Realistic colour assessment in tone-tone dyed woolen sheepskins by means of 'colorindex' software

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Summary

The paper presents a method for realistic estimation of colour by means of an original software-COLORINDEX.

The referred to software enables the hue differences to be determined with the CIE 1976 and 1994 equations.

So far, in the most countries processing woolen sheepskins, the 'tone-tone' feature, that means wool and skin dyed in the same colour, has been estimated visually by the experts in dyeing in the units processing such skins and accepted by the customers.

Several dyed woolen sheepskin sample collected from a Romanian enterprise processing woolen sheepskins were subjected to measurement for remission degree by means of an SPECORD M40 SPECTROPHOTOMETER with INTEGRATING SPHERA and the results were processed by COLORINDEX software.

As in the Member States of the European Community the above system for colour assessment in textiles and leather is the single agreement way between manufacturers and dealers, it has to be disseminated in all enterprises processing textiles and skins for the implementation of a common language.

To this end, laboratories in such enterprises are to be equipped with SPECTROPHOTOMETERS WITH INTEGRATING SPHERE, either fixed or portable.

Of the tone-tone dyed samples of sheepskins, 4 samples have resulted in colour differences below 5 units and can said to be tone-tone dyed, and for the others, values within 10 – 20 range were obtained.

I. Introduction

The paper presents a method for realistic estimation of colour by means of an original software-COLORINDEX.

The referred to software enables the hue differences to be determined with the CIE 1976 and 1994 equations.

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To this end, laboratories in such enterprises are to be equipped with SPECTROPHOTOMETERS WITH INTEGRATING SPHERE, either fixed or portable.
For the dissemination of the method for colour assessment, a data base and dyeing process monitoring have to be set up, both for the support and exhausted dyeing baths.

II. Experimental

Application of COLORINDEX software is performed in four steps, as follows:

- measuring the remission degrees on a UV-VIS SPECTROPHOTOMETERS equipped with an INTEGRATING SPHERE;
- use of the remission degrees for controls in computing colour coefficients by the *simple computing option for a sample*, resulting in colour coefficient values for the ‚*reference colour*' (Figure 1a);
- use of the remission degrees for the samples being compared - skin sample and wool sample, respectively, in computing colour coefficients by the ‚*compare*' option, resulting in a chart where, at the REFERENCE COLOUR, the colour variables *L, a, b, C* and *h* previously computed for the control are introduced (Figures 1-10);
- processing the remission degrees by the established equations for the colour differences, resulting in the colour difference ΔE between two colours described by the colour variables L_1, a_1, b_1 and L_2, a_2 and b_2, respectively.

Delta E (CIE 1976)

$$\Delta E = \sqrt{(L_1 - L_2)^2 + (a_a - a_2)^2 + (b_1 - b_2)^2}$$

Delta E (CIE 1994)

Color difference ΔE between two colors, for the sample (L_2, a_2, b_2) and for the control (reference colour) (L_1, a_1, b_1) is given by the following equation:

$$\Delta E = \sqrt{S_L^2 + S_C^2 = S_H^2}$$

where S_L, S_C, S_H are the algebric sums of color coefficients *L, a, b, c*, and *h*, corrected for the two samples being compared.
The two equations are included in the COLORINDEX software, and the data are processed in EXCEL 2000 on the default charts where the values for the reflectance factors are introduced.
Another variable which also enables the dyeing levelness to be estimated is the hue variation h^0 on the leather surface.

$$h^o = arctg\left(\frac{b^*}{a^*}\right)$$

$$\Delta H^* + \sqrt{(\Delta E)^2 - (\Delta L^*)^2 - (\Delta C^*)^2}$$

$$\Delta C^* = C_p^* - C_r^* = \sqrt{\left(a_p^*\right)^2 + \left(b_p^*\right)^2} - \sqrt{\left(a_r^*\right)^2 + \left(b_r^*\right)^2}$$

X_n=94.81, Y_n=100 and Z_n=107.37 are the three-colour constituents of scatterer for the selected standard light source D65.

The above equations are applied in defining the cylindrical system coordinates:

*L** - brightness

*C**- chroma; $C^* = \sqrt{a^{*2} + b^{*2}}$

The **hue value *h*** is the colour angle between *L** and *a**, measured counter-clockwise, describing the hue.

Chromaticity *C* value is the diagonal of the rectangle made by ***b** (yellow), *a** (red) and grey- axes.**

*b** and *a** axes make a right angle, defining a **chromaticity plan**, and their **crossing point - *U* is neutral** (black, grey, white, depending on the light brightness).

In the **neutral point**, the third axis *L** , which is the light brightness measure, makes a right angle with the plane made by *a** and *b**. L* shows values in the 0-100 range. In this range, the hue angle defines the colours, as follows:

Red: 0 - 90^o

Yellow: 90 - 180^o

Green: 180 - 270^o

Blue: 270 - 360^o

Chart 1a is showing the remission degrees for the red-brick-red dyed sample P1 processed by simple option, where the colour variables are as a reference for the skin colour. The same charts were obtained for wool samples.

The remission degrees for skin and wool were used as inputs for COLORINDEX software with COMPARE option, resulting in HUE DIFFERENCES (ΔH) and COLOUR DIFFERENCES (ΔE) shown in the table 1 and **Charts 1-4.**

Table 1. Colour differences in tone-tone dyed woolen sheepskins

No. Culour	CIE (1976)	CIE (1994)	CMC(2:1)	CMC(1:1)	Notes
1	2	3	4	5	6
P1-2010 Red-brick-red	7,823462	**2,713863**	3,468198	4,1967418	it can be said to be tone-tone; CIE 1994 colour differences is 2,71
P2-2004 Red-cyclamen	11,97034	***5,73734***	6,053218	11,208396	it can be said to be almost tone-tone; CIE 1994 colour differences is 5,73
P3-186 Purple	11,48483	6,140219	5,768904	10,086736	Different
P4-297 beige-honey	6,74608	**3,335116**	3,371152	5,091914	it can be said to be tone-tone; CIE 1994 colour differences is 3,33
P5-134A Brown-yellowish	4,380403	**2,20134**	2,808294	2,9011154	it can be said to be tone-tone; CIE 1994 colour differences is 3,33
P6-134 B Brown – chocolate	13,96193	6,98219	8,594519	14,938002	Different
P7-140 Brown-redish	14,11347	6,94101	8,328174	15,61823	Different
P8-112 Grey	18,00776	9,1168524	9,740076	19,008257	Different
P9-161 light brown	16,04648	8,244333	15,61103	30,731429	Different
P10-111 black	6,082292	**3,455882**	6,193076	11,471148	it can be said to be tone-tone; CIE 1994 colour differences is 3,45

III. Conclusions

1. In the specialized literature two colours are estimated to be similar if the colour differences between them are placed in the 0,5 – 1,0 range.
2. Because when dyeing woolen sheepskins, two different protein-based supports – wool and dermis are dyed with two different dyestuff classes, we suggest the dyed furs with a resulting colour difference within the range 1-5, to be considered to be TONE–to-TONE dyed, this also concurring with the organoleptical assessment.
3. Of the tone-tone dyed samples of sheepskins, 4 samples have resulted in colour differences below 5 units and can said to be tone-tone dyed, and for the others, values within 10 – 20 range were obtained.

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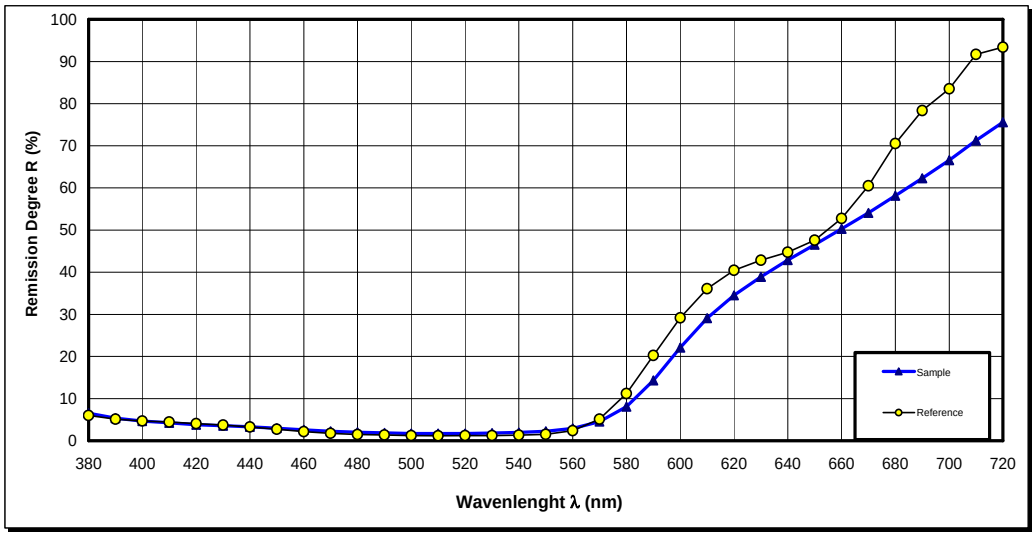
COMPARISON P1-2010 brick-red coloured-(dyed wool as reference)-P1 derma

λ(nm)	R(%)	Ref(%)
380	6,50	5,99
390	5,35	5,13
400	4,68	4,65
410	4,23	4,41
420	3,81	4,02
430	3,57	3,70
440	3,30	3,26
450	2,96	2,72
460	2,58	2,14
470	2,26	1,73
480	1,99	1,46
490	1,84	1,34
500	1,69	1,24
510	1,68	1,19
520	1,69	1,23
530	1,78	1,23
540	1,95	1,32
550	2,22	1,53
560	2,94	2,40
570	4,53	5,10
580	8,08	11,20
590	14,31	20,23
600	22,11	29,13
610	29,12	36,07
620	34,49	40,42
630	38,86	42,82
640	42,89	44,73
650	46,53	47,60
660	50,27	52,77
670	54,05	60,49
680	58,14	70,51
690	62,28	78,36
700	66,59	83,50
710	71,23	91,66
720	75,58	93,39
730	80,19	92,57

REMISSION DEGREE

Chart 1



COLOUR COFFICIENTS

X	Y	Z	R	G	B	L	a	b	C	h
14,80252177	8,573098	3,098921602	33,24420277	1,8644086	2,35097	35,14901	48,75375	26,84168	55,65432	28,835255
x	y	z	Reference colour P1 wool			37,57432	53,36819	32,67532	62,57667	31,477556
0,559122882	0,323824	0,117052892	COLOUR DIFFERENCE			ΔL	Δa	Δb	ΔC	ΔH
						-2,425308	-4,614441	-5,83364	-6,922352	2,7213034

Whitheness Index	WI-CIE	WI-ASTM	WI-Hunter	Hue
	-175,4864	-14,1727115	-45,3760235	-225,4548

COLOUR DIFFERENCE

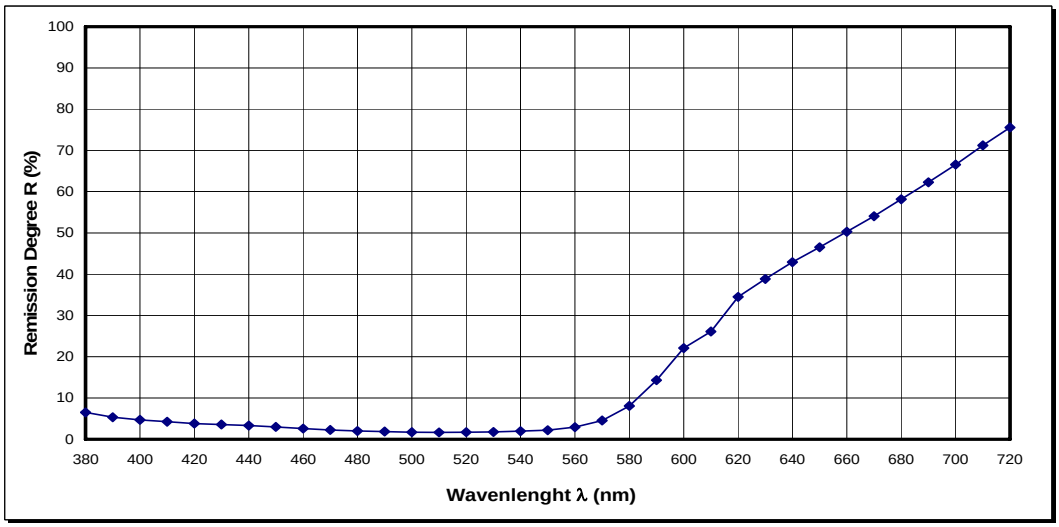
ΔE	CIE (1976)	CIE (1994)	CMC(2:1)	CMC(1:1)
	7,823462	2,713863	3,468198	4,1967418

Sample - P1-2010 dyed wool

Chart 1 a

λ(nm)	R(%)
380	6,5
390	5,35
400	4,69
410	4,23
420	3,81
430	3,57
440	3,3
450	2,96
460	2,58
470	2,26
480	1,99
490	1,84
500	1,69
510	1,68
520	1,69
530	1,78
540	1,95
550	2,22
560	2,94
570	4,53
580	8,08
590	14,31
600	22,11
610	26,11
620	34,49
630	38,86
640	42,89
650	46,53
660	50,27
670	54,05
680	58,17
690	62,28
700	66,59
710	71,23
720	75,58
730	80,19

REMISSION DEGREE



COLOUR COEFFICIENTS

X	Y	Z	R	G	B	L	a	b	C	h
14,80252	8,573098	3,098922	33,2442	1,8644086	2,35097	37,57432	53,36819	32,67532	62,57667	31,477556
x	y	z								
0,55912284	0,32382425	0,117052912								

Whitheness Index	WI-CIE	WI-ASTM	WI-Hunter
	-175,4864	-14,17271	-60,45164

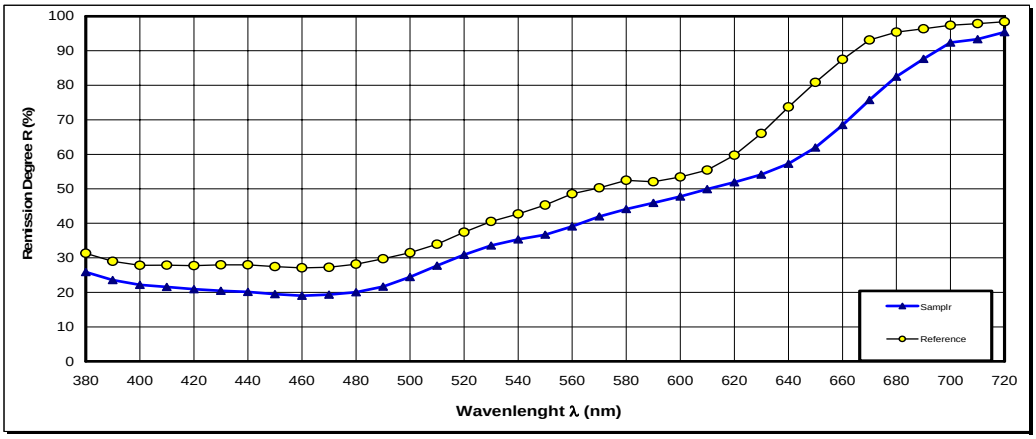
Hue
-225,455

COMPARISON P4-297 Honey-beige coloured (dyed wool as reference)-P4 derma

λ(nm)	R(%)	Ref(%)
380	25,88	31,34
390	23,55	29,01
400	22,16	27,85
410	21,57	27,90
420	20,89	27,74
430	20,45	27,99
440	20,13	27,98
450	19,48	27,44
460	19,02	27,11
470	19,34	27,26
480	20,03	28,17
490	21,66	29,75
500	24,46	31,48
510	27,76	33,95
520	30,91	37,45
530	33,58	40,54
540	35,33	42,74
550	36,69	45,29
560	39,07	48,55
570	41,98	50,29
580	44,15	52,45
590	45,95	52,02
600	47,78	53,44
610	49,88	55,45
620	51,89	59,73
630	54,1	66,04
640	57,27	73,71
650	61,98	80,85
660	68,5	87,50
670	75,74	93,12
680	82,49	95,38
690	87,63	96,38
700	92,41	97,38
710	93,38	97,88
720	95,38	98,38
730	96,38	99,38

REMISSION DEGREE

Chart 2



COLOUR COEFFICIENTS

X	Y	Z	R	G	B	L	a	b	C	h
39,22819683	37,50006	21,68301069	58,66518895	33,228709	17,457	67,65052	12,00126	26,89086	29,44739	65,94902
x	y	z	Reference colour P4 wool			73,21852	11,98846	23,08229	26,00991	62,553576
0,398614887	0,381055	0,220330567	COLOUR DIFFERENCE			ΔL	Δa	Δb	ΔC	ΔH
						-5,568004	0,012805	3,808573	3,437482	1,6398515

COLOUR DIFFERENCE

	CIE (1976)	CIE (1994)	CMC(2:1)	CMC(1:1)
ΔE	6,745966	3,335796	3,372805	5,0933945

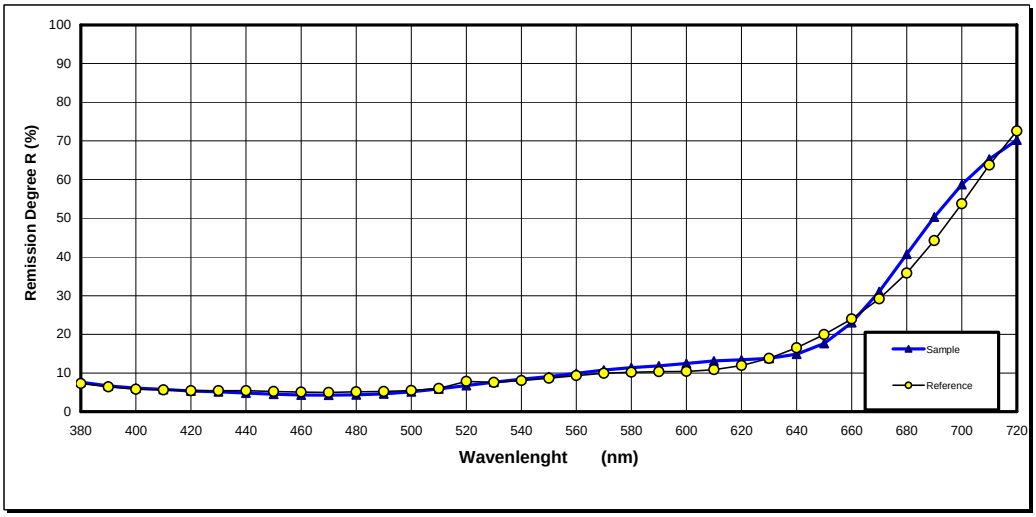
Whiteness Index	WI-CIE	WI-ASTM	WI-Hunter	Hue
	-115,4446	-31,70928632	-13,02206863	-43,79794

COMPARISON P5-134A-medium brown coloured (dyed wool as reference)- P5 derma

λ(nm)	R(%)	Ref(%)
380	7,62	7,29
390	6,65	6,43
400	6,1	5,8
410	5,74	5,64
420	5,32	5,44
430	5,1	5,42
440	4,81	5,41
450	4,5	5,22
460	4,33	5,05
470	4,24	4,96
480	4,35	5,11
490	4,61	5,24
500	5,15	5,49
510	5,88	6,02
520	6,79	7,82
530	7,65	7,57
540	8,4	8,07
550	9,05	8,64
560	9,87	9,35
570	10,77	9,93
580	11,37	10,22
590	11,83	10,37
600	12,47	10,41
610	13,1	10,86
620	13,45	11,94
630	13,77	13,78
640	14,85	16,52
650	17,65	19,93
660	23,03	23,98
670	31,06	29,15
680	40,75	35,81
690	50,33	44,22
700	58,73	53,78
710	65,3	63,78
720	70,22	72,59
730	74,49	80,36

REMISSION DEGREE

Chart 3



COLOUR COEFFICIENTS

X	Y	Z	R	G	B	L	a	b	C	h
10,24903567	9,309892	5,054249972	16,38136414	7,7413777	4,01463	36,57422	11,56165	18,43418	21,75984	57,904649
x	y	z	Reference Colour P5 wool			35,80867	9,948626	14,43418	17,53057	55,423803
0,416404411	0,378248	0,205347318	COLOUR DIFFERENCE			ΔL	Δa	Δb	ΔC	ΔH
						0,765554	1,613029	4	4,22928	0,845608

COLOUR DIFFERENCE

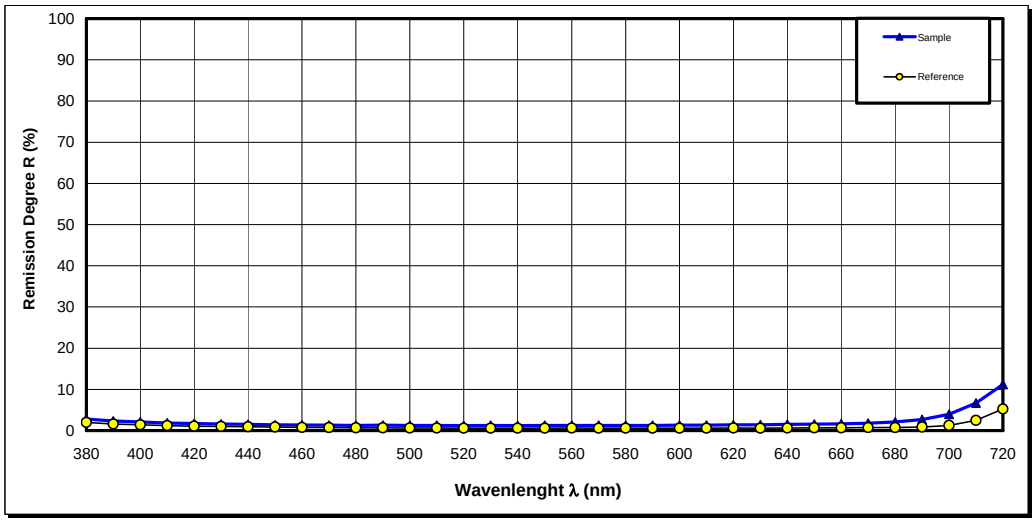
	CIE (1976)	CIE (1994)	CMC(2:1)	CMC(1:1)
ΔE	4,380403	2,20134	2,808294	2,9011154

Whiteness Index	WI-CIE	WI-ASTM	WI-Hunter	Hue
	-153,0957	-9,097540083	-18,72831555	-61,63259

COMPARISON P10- 111 black coloured (dyed wool as reference)-P111 derma

λ(nm)	R(%)	Ref(%)
380	2,83	2,01
390	2,31	1,59
400	2,08	1,43
410	1,86	1,21
420	1,68	1,05
430	1,62	1,04
440	1,51	0,94
450	1,42	0,85
460	1,35	0,78
470	1,33	0,75
480	1,28	0,69
490	1,29	0,68
500	1,26	0,64
510	1,27	0,62
520	1,23	0,57
530	1,26	0,57
540	1,23	0,59
550	1,25	0,56
560	1,24	0,62
570	1,25	0,57
580	1,24	0,57
590	1,25	0,59
600	1,32	0,56
610	1,32	0,59
620	1,4	0,61
630	1,43	0,59
640	1,51	0,63
650	1,54	0,66
660	1,66	0,68
670	1,78	0,71
680	2,09	0,73
690	2,68	0,87
700	3,99	1,27
710	6,67	2,46
720	11,21	5,22
730	17,67	10,61

REMISSION DEGREE Chart 4



COLOUR COEFFICIENTS

X	Y	Z	R	G	B	L	a	b	C	h
1,284493254	1,284493	1,555759979	1,412314576	1,2293465	1,45431	11,1666	2,094087	-1,91751	2,839371	317,52042
x	y	z	*Reference Colour*		*P10 wool*	5,469215	1,778306	-4,02331	4,398795	293,84546
0,31141148	0,311411	0,37717716	COLOUR DIFFERENCE			ΔL	Δa	Δb	ΔC	ΔH
						5,69738	0,315781	2,105805	-1,559424	1,4499411

COLOUR DIFFERENCE

	CIE (1976)	CIE (1994)	CMC(2:1)	CMC(1:1)
ΔE	6,082292	3,455882	6,193076	11,471148

Whiteness Index	WI-CIE	WI-ASTM	WI-Hunter	Hue
	36,496	1,943283416	16,91911085	-10,58295