Experimental CIEL*a*b* D50 colour and moisture analysis of fruits and vegetables stored in different conditions

[1]Hitesh Singh Waskale, [2]Mahesh Ganpat Bhong
[1,2]Department of Mechanical Engineering,
[1]Indira College of Engineering and Management, Pune,India

*Abstract- Harvested fruits and vegetables needs to be kept fresh until it reaches to consumer. The food supply chain has to maintain suitable storage condition so as to maintain the nutrition, vitamin and colour value of fruits and vegetables. This experiment aims to study the colour change and moisture reduction in fruits and vegetables during storage in freezer, crisper and expose to atmospheric condition. Botanically, vegetables used in experiment belong to solanaceae family and fruits used are classified as hesperidi um, fleshy and aggregate fruits. High definition photos of fruits and vegetables were taken and converted into CIE L*a*b* colour space using MATLAB 2015a V2.1 and reproducing the colour using CIE L*a*b* D50 colour appearance model in Adobe Photoshop Creative Studio 6 V13.0.1. The moisture loss for group of same classified category of fruits and vegetable family does not show any relation to each other but the trend in changing colour seems identical among them under respective storage condition.*

*IndexTerms - CIE L*a*b*,MATLAB,Fruits and vegetables storage.*

I. INTRODUCTION

Home storage is a good and cheap way to retain fruits and vegetables. When stored properly, their nutrition value and original flavor remain intact. Successful storage depends on maintaining suitable temperature and humidity, and care during the storage period [1]. As urbanization outspread, the demand of fresh and quality eatables also increases [2]. The fruits and vegetables we buy has to be kept in suitable storage condition to maintain its freshness. Different category of fruits and vegetables requires different storage temperature [3]. Moisture of eatables decreases as they are stored for longer period of time. The highest moisture contain observed in fruits and vegetables are 92% and 96% respectively which was high enough for faster habitat of bacteria during storage [4]. The moisture can be determined by wet basis or dry basis as per requirement [5]. Mostly wet basis were used to calculated the moisture contain of fruits and vegetables.

Measurement of colour in horticultural crops is reviewed by Francis [6]. The fresh produce industry uses produce-specific colour matching charts to assist in the grading and shelf-life assessment of many fruits. These charts are cheap and easy to use for training personnel. In larger pack houses, photoelectric techniques may be installed to sort out strongly coloured products at least in three grades [7]. For research purposes, colour is generally measured using a surface colour-difference meter or spectrophotometer (e.g. those manufactured by Minolta or Hunter) [8]. This type of instrument measures the characteristics of light reflected from the product surface. The output is processed to give a standard data based on a tristimulus system, for example, numbers for hue, Chroma and lightness, which together accurately describe the colour of the object [9]. The main limitation of this kind of spot colour measurement is the lack of uniformity in the procedure itself, for example an apple or mango may be a completely different colour on one side compared to the other.

This experiment undertake different approach to capture, encode colour detail and regenerating the average surface colour of fruits and vegetables which were stored in different storage condition. High definition photos were taken and converted to CIE L*a*b* colour value using MATLAB image processing tool. The generated CIE L*a*b* value are regenerated into visible colour model using Adobe Photoshop Creative Studio and the colour produced by stored fruits and vegetables were compared and analyzed.

II. EXPERIMENTAL SETUP

Three set of fruits and vegetables Set 1, Set 2 and Set 3 were kept in freezer, crisper and atmosphere respectively. Each set comprise of Capsicum, Jalapeno chili, Lemon, Sweet lime, Apple, Sapodilla, Tomato and Strawberry. The refrigerator used was Whirlpool (Corona Deluxe) Model WRCQ160K20 where the freezer and crisper temperature was maintain at -18 C and 10 C respectively. The average atmospheric temperature was 32.57 °C high and 14.28 °C low during the one week of trial [10].

Weight of each item of each set was measure using nfistock ISCALE-1 Electronic Digital Weighting Scale having accuracy resolution of 1 g, 0.1 oz. High definition micro photo of resolution 3264x2448 with 72 dpi of items was taken using Apple iPhone 5C having 8 megapixel Sony sensor 1/32 inch, 1.4 micron sensor pixels and f /2.4 lens[11]. Constant light intensity was maintain during photography. The high definition photo was imported to MATLAB 2015a V2.1 where CIE L*a*b* colour value was obtain by using image processing tool. The CIE L*a*b* colour value was reproduce in CIE L*a*b* D50 colour appearance model [12] in Adobe Photoshop Creative Studio 6 V13.0.1 [13]. Same test was repeated after frequency of 24 hours till next 6 days.

Table 1 Sample weight and CIE L*a*b* colour value

Sr. No.	Eatables	Set 1				Set 2				Set 3			
		Weight (g)	L*	a*	b*	Weight (g)	L*	a*	b*	Weight (g)	L*	a*	b*
1	**Tomato**	78	28.9	37.4	32.1	64	31.3	36.2	33.7	70	24.6	36.7	27

2	Capsicum	47	37.4	-25.1	40.3	54	31.1	-20.5	33.9	44	35.1	-21.9	33.7
3	Jalapeno chili	20	26.2	-12.8	25.1	21	26.9	-17.1	27.1	16	25.9	13.1	25.4
4	Sapodilla	59	17.5	9.8	13.7	56	30.3	6.5	16.2	35	30.4	5.6	15.6
5	Lemon	35	48.6	4.4	47.9	38	55.2	-3.3	52.6	31	50.2	-0.4	49.2
6	Apple	177	27.4	28	11.4	184	27.9	38.9	19.5	172	22	33.6	19.8
7	Strawberry	17	21.3	34.4	17.6	23	24	32	16	9	14.1	18.2	5.1
8	Sweet lime	184	52.1	11.7	56.7	128	52.9	4.8	55.7	115	56.7	5.2	59.4

Table 2 Sample weight and moisture percentage

| Time (hrs.)	Set1	Set 2	Set 3	Set1	Set 2	Set 3
	Weight (g)			Moisture (%)		
0	85	68	76	100	100	100
24	85	67	74	100	98.52941	97.36842
48	84	66	73	98.82353	97.05882	96.05263
72	83	65	72	97.64706	95.58824	94.73684
96	82	65	72	96.47059	95.58824	94.73684
120	82	65	72	96.47059	95.58824	94.73684
144	78	64	70	91.7647	94.1176	92.1052

III. RESULTS AND DISCUSSION

Capsicum and Jalapeno chilies belong to same family Solanaceae [14][15] of Plantae kingdom. Graph 1 and 2 shows the trend of moisture loss in Set 1, Set 2 and Set 3 when kept in freezer, crisper and open atmosphere for both items which resembles identical. The difference observed was the amount of moisture removed during experiment. For Capsicum, the average moisture loss per 24 hours in freezer, crisper and open atmosphere was 0.3472 %, 1.1494 % and 2.8301 % respectively. Whereas for Jalapeno chili, the average moisture loss per 24 hours in freezer, crisper and open atmosphere was 0.8334 %, 2.6667 % and 6.7901 % respectively. The moisture loss was more in Jalapeno chili as compared to Capsicum for same storage time.

The colour change observed for Capsicum and Jalapeno chili in Fig. 1 and 2 seems to be shifting from lighter colour shade to nearly same for Set 1, darker for Set 2 and darkest for Set 3. This indicates that storing Solanaceae family vegetables in freezer result in colour conservation whereas those kept in crisper and atmosphere shows more colour variation. The reason could be maturation of Solanaceae family vegetables. Both Capsicum and Jalapeno chili have natural tendency to become mature which means there colour shifts from green to yellow and to darker shades. The result shows that Jalapeno chili get fast mature when store in open atmosphere as compare to those stored in freezer. Therefore storing Solanaceae family vegetables (which have natural tendency to become mature) in freezer, will maintain its natural colour value and decrease the rate of maturation.

Lemon and Sweet lime both belong to Hesperidium [16][17]group of fruits classification. Graph 3 and 4 shows the trend of moisture loss in Set 1, Set 2 and Set 3 when kept in freezer, crisper and atmosphere for both items which resemble identical. The difference observed was the amount of moisture removed during experiment. For Lemon, the average moisture loss per 24 hours in freezer, crisper and open atmosphere was 0.4629 %, 0.8334 % and 3.75 % respectively. Whereas for Sweet lime, the average moisture loss per 24 hours in freezer, crisper and open atmosphere was 0.09 %, 0.7462 % and 1.574 % respectively. The moisture loss was more in Lemon as compare to Sweet lime for same storage time. This could be because Sweet lime has hard peel covering as compared to Lemon.
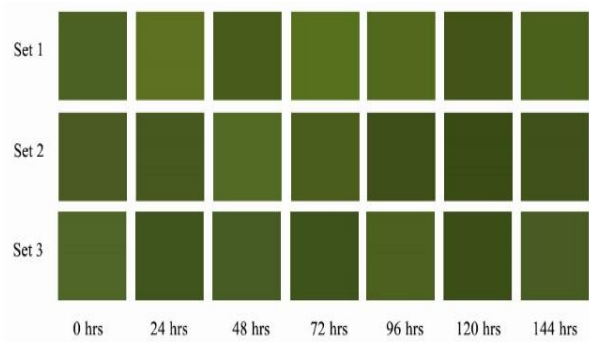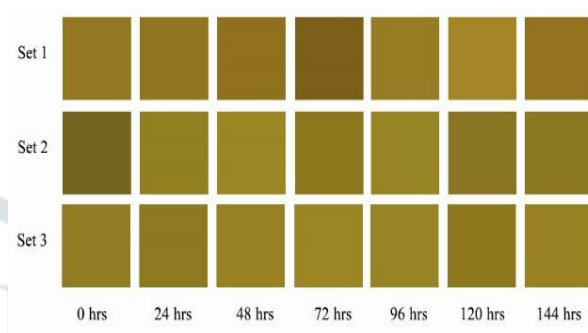
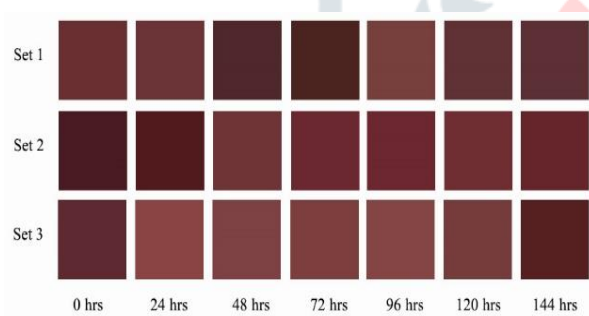**Figure 1** CIE L*a*b* D50 colour variation for Capsicum during storage
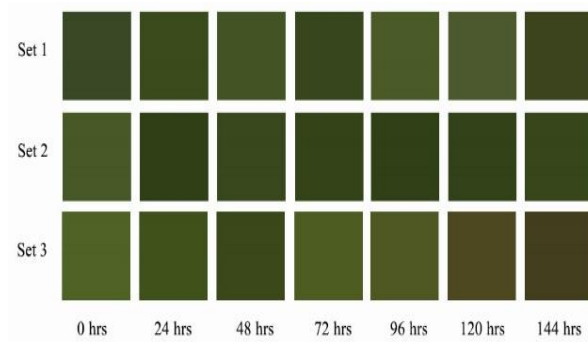
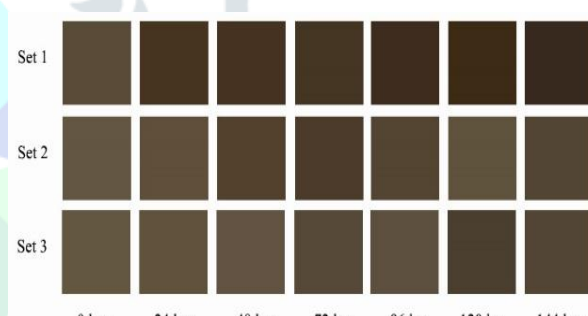**Figure 2** CIE L*a*b* D50 colour variation for Jalapeno chili during storage
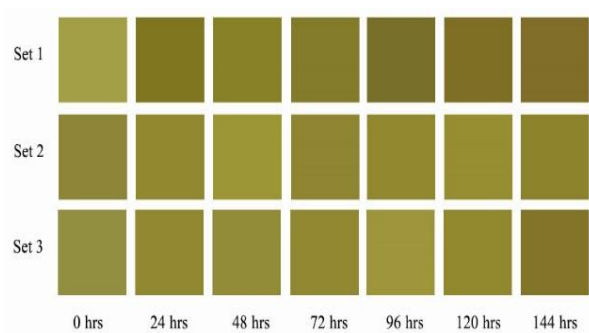
Figure 3 CIE L*a*b* D50 colour variation for Lemon during storage
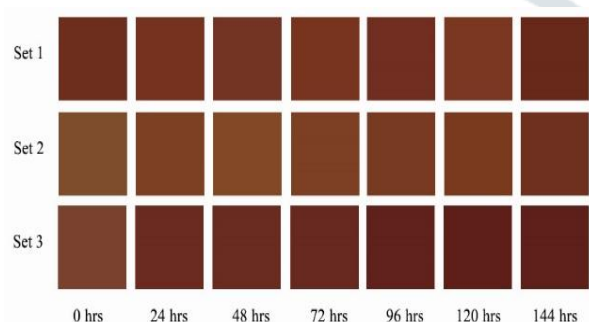

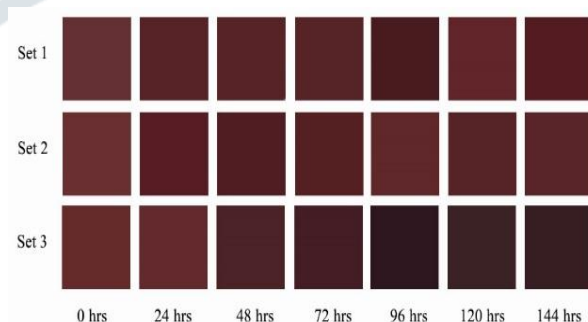**Figure 4** CIE L*a*b* D50 colour variation for Sweet lime during storage

Figure 5 CIE L*a*b* D50 colour variation for Apple during storage

**Figure 6** CIE L*a*b* D50 colour variation for Sapodilla during storage

Figure 7 CIE L*a*b* D50 colour variation for Tomato during storage



**Figure 8** CIE L*a*b* D50 colour variation for Strawberry during storage

Hesperidium fruits contain a high amount of citric acid. They have natural tendency of deterioration. Storing them visibly result in darker colour value shift as seen in Fig. 3 and 4. Both Lemon and Sweet lime shows darker value of colour when kept under different condition. The Set 1 colour shifted from light to much darker colour value as compare to Set 2 and Set 3. This indicated that storing Hesperidium fruits in freezer maintain its nature level of moisture but the rate of deterioration increases. Hence storing Hesperidium fruits in open atmosphere or in crisper results in maintaining its freshness.
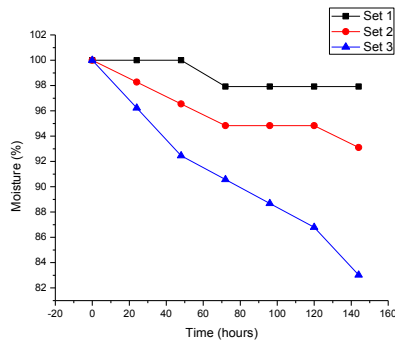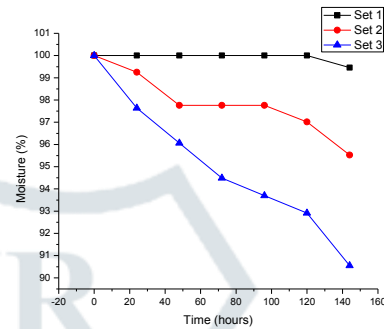
Graph 1 Rate of change of moisture in Capsicum during storage period
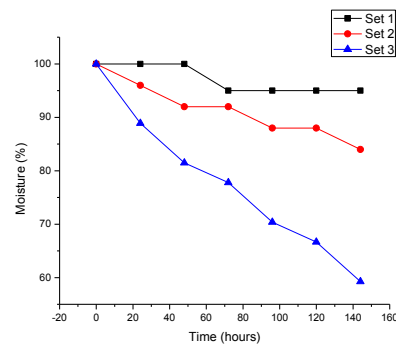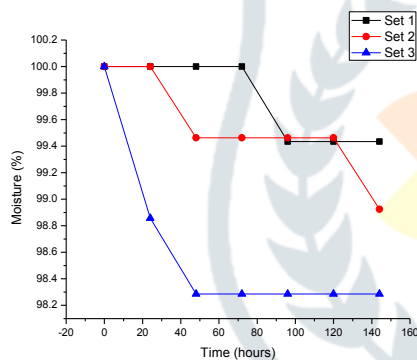

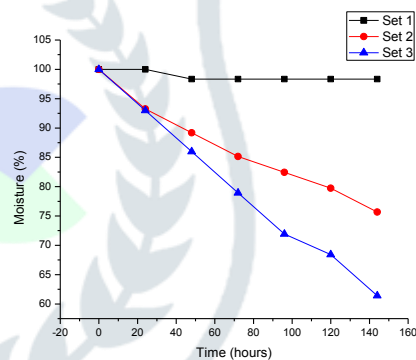**Graph 2** Rate of change of moisture in Jalapeno chili during storage period
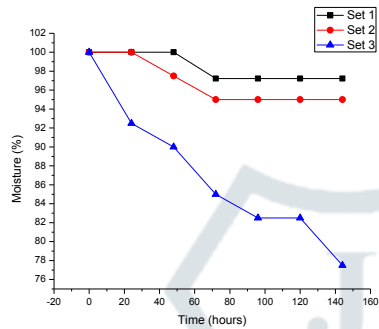
Graph 3 Rate of change of moisture in Lemon during storage period
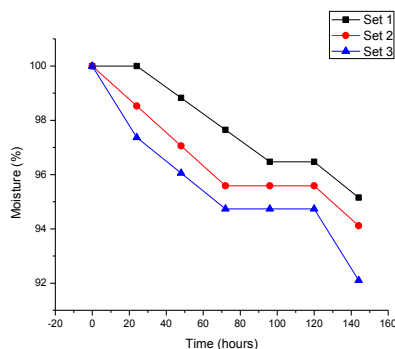

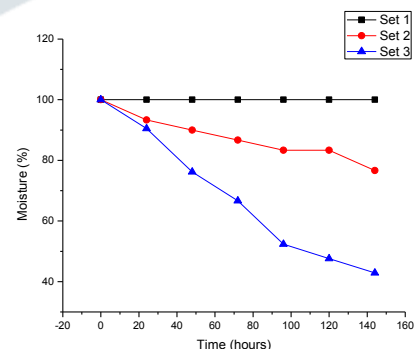**Graph 4** Rate of change of moisture in Sweet lime during storage period

Graph 5 Rate of change of moisture in Apple during storage period

Graph 6 Rate of change of moisture in Sapodilla during storage period

Graph 7 Rate of change of moisture in Tomato during storage period

Graph 8 Rate of change of moisture in Strawberry during storage period

Apple, Sapodilla and Tomato belongs to fleshy fruits [18]group of fruits classification; under Pome [19], Drupe [20] and Bacca [21] subclassification respectively. The average moisture loss per 24 hours observed in Graph 5 for Apple stored in freezer, crisper and open atmosphere was 0.0941 %, 0.1792 % and 0.2857 % respectively. This is because Apple has natural moisture loss protection outer cover. Whereas Sapodilla and Tomato have thin outer layer for moisture loss protection as compare to Apple and losses moisture more rapidly as seen in Graph 6 and 7 respectively where the average moisture loss per 24 hours for Sapodilla was 0.2778 %, 4.054 % and 6.4327 % and for Tomato it was 1.3725 %, 0.9803 % and 1.3157 % when they are kept in freezer, crisper and open atmosphere respectively. Sapodilla shows

less moisture loss when kept in freezer but Tomato shows high moisture loss rate when kept in freezer. The moisture loss for Sapodilla was high when kept in crisper and open atmosphere as compare to Tomato.

Apple even though having good moisture lock layer, its shows colour value shift during storage. Fig 5 shows that the Apple kept in crisper shows colour value shift from dark to lighter shades. Whereas Apple kept in open atmosphere shows colour value shift from lighter to darker shades. Apple which was placed in freezer maintained its natural colour shade even after one week. Sapodilla and Tomato kept in all there storage condition harvested same result as seen in Fig. 6 and 7. There colour value shift from lighter to darker shades. This indicates that Apple maintain its moisture and colour value when kept in freezer whereas Sapodilla losses its moisture faster in crisper and open atmosphere and colour value shifted to darker shades rapidly as compared to other storage condition. Contradict to Sapodilla, Tomato shows higher colour value shift to dark when kept in open atmosphere.

Strawberry belongs to Aggregate fruits [22] [23]group of fruits classification. Its contain 92 % of moisture. During storage, Strawberry undergoes decay process rapidly. From Graph 8, we observed that Strawberry kept in freezer maintain its natural moisture with average moisture loss per 24 hours of 0 %. Whereas Strawberry kept in crisper and open atmosphere showed rapid change in moisture percentage. The average moisture loss per 24 hours per for Strawberry kept in crisper and open atmosphere was about 3.8889 % and 9.5238 %.From Fig. 8, Strawberry stored in freezer showed colour value shift from lighter to dark for Set 1, darker for Set 2 and darkest for Set 3. This indicates that Strawberry stored in open atmosphere decay fast as compare to those stored in crisper and freezer.

IV. CONCLUSION

Capturing fruits and vegetables photo with high definition photography device and calculating itspixel's average CIE L* a* b* value in MATLAB and reproducing the same colour value in CIE L* a* b* D50 colour appearance model in Adobe Photoshop Creative Studios; holds true and realistic.High moisture loss was observed when fruits and vegetables were stored in open atmosphere whereas low moisture loss was observed when kept in crisper and lowest in freezer. Storing fruits and vegetables in freezer though help to prevent moisture loss but change in colour value still visually remarkable. Vegetables belong to Solanaceae family which have natural tendency of getting mature shows less maturation via colour observation when kept in freezer as compare to those stored in crisper and open atmosphere. Storing Hesperidium fruits in freezer helps to maintain its natural moisture but rate of deterioration increases. Hence they should be stored in open atmosphere or in crisper. Fleshy fruits shows random colour change behavior based on the subclassification. Pome fruits maintain its natural colour value and moisture level when kept in freezer. Whereas Drupe and Bacca fruits losses there moisture and colour value regardless of storage condition. Aggregate fruits showed higher moisture loss rate and high decay rate when stored in open atmosphere as compare to those which were stored in crisper and freezer. The amount of moisture loss for group of same classification and family of fruits and vegetables were random but the colour change value seem identical during storage in different conditions.

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