^0-360^0 ($a^+=0^0$; $b^+=90^0$; $a^-=180^0$; $b^-=270^0$).

Where:

- L^*- represents the lightness
- C^*- represents chroma

- H*- represents nuance

The rectangular and cylindrical coordinates of CIELAB space are presented in figure 1.

The difference in colour between the sample and standard sample is represented by the distance between the respective positions in CIELAB space and is given by the equation: [1,2,3,4, 9-14]:

$$\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2} \quad \textbf{(11)}$$

If each colour difference can be decomposed into components: brightness difference, chroma difference and nuance difference and if ΔE, ΔL^*, ΔC^* may be calculated in CIELAB units than colour difference can be calculated in the same units as in the equation: [1,2,3,4, 9-14]:

$$\Delta H^* = [(\Delta E)^2 - (\Delta L^*)^2 - (\Delta C^*)^2]^{1/2} \quad \textbf{(12)}$$

It was agreed to write down with (+ ΔH^*) when the sample is added counter clockwise direction versus standard sample and (- ΔH^*) when the sample is found in the clockwise direction toward standard sample.

The tristimulus values X_n, Y_n, Z_n, define normal white colour of the object colour - stimulus for tristimulus values of the illuminant.

Thus it were made chromaticity diagrams $a^*=f(b^*)$ and L* for dying variant. The results are presented in table 2, figure 2 and figure 3

Table 2: *The trichromatic values and the rectangular coordinates*

sample	X	Y	Z	L*	a*	b*	C^*	H^*	ΔE	ΔL^*	Δa^*	Δb^*	ΔC^*	ΔH^*
1	5.880	5.830	5.345	28.979	1.820	6.302	6.560	0.060	6.316	-5.696	1,678	2.154	2.409	1.286
2	5.000	4.916	5.000	26.494	2.238	3.584	4.225	0.028	8.464	-8.181	2,096	-0.564	0.074	2.17
3	6.181	6.102	5.516	29.668	2.134	6.738	7.068	0.055	5.979	-5.007	1,993	2.59	2.917	1.472
4	5.127	5.043	4.636	26.857	2.230	5.943	6.348	0.046	8.289	-7.818	2,089	1.795	2.197	1.661
5	6.492	6.438	5.894	30.492	1.868	6.549	6.810	0.061	5.123	-4.183	1,727	2.401	2.659	1.293
6	4.551	4.481	4.254	25.202	2.083	5.010	5.426	0.042	9.709	-9.473	1,942	0.861	1.275	1.699
7	5.523	5.490	5.095	28.087	1.621	5.893	6.112	0.063	6.973	-6.588	1,479	1.744	1.961	1.178
8	4.768	4.669	4.461	25.770	2.445	4.936	5.508	0.035	9.232	-8.905	2,304	0.787	1.357	2.021
9	5.476	5.349	4.757	27.707	2.716	6.823	7.344	0.044	7.896	-6.968	2,575	2.674	3.193	1.895
10	5.582	5.493	5.019	28.096	2.266	6.257	6.655	0.048	7.229	-6.58	2,125	2.109	2.504	1.641
11	5.476	5.349	4.757	27.707	2.716	6.823	7.344	0.044	7.896	-6.968	2,575	2.674	3.193	1.895
12	5.668	5.542	4.939	28.226	2.685	6.855	7.362	0.045	7.442	-6.449	2,544	2.707	3.211	1.867
13	4.961	4.911	4.740	26.480	1.816	4.789	5.122	0.046	8.389	-8.195	1,675	0.64	0.971	1.508

The differences ΔL^*, Δa^*, Δb^*, ΔC^* şi ΔH^* are expressed in CIELAB units.

The value ΔE is a measure of the colour difference size perceived between a standard sample and the sample analyzed, but cannot indicate the nature of that difference. Considering colour difference

components, they can be interpreted:

- ΔL^* - the difference in brightness is (+) for samples 1, 3, 5,7 that are lighter than the standard sample (more living) and is (-) for samples 2,4,6, 8,9,10,11,12,13 that are full shade.
- Δa^* and Δb^* - show the differences between the positions of samples (samples and standard samples) in diagram a^*b^*
- ΔC^* – the difference in saturation is (+) for samples 1,3,4,5,7,9,10,11,12,13 that have a higher saturation that the standard sample and is (-) for the samples 2,6,8 that have a lower saturation.
- ΔH^* – difference in shade (nuance) is (+), samples are in the counter clockwise direction toward standard

Red (+) - the sample is more yellow than the standard sample
Yellow (+) - the sample is greener than standard sample
Green (+) - the sample is bluer than standard sample
Blue (+) - the sample is greener than standard sample

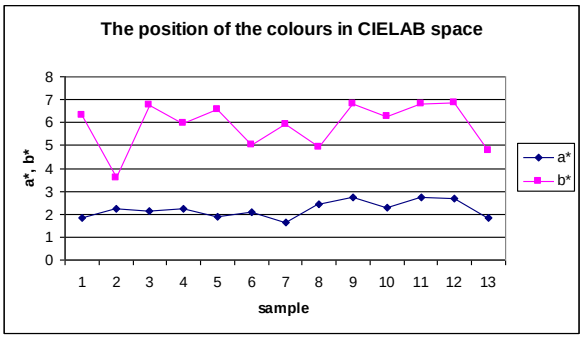

***Fig.2**: The position of the colours in CIELAB space*

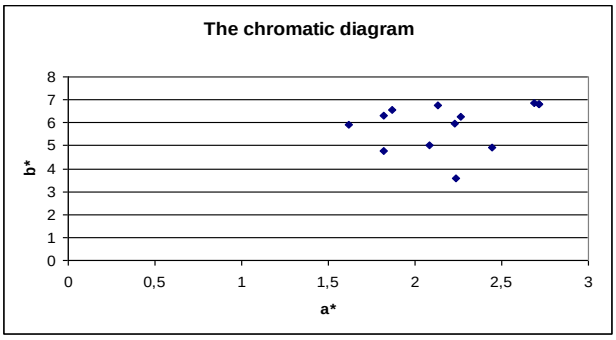

***Fig.3**: Chromatic diagram a*=f(b*) for the variant of dye*

It is found that maximum absorption is achieved for sample 6, which was confirmed by minimum brightness registered within the same samples (fig. 4)

From this graph results that sample 5 has the highest brightness, having the lowest concentration 0,5 g plant/g material, followed by sample 3 with the concentration 0,7 g plant/g material, than sample 1 with concentration 0,7 g plant/g material, sample 7 with 1g plant/g material, samples 9-13 with 1g plant/g material, samples 4 and 2, sample 8 and sample 6.

The biggest difference between samples and standard colour has sample 6, followed by sample 8, sample 2, sample 13, sample 4, sample 9, sample 11,12,10,7,1,3 and sample 5, So the colour difference decreases with decreasing concentration of dye extracted

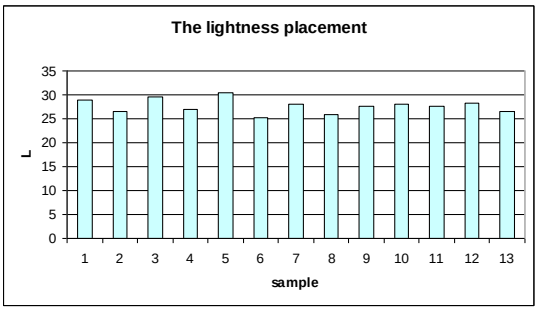

***Fig. 4**: The lightness placement*

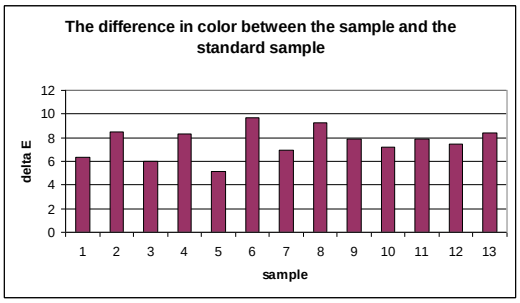

***Fig. 5**: The difference in colour between the sample and the standard sample*

4. CONCLUSIONS

- Differences in colour are due to a dependence between the capacity of absorption, dye concentration in dyeing bath and the temperature at which the dying is done
- Differences in colour are generally a mixture of differences of brightness, saturation and nuance
- It is found that maximum absorption is achieved for sample 6 confirmed by minimum brightness recorded within the same samples
- Minimal absorption is achieved for sample 5 as confirmed by the maximum brightness

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