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Application of Computer Vision Systems in Colour Evaluation of Kunda: A Heat Desiccated Dairy Product

A.S. Vyawahare and K. Jayaraj Rao
Dairy Technology Section, National Dairy Research Institute (Southern Campus), Adugodi, Bangalore, 560 030, India

Corresponding Author: A.S. Vyawahare, Dairy Technology Section, National Dairy Research Institute (Southern Campus), Adugodi, Bangalore, 560 030, India

ABSTRACT
Color is an important attribute of food quality that is the first impression consumers get of the food. Hence, in order to maintain a uniform colour, a reliable and faster method of colour measurement is required. In this context, computer-vision technology proves to be a useful method. In this study, 2 computer vision methods have been used. First method involved use of scanner. Kunda, an Indain dairy product, was taken into a suitable transparent material and surface scanned using the scanner. The product surface was also photographed using a digital camera under defined conditions. The images obtained by both methods were opened using Adobe Photoshop software and colour parameters viz. R, G and B have been measured by the Graphical Editor of Photoshop. The overall L, R, G and B values ranged between 124.43 to 127.7; 162.13 to 163.3; 116.24 to 119.94 and 67.51 to 73.71, respectively on a scale of 256, by scanner method. Scanner variables had little impact on magnitude of these colour parameters but the material in which product kept for scanning has to be specified. For camera method the values were 98.82 to 100.24; 137.99 to 141.26; 89.97 to 91.26 and 34.87 to 36.82, respectively. These values depended on the resolution of the camera used, distance between object and lense and the illumination. The accuracy of the methods was indicated by low coefficient of variation values. Overall results showed that computer vision can be used as an objective, rapid and non-contact method to quantify the colour of kunda.

Key words: Kunda, adobe photoshop, digital camera, coefficient of variation, RGB mode, flatbed scanner

INTRODUCTION
Today quality and safety are major drivers for the food industry. The increased awareness and sophistication of consumers is escalating the expectation for improved quality in food products, which results in increased need for enhanced quality monitoring (Gunasekaran, 1996). For the sensory analysis of agricultural and food products, a new inspection systems, mainly based on scanner or camera-computer technology have been investigated. Computer vision technology is highly relevant and successful in providing objective measurements various agricultural and food products, particularly for visual attributes like color or shape of food products. Therefore, computer vision method for food quality and safety evaluation is gaining much attention. And usefulness of computer vision in the food industry is authenticated by several experiments carried out throughout the world (Brosnan and Sun, 2004).

Brosnan and Sun (2002) reported Computer vision has long been recognized as a potential technique for the guidance or control of agricultural and food processes . Therefore, over the past 20 years, extensive studies have been carried out, thus generating many publications. Measurement of colour is one area which plays an important role in perceiving food quality and also aids in detection of anomalies or defects that food items may present (Gokmen and Sugut, 2007). From the times immemorial humans devised some means of colour measurement, though by sensory organs and by comparison. From the times of Munsell colour discs, colour measurement has undergone enormous transformations and developments, thanks to today's computerized revolutions in almost all the fields of human life. Computers can play a significant role in field of colour measurement offering vast opportunities for the researchers. By computer vision system, the colour components can be accurately measured.

For agricultural and food products, Sorting and grading during handling processes and commercial purposes is one of the important attributes. For this Computer vision can be non-destructive and cost-effective technique. (Narendra and Hareesh, 2010). Gokmen and Sugut (2007) reported that, the chromatic and geometric attributes of any object should be accounted for making visual or instrumental assessment of appearance. It is well known that, as colour observation allows the detection of certain anomalies or defects of a product, colour can be uses as a tool to accept or reject the product. Thus colour measurement is an important tool in the hands of food technologists for determining and monitoring quality of the food product. It could also act as a controlling means of certain processing conditions. Tossavainen and Kallioinen (2008) suggested that colour measurement can be used to follow the advanced maillard reactions in milk. Colour spectrophotometers are now commonly used for measuring colour and colour stability of various meat and vegetable products like chicken patties (O'Sullivan *et al.*, 2004), processed mango slices (Chauhan *et al.*, 2006), sattu, a soybean product (Mridula *et al.*, 2007), French fries (Koh, 2007), mango gel (Das Gupta *et al.*, 2007), chicken balls (Huda *et al.*, 2009), chilled beef (Balev *et al.*, 2011), frozen and osmotically dehydrated tomato (Chottanom and Srisa-Ard, 2011) and potato crisps (Abong *et al.*, 2011). The colour of all these products was measured in terms of Hunter L, a and b; CIE- L* i.e., lightness on a scale of 0 (black) to 100 (white), a* (red colour component) and b* (yellow colour component). It may be observed that all of the above reported studies employed reflectance principle and utilized Hunter method of colour evaluation or CIE methods of colour expressions. Few studies are reported on utilization of commonly available software like Adobe Photoshop in colour measurement in foods but effectively used in the field of photography.

Kunda is an important traditional product of India especially in some parts of Maharashtra and Karnataka provinces; it bears a great social, religious and economic importance so much so that the entire district of Belgaum is associated with Kunda. Kunda is a heat desiccated, brown coloured product prepared by the continuous heating of milk mixed with calculated amount of sugar. Traditionally, buffalo milk which is consumed by majority of people in Indian sub continent, is used for the preparation of kunda (Kulkarni *et al.*, 2001). The sweetened milk is heated continuously by simmering on a low flame till a brown coloured product forms. If necessary to develop desired brown colour, aliquots of water are added and desiccation continued till a brown colored kunda is formed (Navajeevan and Jayaraj Rao, 2005). In present study, the possibility and suitability of using reflectance systems such as scanner, digital camera and digital image-processing software for the numerical quantification of the colour intensity of heat desiccated products like kunda was studied.

MATERIALS AND METHODS

Scanner and adobe photoshop method: The study was carried out during the period Aug, 2009-May, 2010. Kunda samples were conditioned at 30°C and blended properly in pestle and mortar. With the help of a spatula, the product was taken in a clean, scratch less glass petri dish. The petri dish containing the sample was placed on the bed of the scanner and was covered by scanner top (Fig. 1). Scanning was performed and the image was saved as JPEG file (Fig. 2). The effect of following scanner variables on colour parameters were then studied: resolution (DPI 75 to 1200); sharpness (low, medium, high and extreme); image quality (low, medium and high); background of sample (black and white); thickness of sample inside the petri dish (0.5, 1 and 1.5 cm) and type of packaging material used (cellophane, glass and LDPE).

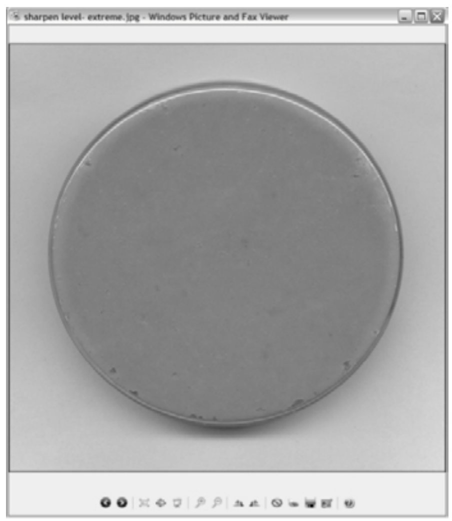

Fig. 1: Scanned images of (a) kunda saved as JPEJ file

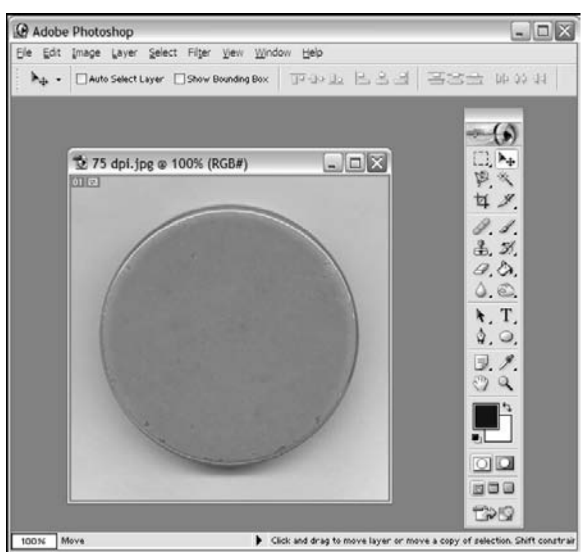

Fig. 2: Scanned image opened in Adobe Photoshop programme

Colour analysis software namely Adobe Photoshop Version 8.0, running under the Microsoft Windows XP environment, was used to extract and analyze colour information from the scanned image (Yam and Papadakis, 2004). The scanned image in JPEG format was opened with Adobe Photoshop (Fig. 2) and the following parameters were measured in RGB mode: Lightness (L), Red (R), green (G) and blue (B).

Camera and adobe photoshop method: Samples of kunda were blended properly with spatula and made into uniform texture by breaking the lumps. The product was then taken into petri dish as mentioned earlier.

Image acquisition assembly: While capturing image using camera, proper lighting is of utmost importance, since the colour of the food sample depends on part of spectrum reflected from it (Francis and Clydesdale, 1975). The computer vision system used in this study includes an enclosure for sample, a digital camera, fluorescent lamps, stand for holding the lamps and a computer. The high-resolution digital camera was fixed with solid support of stand on which it can be fixed at varying heights. The sides of the enclosure for sample were covered with white fabrics/papers to provide a uniform lighting to the object. The light sources used were 2 CFLs (compact florescent lights, Philips make-14 Watt, B22, 220-240 V, 50 Hz, 760 lumens) fixed one on each of two sides of the object at an angle of 45 degrees. Images were captured in night in order to avoid effect of surrounding light and to provide uniform intensity of light throughout the research work.

Analyzing colour

Adobe photoshop: The photo images were transferred to computer hard disc and opened with Adobe Photoshop software. Colour parameters were measured in three colour modes viz. RGB mode- Lightness, red, green and blue; The separation of colours of scanned images and the determination of the luminosity of R, G and B channels were made using the accessories in Adobe (R) Photoshop 8.0 software.

Statistical analysis: In order to analyze, the statistical significance among the colour parameters, the following statistical tools were employed: 1) Standard deviation-All the mean values were expressed as ±SD 2) Coefficient of Variation (CV) -it was determined by the formula: Standard Deviation/Mean (σ/x) (Snedecor and Cochran, 1994) 3) One way ANOVA and 4) The Students t-test was used to calculate the significant difference between two treatments, like scanner background (Gupta, 2009).

All calculations were carried out with Microsoft Office Excel 2007 software (version 8.0, Microsoft Inc., Redmond, WA) and the statistical significance expressed at 5% level of significance ($p<0.05$) as described in Sundararaj *et al.* (1972).

RESULTS AND DISCUSSION

Scanner and adobe photoshop method: The quality of the scanned images depends on several factors such as scanner resolution, image quality, sharpen level etc. The scanners are mostly designed for scanning text and photograph materials. They probably are not specially designed for any colour measurement purpose, though colour scans are commonly employed for various applications. However, because of availability of specialized software like Adobe Photoshop, the scanned images could be utilized for colour measurement purposes (Vyawahare, 2010).

Effect of scanning resolution: One of the qualifying parameters for a scanner is its resolution, measured in pixels per inch (ppi) and more accurately referred to as dots per inch (dpi). The resolution defines the fineness of the scan. During scanning, scanner head moves over the document line by line more specifically dot by dot. Each line which is made up of basic dots, corresponds to pixels. The range for resolution of scanner varies from manufacturer to manufacturer. But, generally the order of magnitude of the resolution ranges from 75 to 2400 dpi and in some advance scanners, it is up to 4800 dpi or above. This scale of resolution is meant for different applications, the lower resolution image occupies less space on hard disk than higher resolution one. It may thus be inferred that colour intensity might vary with the magnitude of resolution adopted for the scanning the objects.

From Table 1, it can be seen that the lightness value (L), R (Red) and G (Green) values showed slightly an irregular trend with increasing resolution. The Analysis of variance (ANOVA) (Table 2) of the data showed that there was no significant difference among colour values at various resolutions. The F-values for L, R, G and B parameters were 0.13, 0.10, 0.14 and 0.39, respectively which were less than the F-critical value (2.45). This signifies that there was no significant effect of scanning resolution on the magnitude of colour parameters. The variation among the batches was analyzed by Standard Deviation (SD) and Coefficient of Variation (CV_{batch}). The variation among the resolution mean values was determined by 'CV_{resol}'. It can be seen from the Table 1 that coefficient of variation within the batches (4.10 to 5.58) is much higher than resolution coefficient of variation (0.47 to 1.66).

Higher standard deviation as well as higher batch-wise coefficient of variation may be attributed to varying processing parameters like intensity of heat treatment applied, duration of heating, extent of stirring and scraping etc. As the variation attributable to resolution is very less as compared with the variation attributable to manufacturing batches of kunda, any of the scanning resolutions provided in the instrument can be used for colour measurement purpose.

Table 1: Effect of scanner resolution on colour values of kunda in RGB mode

	75 DPI	100 DPI	150 DPI	300 DPI	400 DPI	600 DPI	1200 DPI	CV batch/resol
L	127.70±5.31	127.58±5.13	126.30±4.80	126.52±5.36	126.16±5.08	125.59±5.18	127.45±5.20	5.15/0.65
R	163.84±5.59	164.80±5.93	163.19±5.45	162.87±5.55	162.96±5.42	162.49±5.57	163.43±4.99	5.50/0.47
G	119.61±5.88	119.94±5.67	118.34±5.33	117.92±5.62	118.05±5.24	117.75±5.79	119.50±5.56	5.58/0.77
B	70.46±4.76	69.95±4.10	68.39±3.76	68.97±4.51	69.07±4.06	67.62±3.47	67.33±4.02	4.10/1.66

Note: All values in a Column are not significantly different at p>0.05, CV: Coefficient of variation L: luminance or lightness component, R: Redness component, G: Greenness component, B: Blueness component

Table 2: ANOVA for effect of scanning resolution

		L		R		G		B	
Source	Df	MSS	F-value	MSS	F-value	MSS	F-value	MSS	F-value
Between scanning resolution	6	3.38	0.13^{NS}	2.91	0.10^{NS}	4.23	0.14^{NS}	6.56	0.39^{NS}
Error	28	26.55	-	30.34	-	31.23	-	16.94	-
Total	34	-	-	-	-	-	-	-	-

NS = Not significant (p>0.05)

Ravindra and Goswami (2008) concluded that the computer vision system involving measurement of peel colour in terms of lightness (L), a, b values using histogram window method of Adobe Photoshop, standard L*, a*, b* values, the hue and chroma values along with the total colour difference could be used to quantify overall changes of peel and pulp of mangoes, thus, enabling customization, standardization and storage studies of various fruits.

Effect of sharpen level: Sharpening defines contrast of an image. More specifically, sharpening emphasizes details in images by increasing the contrast of the boundaries between light and dark areas of an image. This increase in contrast sharpens the focus and accentuates the difference between areas of light and dark making for a sharper scanned image. Thus, sharpening level may affect the clarity and quality of scanned images.

In most of the scanners, sharpen level ranges from low to high. Since sharpen level is likely to have an effect on colour parameters, the effect of sharpen level on colour values kunda was studied. In general, the lightness and B values showed decreasing, while G and R values showed almost similar values with increasing sharpen level from low to extreme (Table 3). The Analysis of Variance (ANOVA) of the data showed that there was no significant difference among colour values at various levels of sharpness (Table 4). Comparison of F-values of L, R, G and B parameters (0.01, 0.016, 0.012 and 0.31) with F-critical value (3.24) showed that sharpness level had little influence on the various colour parameters measured. In Table 3, each of the value under given sharpen level is an average of five different batches. The variation among the batches was analyzed by Standard Deviation (SD) and coefficient of variation, 'CV_{batch}'. The variation among the mean values vis-à-vis sharpen level was also determined and reported by '$CV_{sharpen}$'. It can be seen from the table-3 that batch coefficient of variation (3.92 to 5.71) is much higher than sharpen level coefficient of variation (0.18 to 1.41).

Table 3: Effect of sharpen level on colour values of kunda in RGB mode

	Low	Medium	High	Extreme	CV_{batch}	$CV_{sharpen}$
L	126.13±4.95	125.88±4.98	125.86±4.90	126.33±5.59	5.10	0.18
R	162.80±5.55	162.77±5.49	162.77±5.96	162.13±5.36	5.59	0.20
G	117.09±5.43	117.76±5.80	118.13±5.40	118.44±6.21	5.71	0.23
B	70.30±3.76	69.24±4.48	67.91±3.91	69.13±3.53	3.92	1.41

Note: all values in a row are not significantly different at p>0.05, CV: Coefficient of variation L: luminance or lightness component, R: Redness component, G: Greenness component, B: Blueness component

Table 4: ANOVA for effect of sharpen level

		L		R		G		B	
Source	Df	MSS	F-value	MSS	F-value	MSS	F-value	MSS	F-value
Between sharpen levels	3	0.245	0.01^{NS}	0.565	0.016^{NS}	0.383	0.012^{NS}	4.78	0.31^{NS}
Error	16	26.12	-	35.70	-	32.70	-	15.50	-
Total	19	-	-		-	-	-	-	-

NS = Not significant (p>0.05)

Effect of image quality: Similar to scanning resolution another parameter that affects scanned image is its image quality. It ranges from low to high. This scale of image quality is meant for different applications. Products from different batches were scanned at constant resolution and sharpen level but saved with different image quality.

It was seen that the lightness, R, G and B values of kunda showed increasing trend with increasing image quality from low to high (Table 5). However, there was no significant difference among colour values at various levels of image quality (Table 6).

It can be seen from the Table 5 that batch wise coefficients of variation (4.31 to 5.37 in kunda) were much higher than image quality coefficient of variation (0.34 to 1.28 in kunda). Higher standard deviation as well as higher batch wise coefficient of variation may be attributed to various processing parameters like heat treatment applied, time period of heating, stirring and scraping etc. As the variation attributable to various levels of image quality is very less as compared with the variation attributable to batch of kunda, measurement of colour values of kunda in RGB mode can be done at any level of image quality.

Effect of thickness/height of sample: Thickness refers to height of product in petri dish. It is measured in centimeters (cm). During scanning, the captors convert the reflected light intensities into electrical signals which are in turn converted into digital data by an analogue-digital converter. These light intensities may change with change in thickness of sample.

Product with varying thickness/height was scanned at same resolution keeping all other parameters constant. In general, the lightness value, R, G and B values showed decreasing trend with increasing sample thickness from 0.5 to 1.5 cm (Table 7). The Analysis of Variance (ANOVA) of the data showed that there was no significant effect of sample thickness among L and G values whereas significant effect was observed on R and B values. Colour values at various levels of product thickness (Table 8). This was noted by the lower F-values of L and G parameters (1.30 and 0.08) and higher F-values of R and B parameters (6.94 and 7.27) than F-critical value (3.40).

Table 5: Effect of image quality on colour values of kunda in RGB mode

Parameters	Low	Medium	High	CV_{batch}	CV_{image}
L	124.43±5.31	124.45±4.82	125.39±4.77	4.97	0.45
R	162.88±6.87	162.97±4.72	163.30±4.54	5.37	0.34
G	116.24±4.62	117.50±5.66	117.54±5.11	5.13	0.63
B	67.51±5.29	67.86±4.30	69.17±3.66	4.31	1.28

Note: all values in a row are not significantly different at p>0.05, CV: Coefficient of variation L: luminance or lightness component, R: Redness component, G: Greenness component, B: Blueness component

Table 6: ANOVA for effect of image quality

		L		R		G		B	
Source	Df	MSS	F-value	MSS	F-value	MSS	F-value	MSS	F-value
Between image quality	2	1.90	0.077^{NS}	1.523	0.05^{NS}	3.292	0.12^{NS}	4.59	0.24^{NS}
Error	15	24.74	-	29.96	-	26.51	-	18.90	-
Total	17	-	-	-	-	-	-	-	-

NS = Not significant (p>0.05)

Table 7: Effect of sample thickness/ height on colour values of kunda in RGB mode

Parameters	Low (0.5 cm)	Medium (1 cm)	High (1.5 cm)	CV_{batch}	$CV_{thick.}$
L	126.06±6.31	126.06±6.09	125.57±5.99	4.87	0.26
R	163.58±5.98	162.66±5.59	162.57±5.44	3.48	0.34
G	118.81±6.72	118.76±6.79	118.71±6.36	5.60	0.22
B	70.33±5.52	69.94±5.37	69.46±6.23	4.53	

Note: all values in a row are not significantly different at p>0.05; CV: Coefficient of variation L: luminance or lightness component, R: Redness component, G: Greenness component, B: Blueness component

Table 8: ANOVA for effect of thickness/height of sample

		L		R		G		B	
Source	Df	MSS	F-value	MSS	F-value	MSS	F-value	MSS	F-value
Between sample thickness	2	0.72	1.30^{NS}	2.79	6.94*	0.023	0.08^{NS}	1.74	7.27*
Error	24	0.55	-	0.40	-	0.28	-	0.24	-
Total	26	-	-	-	-	-	-	-	-

NS = Not significant (p>0.05), * Significant p<0.05

Fig. 3: Scanned image of product packed in glass and LDPE

Effect of sample container: In order to maintain specific dimensions of the product and to prevent any damage to the scanner surface, the product was taken in a container for scanning purpose. Different containers may be used but because of their varying refractive indices, they may influence the colour parameters of the product. Three containers were used namely glass (petri dish), polythene (LDPE) and cellophane films. The product was wrapped or spread in the containers which were then placed on the scanner surface for scanning purpose (Fig. 3).

It was found that all Lightness, R, G and B value were higher in cellophane followed by LDPE and glass in that order, this might be because of the differences in their refractive indices. There was variation observed in these values because of the type of container as indicated by CV values which ranged from 1.31 to 2.32 (Table 9). The variations within the batches of kunda were given by CV values ranging from 3.78 to 7.24. In general, ANOVA indicated significant differences

Table 9: Effect of type of sample container on colour values of kunda in RGB mode

Parameters	Glass	LDPE	Cellophane pouch	CV_{batch}	CV_{pack}
L	117.89±5.21[a]	119.65±5.12[b]	121.79±5.39[c]	7.12	1.63
R	150.84±4.66[a]	153.42±4.91[b]	157.18±3.83[c]	7.24	2.07
G	110.17±3.73[a]	111.25±3.46[a]	113.07±3.53[b]	4.37	1.31
B	70.70±2.77[a]	73.61±3.10[b]	75.31±2.79[a]	3.78	2.32

Note: Values with different superscript in a column are significantly different at p<0.05, CV: Coefficient of variation, L: luminance or lightness component, R: Redness component, G: Greenness component, B: Blueness component

Table 10: ANOVA for effect of sample container

		L		R		G		B	
Source	Df	MSS	F-value	MSS	F-value	MSS	F-value	MSS	F-value
Between sample containers	2	34.45	29.76*	92.07	91.32*	16.19	31.63*	49.27	190.8*
Error	24	1.16	-	1.01	-	0.51	-	0.26	-
Total	26	-	-	-	-	-	-	-	-

*Significant p<0.05

among the type of container ($p<0.05$) (Table 10). The F-values of L, R, G and B parameters (29.76, 91.32, 31.63 and 190.8, respectively) were much higher than F-critical value (3.40).

Effect of scanner background: During scanning, the sample taken in container is kept on the sample platform and the flap closed. The inner surface of the flap forms the background of the sample and is normally white. During scanning, light from the source incidents on the sample surface and gets reflected back onto the detector. A part of light gets absorbed by the sample and some part of the light passes through the sample and impinges on the background. If the background is white, then the impinging light gets reflected back into the sample. If the background is black then the light is absorbed in which case, magnitude of colour parameters is likely to vary. Hence, to determine whether background of the sample has any effect on the colour parameters, two backgrounds were chosen for the study: white and black, the former having the property of reflecting all the light and the latter having the property of absorbing all the light (Fig. 4 and 5). The L, R, G and B values of kunda with white background were 125.89, 162.37, 118.10 and 71.57, respectively and these values for black background were 122.63, 158.74, 114.92 and 65.94. These values indicate that black background produced smaller values than the white background which is statistically significant as indicated by t- test ($p<0.05$). This is because the rays from the light source were completely reflected by white background some of which in turn interfered with the light reflected by the sample giving more colour values Fig. 5. When black background was used, the light falling around the sample was absorbed by the background leaving only that light which was reflected from the sample, for measurement purpose. This can be seen from the Fig. 4 where in the sample with white background appears brighter than the one with black background.

Thus, it was inferred that measurement of colour values of kunda could be done at any level of the scanner parameters like resolution, image quality and sharpen level but the product has to be taken in a specified container-petri dish or cellophane or polythene film with specified

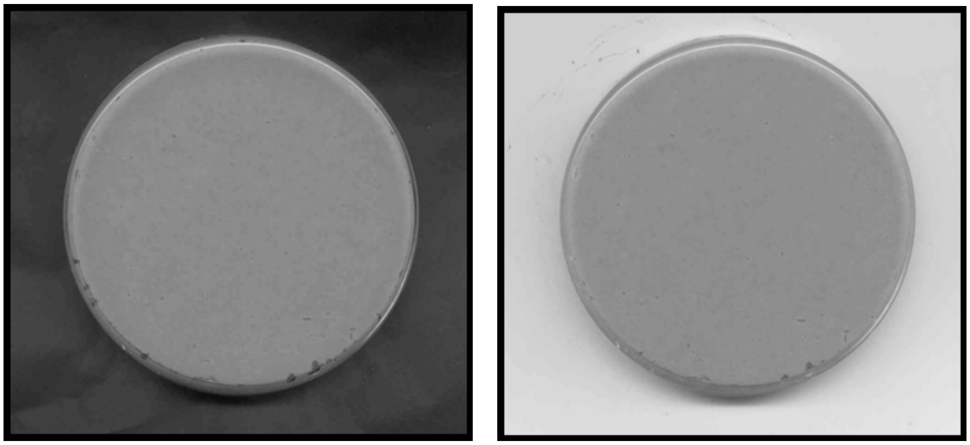

Fig. 4: Scanned image of product with backgrounds black and white

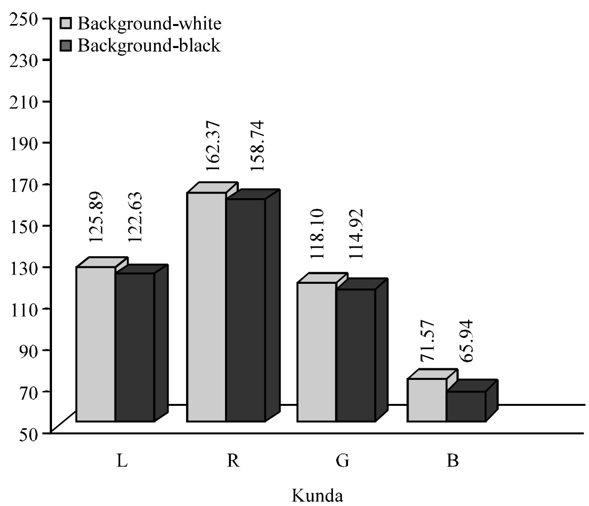

Fig. 5: Effect of scanner background on colour parameters of kunda in RGB mode. Note: All parameters shows significant difference at $p<0.05$

background (black or white). The results obtained could not be exactly evaluated against works reported in literature which are very few in dairy products. Nawale *et al.* (2009) used flatbed scanner and Adobe Photoshop method for the comparing colours of espresso drinks prepared with and without whey as a base ingredient. Fresh coffee samples were scanned at a constant scanning resolution, the scanned images were then transferred to Adobe Photoshop and colour values in terms of R, G and B value were noted down. It was found that colour of whey coffee was almost similar to colour of milk coffee. It was suggested in the study that this method for comparison of colours of product was safe and reliable. The similar method was used by Magdaline *et al.* (2009) for the study of colour changes of *gulabjamuns* (sweet milk product) during frying. Fried *gulabjamuns* were scanned and using Adobe Photoshop software chroma, hue L, a and b values were computed. The study established the utility of computer vision system in measuring colours of heterogeneous products like *gulabjamun*. Borin *et al.* (2007) quantified *Lactobacillus* spp. in fermented milks grown in MRS agar by use of digital colour images obtained by scanning agar under flatbed scanner. For this, they used glass petri plate as container for containing product while scanning.

Digital camera and adobe photoshop method: Use of digital cameras opened up new vistas in image analysis in process controls, monitoring, diagnostics, clinical field and many other fields. Since it offers the actual image of the materials, it gives the real and firsthand account of the appearance of the products. Hence, it is also useful for capturing images for colour measurement purposes. Since images captured in digital cameras are ultimately in the form of dots/pixels, colour measurement is possible by suitable software like Adobe Photoshop. However, the accuracy of colour measurement depends on the 'pixels' of the camera. A digital camera with a minimum resolution of 1600×1200 pixels is recommended, which is equivalent to a 2.1 megapixels (Yam and Papadakis, 2004). Accuracy of colour measurement also depends on the light source, intensity, distance between the camera and the object etc. In this study, an attempt was made to use digital camera to measure the colour parameters of kunda in RGB mode.

Effect of distance between camera and sample: Distance between object and camera may have effect on quality of image and thereby on colour parameters of image. Two distances were tried viz. 20 and 40 cm between the sample and the camera. The RGB mode results are presented in Fig. 6.

It may be observed from the table that significant difference existed between the values obtained at 20 cm distance and 40 cm distance. The colour values at 40 cm distance were significantly less than those obtained at 20 cm distance as indicated by t-test. This difference could be attributed to the decreasing light intensity reaching the camera; at 20 cm distance the light intensity was more, so the images were brighter, whereas at 40 cm distance, less intensity of light was reflected by the product. This shows that the distance between the sample and the camera is important for colour measurement purposes.

Effect of distance between sample and source of illumination: The proximity of light source to the object is important to obtain good quality images because too less a distance might result in glare and too long a distance may result in unnatural and darker colour. Two distances were

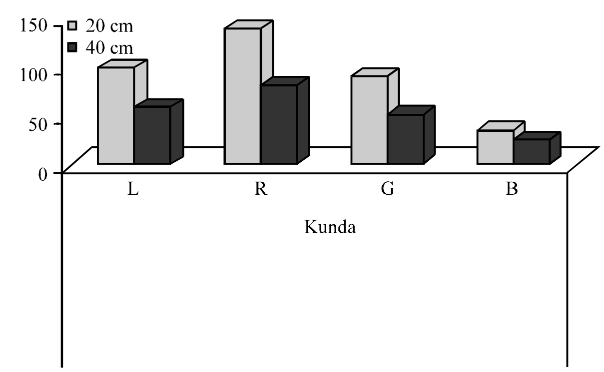

Fig. 6: Effect of distance between sample and camera on colour parameters of kunda in RGB mode.
Note: Significant parameters - L, R, G, B for Kunda at $p<0.05$

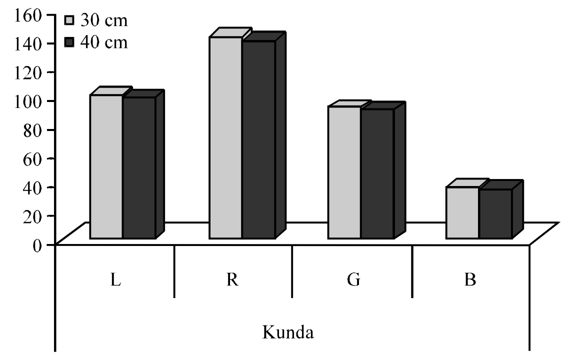

Fig. 7: Effect of distance between sample and source of illumination on colour values. Note: Significant parameters: R, for kunda at 5% level; No -Significant parameters: L, G, B for kunda at $p<0.05$

studied viz. 30 and 40 cm. There was no significant difference between the two data except for R values as indicated by t- test values (Fig. 7).

Overall results indicated that a distance of 30 or 40 cm between the sample and the light source did not matter much, however, longer distances might influence the colour parameters. Longer distances may have the disadvantage that the image may not actually resemble the original product because of insufficient light.

Effect of digital zoom: Digital zoom is a method of decreasing (narrowing) the apparent angle of view of a digital photographic image. Digital zoom is accomplished by cropping an image down to a centered area with the same aspect ratio as the original and usually also interpolating the result back up to the pixel dimensions of the original. It is accomplished electronically, without any adjustment of the camera's optics and no optical resolution is gained in the process and in this process may cause image quality degradation. Zooming option is used to capture an object from distance. This is also designed to capture desired portion of an object. So two options were studied viz. images captured with full zooming and images captured without zooming.

These colour values for kunda without zooming were significantly higher than those obtained for with zoom. There was significant difference between the two data for L and R value of the parameters as indicated by t- test values.

Significant difference between colour parameters may be because digital zoom is a technology where the camera shoots the photo and then crops and magnifies it to create an artificial close-up photo. This process requires magnifying or removing individual pixels which can cause image quality degradation. This shows that the option of zooming has significant effect for colour measurement purposes.

Thus, it was observed that the colour values, at 40 cm distance between sample and camera were significantly less than those obtained at 20 cm distance as indicated by t-test (Table 11). The results also indicated that distance of 30 or 40 cm between the sample and the light source did not matter much with 18 watt Compact Florescent Lights (CFL), however, longer distances might influence the colour parameters significantly. It was also observed that the option of zooming had significant effect for colour measurement purposes.

Table 11: Effect of digital zoom on colour values of kunda

Parameters	Zoom	Without zoom	t-value
L	98.85±3.86	100.24±2.02	3.09*
R	137.99±3.44	141.26±2.51	6.79*
G	89.97±2.20	91.26±2.23	2.02^{ns}
B	36.82±2.45	34.28±3.42	2.84^{ns}

Note: * Significant at $p<0.05$; ns: not Significant at $p>0.05$

CONCLUSION

It was concluded that, Scanner-Adobe Photoshop method can be used to measure colour of products like kunda in which natural colour variations occur because of several reasons. For all of the above variables studied, except type of container and colour of background, it was observed that variations in colour parameters attributed to natural batch to batch variations were more than the variations caused by scanner parameters. Therefore, measurement of colour values of kunda could be done at any of the scanner parameters but the sample background has to be specified and sample has to be taken in a specified container-glass petridish or cellophane or LDPE film.

It was also concluded that digital camera-Adobe Photoshop method can be used to measure colour of products like Kunda at specified variables like distance between sample and camera, sample and source of illumination etc.

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