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STATISTICAL PROPERTIES TESTED ON COLOUR DIFFERENCE VECTORS

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A b s t r a c t. The method of colour difference vectors can help in evaluating the external fruit quality. Now, the statistical distributions will be tested on their results.

K e y w o r d s: apple, colour difference vector, maturation, distribution

INTRODUCTION

Colour preferences are change more rapidly now than in the past. A red apple was the preferred fruit in the last centuries up to the past decades that were the age of the green apple (e.g., Granny Smith) for numerous consumers. It can be stated that there are consumers preferring red apples, others who prefer green apples and a third group that prefers apples with great colour difference between their two sides (colourful varieties).

MATERIALS AND METHODS

Our first colorimeter was a Hungarian built tristimuluous MOMCOLOR 100. We measured sour cherries [6,8], apricots [5], tomatoes [4] and other vegetables [7]. In the recent years, we used a Hunterlab Ultrascan spectrocolorimeter. The measured products were mushrooms [7] and mainly apples [2]. The statistical properties of the colorimetric data were reported on apples [7,9,10]. As these instruments can be used for measuring one point of the fruit (or a round shape placed on their surface), we chose to measure the reddest and the greenest side of the apples. This method meets the practice of the fruit grower experts who call the red side of the fruit the "foreground colour" and the green side-the "background colour". As it is well known, the colour of the green side relates to maturity. All the colours existing on the surface belong to a range between these two colours that we can use as limits.

The other colorimetric property is the "colour coverage" which is the percentage of the cover colour related to the whole surface. The surface cannot be measured, it can only be estimated using point-type colorimeters. We cannot replace this property with our colour difference method but the result characterises the fruit in a similar way.

A previously developed computer programme [7] computes the components of the colour difference vectors as an absolute value and direction angle. This programme was upgraded for computing the colour differences, too.

The cultivars tested in the recent years were [2,9]: Gloster, Golden Spur, Jonagold, Jonnee, Jonathan M41, Mutsu.

We tested other cultivars in the last year (Elstar, Royal Gala, see [7]).

CALCULATION METHODS

The first step is using the original programme of the Hunterlab. By this programme we can

compute the results consisting of the data in CIE 1931colorimetric system either as chromaticity co-ordinates or as colour stimuli. The data was also computed in CIE 1976 CIELAB system. The results were exported by the programme into ASCII data format. The properties of these systems are defined in the International Lighting Vocabulary [1]. Each system is an attempt to come close to the human colour perception which is logarithmic when there are no possibilities for chemical measurements we couldnot test the pigment contents.

The results of the first years were computed according to the C standard ray distribution, which is an old standard now. If we replaced it by the D65 ray distribution, problems with comparison of results in different generations would occur.

We use a locally developed computer programme for converting our data in to a character delimited form, which is useful for Lotus, Quattro, Excel and Statgraphics-type evaluating programmes. The new features in our programme are:

- This programme is for computing data to present the Nemcsics's COLOROID system.
- The programme computes the co-ordinates of the colour difference vectors, displays them on the screen together with the average vector, and prints the average.
- The programme makes output in a file consisting of the colour difference values for further computing purposes.

The COLOROID system was developed for architecture, colour dynamics and interior design purposes [5]. We use it for two reasons:

- It has a well-defined colour number (hue) strictly determined on the CIE 1931 colour stimuli.
- It is created using the theory of the aesthetically equidistant scales. We think that the consumers choose fruit by the aesthetic impression when buying (together with other properties such as: flavour, etc.).

The properties of the COLOROID system are: A hue, T saturation and V lightness. The programme calculates the hue data converted into a continuous range instead of the original so that the average and standard deviation can be calculated. As the original hue scale is discontinuous, we display it in its converted form.

The colour difference vectors are for expressing how colourful is a piece of fruit. Colour difference is defined by subtracting the back ground colour from the foreground colour. Using this definition we get positive values increasing with maturation. Hence, this method follows the ripening process. The higher the maturation level the higher the number. This method is not planned to replace the previously applied methods, using the background colour for measuring the maturity but a supplement of it.

We chose the two most significant properties from the three most important colorimetric systems plotting them on a plane:

- x, y CIE 1931 chromaticity co-ordinates;

Table 1. χ square tests

Colorimetry system	Property	Lognormal		Normal		Weibull		Skewnes
		test	signifi-cance	test	signifi-cance	test	signifi-cance	value
CIE 1931 coordinates	value	24.18	0.0021	7.081	0.5278	8.090	0.5251	0.521
	direction	7.752	0.0512	8.607	0.0716	45.29	10^{-8}	3.39
CIE stimuli	value	31.64	0.00045	12.87	0.1684	12.88	0.1677	-0.065
	direction	9.063	0.1065	9.982	0.0757	-	-	4.902
CIELAB	value	28.94	0.0032	18.49	0.0178	18.75	0.0162	-0.033
	direction	15.96	0.0139	15.40	0.0173	19.14	0.0018	-2.85
COLOROID	value	32.92	0.00028	32.18	0.00037	25.16	0.0027	-0.155
	direction	10.77	0.0956	14.45	0.0436	45.28	10^{-6}	4.65

Table 2. Kolmogorov-Smirnov tests

Colorimetry system	Property	Lognormal		Normal		Weibull		Skewnes
		test	signifi-cance	test	signifi-cance	test	signifi-cance	value
CIE 1931 coordinates	value	0.1103	0.1972	0.0755	0.6498	0.0807	0.5651	0.521
	direction	0.1021	0.2743	0.1009	0.2878	0.1784	0.0047	3.39
CIE stimuli	value	0.1187	0.1370	0.0725	0.6998	0.0711	0.7222	-0.065
	direction	0.1115	0.1878	0.1159	0.1554	-	-	4.902
CIELAB	value	0.0032	0.1001	0.0929	0.3848	0.0965	0.3388	-0.033
	direction	0.0139	0.1128	0.0173	0.1078	0.1261	0.0972	-2.85
COLOROID	value	0.0003	0.1547	0.0004	0.0971	0.0982	0.3176	-0.153
	direction	0.0956	0.1082	0.0436	0.1213	0.1754	0.0057	4.65

- X, Y CIE 1931 colour stimuli;
- a*, b* CIE 1976 CIELAB chroma vectors;
- A, T COLOROID system.

The output file consists of the absolute values and the direction angles for these systems. This way the statistical tests can be computed (Jonagold): (Tables 1 and 2).

Plotting the colour developing data, different paths can be observed for different varieties.

CONCLUSIONS

The author elaborated a new method to follow maturation and to help measuring quality using colour difference vectors. Distributions with different skewness can be found for equal numbers, so there is no reason to use any other type as normal distribution.

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