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A SIMPLE DIGITAL IMAGING METHOD FOR THE ANALYSIS OF THE COLOR OF FOOD SURFACES

Ivana Markovic*, Jelena Ilic, Dragan Markovic, Vojislav Simonovic, Sanja Dejanovic, Snezana Golubovic

Faculty of Mechanical Engineering, University of Belgrade, Serbia
**imarkovic@mas.bg.ac.rs*

Abstract

*Compared to manual inspection, which is inconsistent and subjective, sorters are able to assure product quality and food safety by more effectively identifying and removing defects and foreign material, while at the same time reducing labor costs and improving operating efficiencies. In this paper we analyzed color of the green beans in the way to find certain parameter which defined good color, acceptable for consumers because homogeneity and appearance have a significant impact on the consumer's decision and to see does and how different lighting effect on the color. The color recorded in the image is not an inherent value of observed object, because it is also influenced by the illumination properties (illuminance, spectral intensity distribution, color rendering index), as well as geometry and surfaces of neighboring objects. The CIE La*b* color space gave good results in a way that it define better the ranges of parameter a*.*

Keywords:

Color, green beans, color space, sorter

1. Introduction

Automated optical inspection systems (also called sorters) have been widely adopted for decades in the fruit and vegetable processing industries.

Some sorters inspect only an object's color, others inspect an object's color, size, and shape, and some sort based on the object's structural properties, including differing levels of chlorophyll. The processor's products and business objectives determine the suitable sorter configuration.

Some sorters even allow the user to define a defective product based on the total defective surface area of any given object. These object-based considerations put more power into the processor's hands to produce optimal product quality. The use of computer vision technology for food analysis are widely reviewed [1, 2]. The use of different color spaces, quantitative values of color are obtained. Coordinate transformation of the RGB color space to other color spaces is possible and it facilitates achieving greater accuracy and improves color calculation when it comes to food products. The idea of this paper is to examine the influence several types of illuminations on color of the image of the product and to defined range of color values of the good product in RGB and CIELab color space.

2. Materials and methods

In this paper, the color of previously frozen green beans (-18 °C) have been investigated. Product were put in black chamber, dimensions 50x50x50 cm. Olympus VG-110 camera was used. As the illumination Philips bulbs, of color rendering index (CRI) Ra8, and color temperature 2700 K were used. In Table 1, other primary characteristics of illuminations are shown. The snapshots were taken from height of 40 cm in dark room. Total measurements were performed within 10 minutes.

Table 1.Main features of the applied illuminations

Types of illumination	Power (W)	Luminous flux (lm)	Luminous intensity (cd)
Clear	60	655	
Reflector	60		750
Soft White	60	630	
Warm White	14-68	856	

After shooting, pictures are obtained in Adobe Photoshop® 7.0., where they are cropped in dimensions of 50x50 pixels. The obtained images are further processed in Matlab®. A digital color image is represented in RGB form with three components per pixel in the range from 0 to 255 and conventionally stored using eight bits per color component. Each parameter of color: red, green and blue is presented in the form of 50x50 matrix. By subsequent transformation of the images in CIELab color space, parameters *L*, *a** and *b** are also presented in the same form. The *L** defines lightness, *a** denotes the red/green value and *b** the yellow/blue value. The red/green opponent colors are represented along the *a** axis, with green at negative a* values and red at positive a* values. The yellow/blue opponent colors are represented along the b* axis, with blue at negative *b** values and yellow at positive *b** values. The scaling and limits of the a* and b* axes will depend on the specific implementation of*La*b** color, but they often run in the range of ±100 or -128 to +127. Figure 1 show the ilustration of CIELab color space.

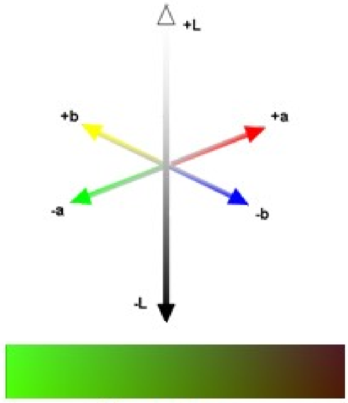


Figure 1. Display L, a and b* coordinates and green color in CIELab color space*

Further statistical analysis where performed in IBM SPSS® 21. At first, descriptive analysis were performed, after that Frequencies test and Wilcoxon signed-rank test were used.

3. Results and discussion

In Table 2, taken images of examined green beans under different illumination are shown.

Table 2.Display samples of beans captured under different illumination

Type of illumination	1 bulb	2 bulbs	Resolution
Clear			50x50
Reflector			50x50
Soft White			50x50
Warm White			50x50

Results of descriptive statistics are summarized in Table 3 for *R*, *G*, *B* and in Table 4 for *L*, *a** i *b** parameters. Based on showed results, we can conclude that the CIELab colors space are more suitable for determinating the range of good color because of the much closer mean values of color parameters and much lower standard deviations of color parameters for all applied illuminations.

Table 3.Descriptive statistics for R, G, B values

	Main values						Standard deviation					
	Red		Green		Blue		Red		Green		Blue	
	1 bulb	2 bulbs	1 bulb	2 bulbs	1 bulb	2 bulbs	1 bulb	2 bulb	1 bulb	2 bulb	1 bulb	2 bulb
Clear	170.63	163.62	182.15	170.50	152.55	138.18	32.10	34.89	30.35	31.66	31.61	37.75
Reflector	154.41	184.89	158.99	183.73	122.68	143.20	35.69	37.23	32.59	35.90	32.09	34.50
Soft White	155.26	146.17	170.81	161.43	134.29	123.64	31.22	32.90	29.04	30.48	32.33	32.87
Warm White	160.23	159.67	179.96	152.60	147.86	152.60	31.53	32.83	29.81	30.80	33.60	33.87

Table 4. Descriptive statistics for L, a, b* values*

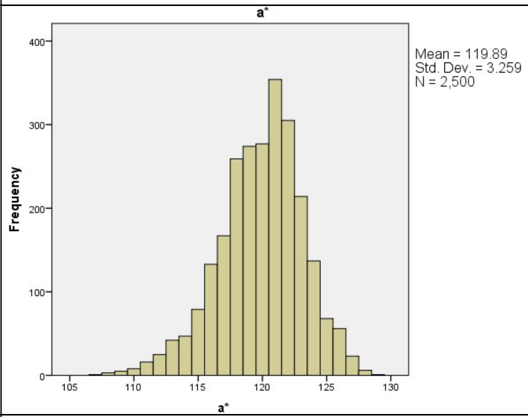
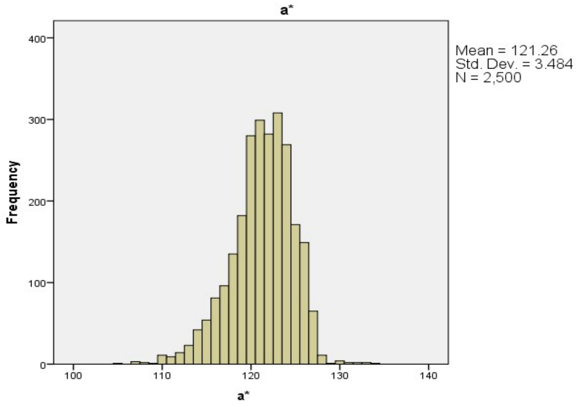
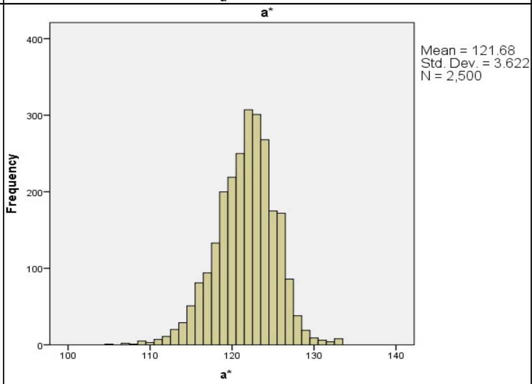
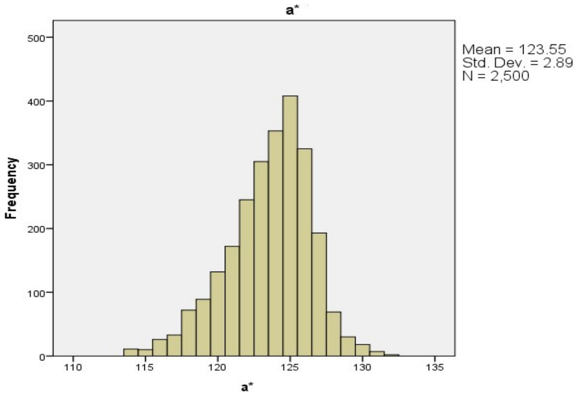
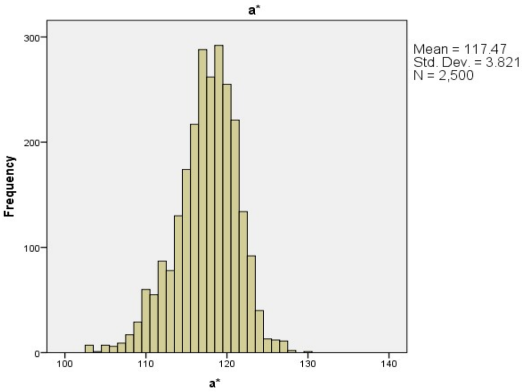
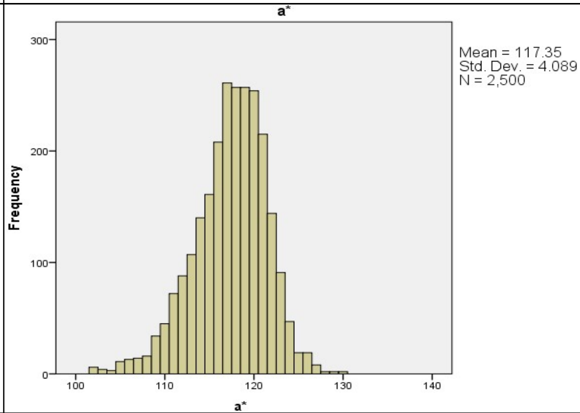
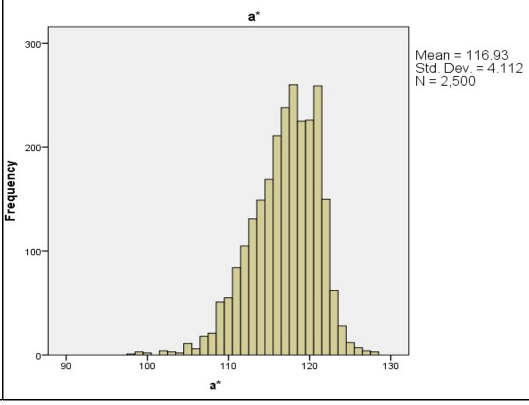
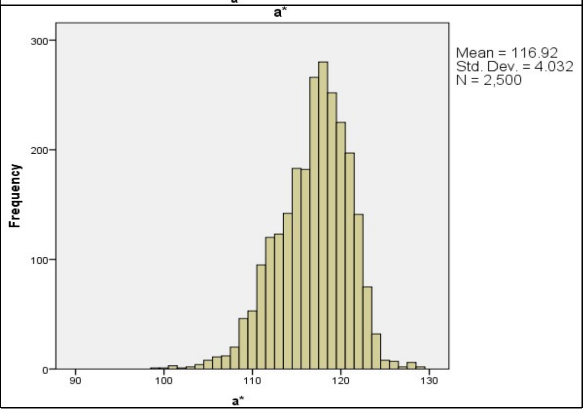
	Main values						Standard deviation					
	L		a*		b*		L		a*		b*	
	1 bulb	2 bulbs	1 bulb	2 bulbs	1 bulb	2 bulbs	1 bulb	2 bulb	1 bulb	2 bulb	1 bulb	2 bulb
Clear	184.62	174.36	119.89	121.26	141.73	143.85	23.54	31.20	3.25	3.48	6.00	6.80
Reflector	163.60	188.03	121.68	123.55	146.43	148.83	32.44	34.72	3.62	2.89	7.61	6.98
Soft White	172.85	163.81	117.47	117.35	145.00	145.85	28.51	30.25	3.82	4.08	7.50	7.97
Warm White	180.29	180.98	116.93	116.92	141.77	139.59	29.04	30.08	4.11	4.03	7.44	7.39

Based on average values and standard deviation from Table 3, the most intensive green color is given by reflector illuminant, and standard deviation are lowest when soft white illuminant were applied. From Table 4, the most intensive *a** values are given by reflector illuminant where standard deviation is lowest. Next, the Frequencies test are performed. Histograms of *a** parameter are given in table 5. Frequences test show us most frequent values. Comparing a* values, it can be defined range of values with minimal standard deviation for every type of illumination and then based on that range in the further research, we can define good color of product.

With visual method we can see differences between illuminations, while differences between the illuminations by one or two bulbs are unclear, as we can see in Table 2.

Anyhow, observing table 5, diferent distributions of *a** parametar can be noticed. In order to examine it using statistics, color parameters were evaluated with Wilcoxon signed-rank test and showed a statically significant change in some cases. Wilcoxon signed-rank test are appropriate for determining whether or not there is a significant association between a dichotomous variable and a continuous variable with independent samples data [3].

Table 5. Histograms of a values*

Types of illumination	1 bulb	2 bulbs
Clear		
Reflector		
Soft White		
Warm White		

.Significant difference is present when Asymp. Sig. (2-tailed) – is below $p<0,005$ and the degree of the difference is determined by the value of r which is defined by equation 1:

$$r = \frac{Z}{\sqrt{N}} \tag{1}$$

where is N- total number of cases.

Cohen (1988) [4], suggesting that an r of 0.1 represents a 'small' effect size, 0.3 represents a 'medium' effect size and 0.5 represents a 'large' effect size. Table 6 shows results of Wilcoxon signed-ranktest. It compares values of each colorparametar (*R, G, B, L, a*, b**) when one bulb ofcertain illumination is used, with the value of color parameters when two bulbs of the same illuminationare used.

Results which represent values where exist a large significant difference in amount of applied illumination intensity are labeled. Based on table 6, it can be concluded that the illumination intensity does not have influence on green color only when soft white and warm white illuminationis applied, while in other cases it has significant influence.

Table 6. Wilcoxon signed-rank test for *R,G,B and L, a*, b**parameters

		Z	Asymp. Sig. (2-tailed)	r			Z	Asymp. Sig. (2-tailed)	r
Clear	Red	-28.237	0.000	**0.40**	Clear	L	-38.539	0.000	**0.55**
	Green	-39.480	0.000	**0.56**		a*	-28.129	0.000	**0.40**
	Blue	-41.435	0000	**0.59**		b*	-28.520	0.000	**0.40**
Reflector	Red	-43.271	0.000	**0.61**	Reflector	L	-43.142	0.000	**0.61**
	Green	-43.041	0.000	**0.61**		a*	-31.501	0.000	**0.45**
	Blue	42.477	0.000	**0.60**		b*	-28.845	0.000	**0.41**
Soft White	Red	-12.298	0.000	0.17	Soft White	L	-13.232	0.000	0.19
	Green	-13.450	0.000	0.19		a*	-1.539	0.124	-
	Blue	-13.833	0.000	0.20		b*	-6.297	0.000	0.09
Warm White	Red	-1.546	0.122	-	Warm White	L	-2.918	0.004	0.04
	Green	-3.335	0.001	0.05		a*	-0.104	0.917	-
	Blue	-14.719	0.000	0.21		b*	-29.689	0.000	**0.42**

4. Conclusion

This paper presents a simple method that uses a combination of digital camera, computer and compatible software for measuring and analyzing the color surface of agricultural products. Based on presented results it can be concluded that the CIELab color space is more suitable for determining the good color of tested agricultural products. Soft white or warm white light is the most suitable for determining the optimal range of values of good color from all tested lighting in this paper. The next step in research would be application of these values during the process of recognition of inadequate color product which would be tested.

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6. References

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