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APPLICATION OF A DOCUMENT CAMERA FOR COLOR MEASUREMENT OF DAIRY PRODUCTS

ZlatinZlatev, PhD
Trakia University,
Faculty of Technics and technologies,
38 Graf Ignatiev str., 8602, Yambol, Bulgaria,
e-mail: zlatin.zlatev@trakia-uni.bg

Abstract: *The report presents the advantages and disadvantages of document cameras in using as a tool for presentations and measurement of features of different objects. The analysis of known literature show that there are a few publications related to measurement of color of dairy products and their surface characteristics. There are no known publications in accessible literature of measurement of color of dairy products by document camera. The use of document camera has advantage that it can measure the color for full object area on the surface of the dairy products. The possibility of objective measurement of color of dairy products is assessed by comparing the results with those obtained by colorimeter. Two color models are used – RGB and HSL. High level of correlation (R>0,9) is obtained for both color models, but the sum of squired errors is higher for the RGB color model for surface characteristics with white brined cheese and yellow cheese. The error rates are low and correlation is high for object areas with mold using both color models. The measurement of color of dairy products by document camera demonstrated to be great potential for rapidly quantifying of their surface color.*

Keywords:*Color measurement, Document camera, White brined cheese, Yellow cheese.*

INTRODUCTION

A document camera is a technical tool targeted primarily at the education sector. It can be integrated with an interactive whiteboard or a microscope. This allows the display of additional notes, three-dimensional objects, printed materials, transparent slides, mathematical models of biological processes in the lecture courses (Stoykova et al., 2014; Shivacheva, 2017).

In addition to the main features of the presentation, the state of the art of science and technology, in the available literature (Krastev, 2013; Vasilev, 2016; Dimitrova, 2016) it is stated that a document camera can be used to measure the color, dimensions, surface characteristics of biological objects, food and technical products.

In the available literature (Mladenov et al., 2015; Onac et al., 2016) few publications have been found to measure the color of dairy products with machine vision systems in production conditions and video cameras in laboratory conditions. The use of a document camera for this purpose is unknown. For this purpose Colorimeters are used to determine the degree of maturation of dairy products and the detection of molded object areas on the surface of the product (Gaazi et al., 2014; Bajcheva, 2016; Georgieva et al., 2016; Kobayashi et al., 2017). The application of a document camera for this purpose has the advantage that it is possible to measure the color throughout the object area on the surface of the product, to be used for presentation and training and thereby to obtain primary information which is accessible from any point of The world with Internet access.

The purpose of the report is to assess the possibility of measuring the color of the object areas on the surface of dairy products with a document chamera by comparative analysis with colorimetric measurements.

EXPOSITION

Material and methods used

Used are 5 samples of white brined cheese made by BNS 15: 2010 and 5 samples of yellow cheese produced by BNS 14: 2010. Samples are purchased commercially.They are stored under conditions not prescribed by the manufacturer at a temperature of 20-22^{o}C and a relative humidity of 55%.On the fifth day of storage, measurements were made on the object areas of white brined cheese, yellow cheese and molded areas.

An Epson DC-11, 5 MP document camera with LED light is used.

As a reference measurement, a PCE-RGB2 colorimeter is used, which measures the color in RGB and HSL color patterns.With the colorimeter, 3 consecutive measurements were made for each object area and the average values were taken.

Figure 1 shows the laboratory system with document camera.It consists of a personal computer with installed software for obtaining, processing and analyzing images from a document camera.Some of the samples used with areas of yellow cheese and mold are also shown.

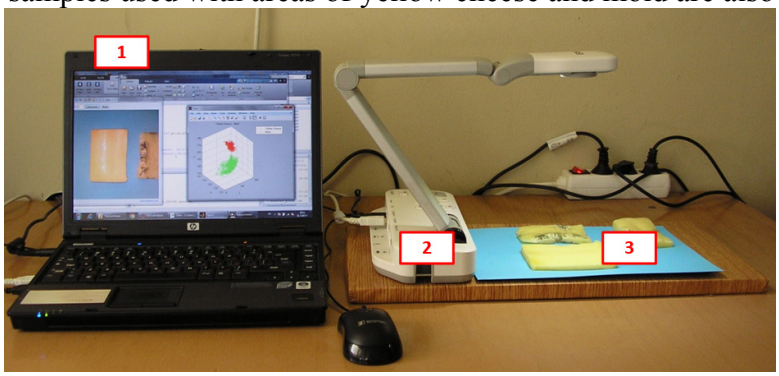


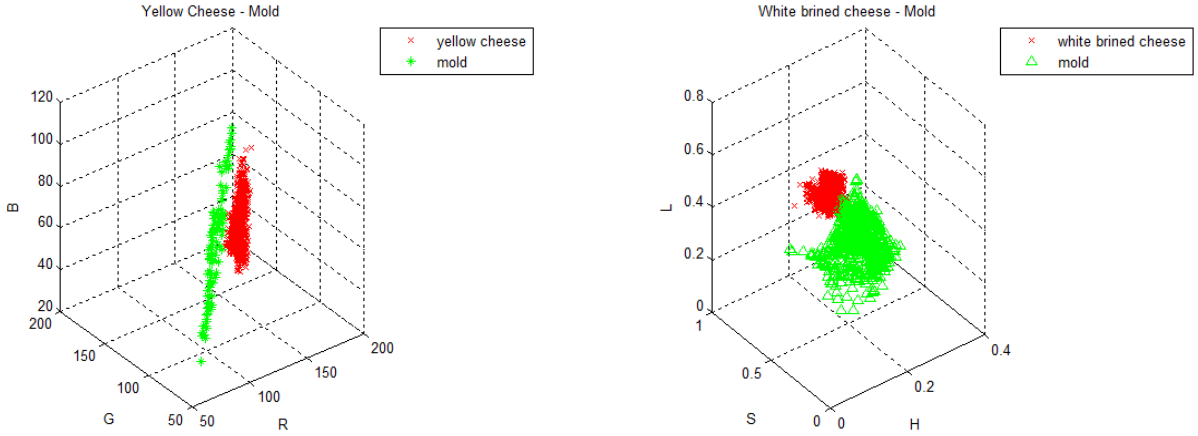
Fig.1. Laboratory system – general view

1-Personal computer with software; 2-Document camera; 3-Measured samples.

The normal distribution of the experimental data was demonstrated by a Shapiro-Wilk test (Shapiro-Wilk test, 2017) at p-level = 0,05. Determined are the Sum of squares of errors (SSE) and root mean square error (RMSE)

RESULTS AND ANALYZES

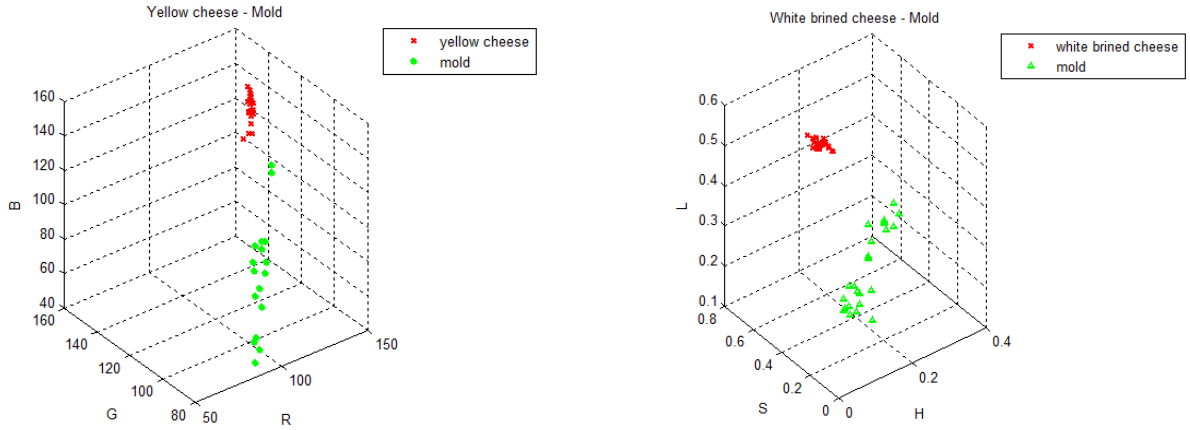
Figure 2 depicts the pixel distribution of RGB color components for object areas with yellow cheese and mold, as well as the HSL color components distribution for areas with white brined cheese and mold.There is a clear distinctness of object areas using two color models.It is also seen that the color component values are grouped according to the object area.



a)RGB color modelyellow cheese b)HSL color model white brined cheese

Fig.2. Distribution of color components in RGB and HSL color models

Figure 3 presents examples of the measured values with a colorimeter of color components from RGB and HSL models.The areas with white brined cheese and mold on it were measured, yellow cheese and mold on yellow cheese too.



a) Yellow cheese RGB color model b) White brined cheese HSL color model

Fig.3. Values from two color models measured by colorimeter

Table 1 lists the results of the comparative analysis between the color characteristics of white brined cheese, yellow cheese and mold in RGB and HSL color components.The comparison is based on root-mean squired errors (RMSE), correlation, and sum of squared errors (SSE).There are high values (R> 0,9) of the correlation coefficient between the values of the color components measured by a document camera and those obtained with the colorimeter.RMSE values are small for all subject areas, while SSE error is higher (21-93) when using the RGB color model in the white cheese brine and cheese areas.

Table 1. Results of comparative analysis of document camera and colorimeter

Object area	**Color component / Criteria**	**R**	**G**	**B**	**H**	**S**	**L**
White brined cheese	RMSE	4,000	1,000	1,000	0,006	0,001	0,016
	Correlation	0,966	0,981	0,987	0,981	0,973	0,910
	SSE	25,402	24,602	92,930	0,000	0,001	0,001
Mold on white brined cheese	RMSE	0,000	0,000	0,000	0,033	0,020	0,153
	Correlation	0,911	0,911	0,922	0,977	0,985	0,625
	SSE	0,518	0,587	0,421	0,001	0,006	0,001
Yellow cheese	RMSE	3,000	4,000	2,000	0,000	0,000	0,004
	Correlation	0,976	0,974	0,979	0,989	0,987	0,964
	SSE	21,530	26,214	26,626	0,000	0,004	0,000
Mold on yellow cheese	RMSE	0,000	0,000	2,000	0,000	0,016	0,000
	Correlation	0,982	0,986	0,993	0,978	0,988	0,983
	SSE	0,367	0,382	0,366	0,000	0,004	0,007
RMSE – root mean squared error; SSE – sum of squared errors							

CONCLUSION

An example of using computer-assisted learning using a document camera as a color measurement system is explored. The usage of document camera has advantage that it can capture the appearance of full inquiry zone on the surface of the dairy products.

The probability of target estimation of surface characteristics of dairy products is studied by differentiating the results with those obtained by colorimeter. Two color models are used – RGB and HSL. High coefficient of correlation (R>0,9) is gotten for both color models, yet the sum of squired errors is higher for the RGB color model for surface characteristics of white brined cheese and yellow cheese. The error rates are low and association is high for object areas using both color models.

The measurement of color of dairy products by document camera appeared to be mind boggling potential for rapidly assessing of their surface characteristics.

The research will be continued with the application of the presented system in the creation of virtual laboratories, using it as an interactive e-learning tool.

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