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Studies on colour kinetics and textural characteristics of sugar and jaggery based papaya leather

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Experimental studies were conducted to investigate the effect of various sweetener and citric acid levels on colour kinetics and textural characteristics of fresh as well as stored papaya leather. The levels of sweeteners were used as sugar, $sugar_{75}$+$jaggery_{25}$, $sugar_{50}$+$jaggery_{50}$, $sugar_{25}$+$jaggery_{75}$ and jaggery with citric acid levels as 0.5 per cent, 0.75 per cent and 1.0 per cent. Developed papaya leather samples were evaluated for coulour kinetics and textural characteristics. Study revealed that brightness (L), redness (a) and yellowness (b) values deceased with increase in citric acid level in each treatment of sweeteners but these values increased during storage period with increase of citric acid level. Data showed that colour change value decreased with increase of citric acid level in samples using sugar as a sweetener. The chroma value decreased with increase of citric acid in all sweeteners. The hue angle increased with increase of citric acid level in papaya leather samples using $sugar_{50}$+$jaggery_{50}$, $sugar_{25}$+$jaggery_{75}$ and jaggery as sweetener. The textural characteristics *viz.*, hardness, cohesiveness, adhesiveness and springiness were obtained lowest as 32.7g, 2.58, 68.71gs and 2.74mm, respectively among the treatments of sweeteners whereas the gumminess and chewiness values were found highest in papaya leather sample using jaggery as a sweetener with 0.5 per cent citric acid level.

Key Words : Papaya leather, Sweetener, Citric acid, Colour kinetics, Textural

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INTRODUCTION

India is the world's largest producer of papaya. During the year 2016-17, India's papaya production was 59.40 lakh metric tonnes (National Horticulture Board, 2017). The papaya can be stored at temperature as low as 7^0C during colour turning stage and might be ripen normally (Thompson and Lee, 1971). Chan *et al.* (1979) observed several changes with in the papaya during its development. Papain concentration in papaya flesh decreased with repining. An and Paull, 1990 obtained the optimum temperature for fruit repining in between 22.5 and 27.5^0C to reach full skin yellowing from the colour brake stage during 10-18 days. Papaya is a rich source of vitamin A (2020 IU per 100g) and sufficient vitamin C (40mg/100g), Bose and Mitra (1996). Pawpaw leather was significantly higher than guava leather in colorific content, water activity, pH and total mold count through the storage period (Babalola *et at.*, 2002). Fruit leathers are restructured fruit made from fresh fruit pulp or a mixture of fruit juice concentrates and other ingredients after a complex operation that involves a dehydration step (Huang and Hsieh, 2005). Plain and spiced tomato

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leathers were prepared using 2 per cent corn flour, acetic acid and 0.7 per cent salt. Leathers were stored well without any deterioration upto three months of storage (Jayalakhsmi and Karthiga, 2009). Fruit leathers are often considered as a health food and health food marketing images such as 'Pure', 'Sundried' or 'Rich' in vitamins are used to describe them (Vatthanakul *et al.*, 2010). Hunter colour parameter (L,a,b) of grape juice during brilling, cooking and of pestil samples (1.53 mm) during drying were investigated and colour changes occurred during hot air or sun drying (Keya *et al.*, 2002). Saxena *et al*. (2012) evaluated the kinetics of colour and carotenoids degradation in jack fruit bulb slices during hot air drying at 50, 60 and 70^{0}C. Visual colour as well as total carotenoids content was found to be influenced by the drying process. The combination of hunter L x b value was found to be represent the colour change adequately. Relationship of total carotenoids content and hunter Lx b value was found to be more consistent through regression analysis with $R^2 \geq 0.979$. Pathare *et al.* (2013) reviewed colour kinetics of various fruits. Colour measurements of food products have been used as an indirect measure of other quality attributes such as flavour and contents of pigments. Different approaches applied to model food colour including reaction mechanisms, response surface methodology and probabilistic and non-isothermal kinetics. Tang *et al.* (1995) studied the effect of pH on the properties of gels prepared with whey protein concentrate by compression in an instron and evaluated hardness, cohesiveness and springiness from double compression curve. They concluded that modulus of elasticity correlated quite well with Ahmad *et al*. (2005) evaluated textural analysis of papaya and tomato fruit bar. Texture study revealed that hydrocolloids incorporation at 1% each of starch + ethyl cellulose and pectin of + starch, 1.5% each caused significant ($P<0.05$) increased in compactness / hardness of texture. Addition of 0.5 and 1% of each starch + ethyl cellulose were effective in maintaining the colour while 0.5, 1 and 1.5% of each pectin + starch was effective in improving the texture during four month storage. Muntoz *et al*. (2007) evaluated the sensory texture attributes of firmness, elasticity and type of breakdown of gelatin. Estimates of sensory firmness by shearing were highly correlated with each other and with mechanical shear and compression force. Manual compression correlated only with surface rupture force while oral compression correlated only with shear maximum force. Shafi *et al.* (2013) analysis the extensibility of roselle - based fruit leather. According to half normal plot analysed, the result shows the xamthan gum, maltodextrin and locust been gum significantly contributed towards the extensibility of fruit leather with value of 56.0 per cent, 19.5 per cent and 5.6 per cent, respectively. Kumar *et al*. (2015) investigated the effect of sugar and jaggery on the quality characteristics of papaya leather. The quality parameters were performed for fresh as well as stored papaya leather for 60 days of storage under room temperature. The maximum overall acceptability score for papaya leather prepared with sugar and jaggery ratio sample T_1 (Papaya pulp + sugar 650g)7.1 in glass jar and the minimum score T_1 6.8 in PET jar at room temperature. Singh *et al*. (2015) conducted experiments to develop and evaluate the quality of jaggery based papaya leather. The organoleptic score of the leather sample in glass jars at 0.75 per cent citric acid level was found to be higher followed by samples packed in PET jars. Kumar *et al.* (2017) conducted study on physico-chemical and sensory attributes of papaya and guava fruit bar 50 per cent papaya pulp and 50 per cent guava pulp (T_4) treatment recorded as best blending ratio with overall acceptability (8.67) as maximum sensory score. Patil *et al*. (2017) evaluated the textural and sensory quality of date mango leather. The sensory level ranked the best product at 1 per cent level of pectin and carboxy methyl cellusoe with respect to colour, flavour, texure and overall acceptability. The results revealed that hardness and gumminess increased with addition of hydrocolloids. Kumar and Shukla (2018) evaluated qualitative attributes of papaya leather sample prepared by sugar as a sweetener exhibited highest over all sensory scores of 7.64 and 7.60 for the sample packed in HDPE and LDPE, respectively after 90 days of storage. The yeast and mould counts and total plate count were found safe for consumption after 90 days of storage at ambient temperature.

Therefore, the study was undertaken to evaluate colour kinetic and textural characteristics of sugar and jaggery based papaya leather.

METHODOLOGY

Ripened papaya was washed with fresh water, peeled, deseeded and rined. Pulping was carried out by electric juicer. Papaya leather was prepared by adopting the procedure reported by Srivastava and Kumar (1994).

Sugar and citric acid (0.5%) were mixed with the juice and boiling was done with continuous stirring for 5 minute, after that smearing stainless steel trays with mustered oil and mixture is poured into it. The trays were than placed in the hot air oven for drying at 50^0C with adoption of layering procedure. After 48 hours, the trays were taken out from oven, cooled and leather was cut into rectangular shape (3.5*3.5*0.5 cm) and packed into LDPE and HDPE at room temperature. The process is again done for the preparation of papaya leather using sugar as a sweetener with 0.75 per cent and 1.0 per cent citric acid level, respectively. The same process repeated for preparation of papaya leather using $sugar_{75}$+$jaggery_{25}$, $sugar_{50}$+$jaggery_{50}$, $sugar_{25}$+ $jaggery_{75}$ and jaggery as a sweeteners with 0.5 %, 0.75% and 1% citric and level, respectively.

Hunter lab (mini scan XE-plus, model 45/O-L) was used to measure the colour parameters (L,a,b) of fresh and stored papaya leather. During the storage period, colour values were taken at the fresh and after 90 days interval as that of the weight measurement. Under colour kinetics total colour change (ΔE), chroma (which indicates colour seturation) and hue angle (which is frequently used to specify colour in food products) were derived from colour scale (L,a,b) using following eq.

$$\Delta E = \sqrt{\left[(L_0 - L_t)^2\right] + (a_0 - a_t)^2 + (b_0 - b_t)^2}$$

where,

L_0, a_0 and b_0 are the initial colour measurements of fresh papaya leather samples and L_t, a_t and b_t are the colour measurements at the prescribed time.

$$\text{Chroma} = \sqrt{a_t^2 + b_t^2}$$

$$\text{Hue angle} = \tan^{-1}(b_t / a_t)$$

Textural characteristics *viz.*, fracturability, hardness, cohesiveness, adhesiveness, springiness, gumminess and chewiness were measured as per Bourne (1978) by texture analyser (stable micro system, TA-XT-plus model) by forcing a probe on the sample until it breaks completely. Force versus time graphs were obtained on data acquisition software (Texture expert exceed[tm]).

OBSERVATIONS AND ASSESSMENT

The study was undertaken to evaluate colour kinetics and textural characteristics of sugar and jaggery based papaya leather. The citric acid levels of 0.5 %, 0.75% and 1.0% were used for sugar, $sugar_{75}$+$jaggery_{25}$, $sugar_{50}$+$jaggery_{50}$, $sugar_{25}$+$jaggery_{75}$ and jaggery as a sweeteners. Changes in the colour of papaya leather samples were monitored by measuring 'L' (lightness),

Table 1: Variation in total colour change, chroma and hue angle value in papaya leather samples using different sweeteners and citric acid levels

Papaya leathers treatments	Total colour change (Δ E)	Chroma	Hue angle (deg)
T_1	2.1748	15.9112	54.82
T_2	2.1654	13.9061	52.85
T_3	1.7456	10.8334	50.42
T_4	1.7496	6.2543	56.13
T_5	1.5138	5.3673	60.94
T_6	1.7541	4.7147	60.67
T_7	1.8041	7.2694	44.42
T_8	1.7224	6.8627	46.93
T_9	1.8070	5.2100	53.26
T_{10}	1.7428	6.1061	39.69
T_{11}	1.8070	4.8734	40.36
T_{12}	1.8387	4.0589	44.71
T_{13}	1.7220	6.0469	43.83
T_{14}	1.8305	4.8883	46.66
T_{15}	1.9076	3.9965	51.11

T_1, T_2, T_3 = 100% sugar based Papaya leather with 0.5, 0.75 and 1.0% Citric acid, respectively
T_4, T_5, T_6 = 75% sugar + 25% jaggery based Papaya leather 0.5, 0.75 and 1.0% Citric acid, respectively
T_7, T_8, T_9 = 50% sugar + 50% jaggery based Papaya leather 0.5, 0.75 and 1.0% Citric acid, respectively
T_{10}, T_{11}, T_{12} = 25% sugar + 75% jaggery based Papaya leather 0.5, 0.75 and 1.0% Citric acid, respectively
T_{13}, T_{14}, T_{15} = 100% jaggery based Papaya leather 0.5, 0.75 and 1.0% Citric acid, respectively

'a' (redness) and 'b' (yellowness) using hunter lab. L,a,b values were obtained for the fresh and after 90 days storage period. The data revealed that L value decreased with increase in concentration of citric acid in each treatment of sweeteners and L value increased during storage period with increase of concentration of citric

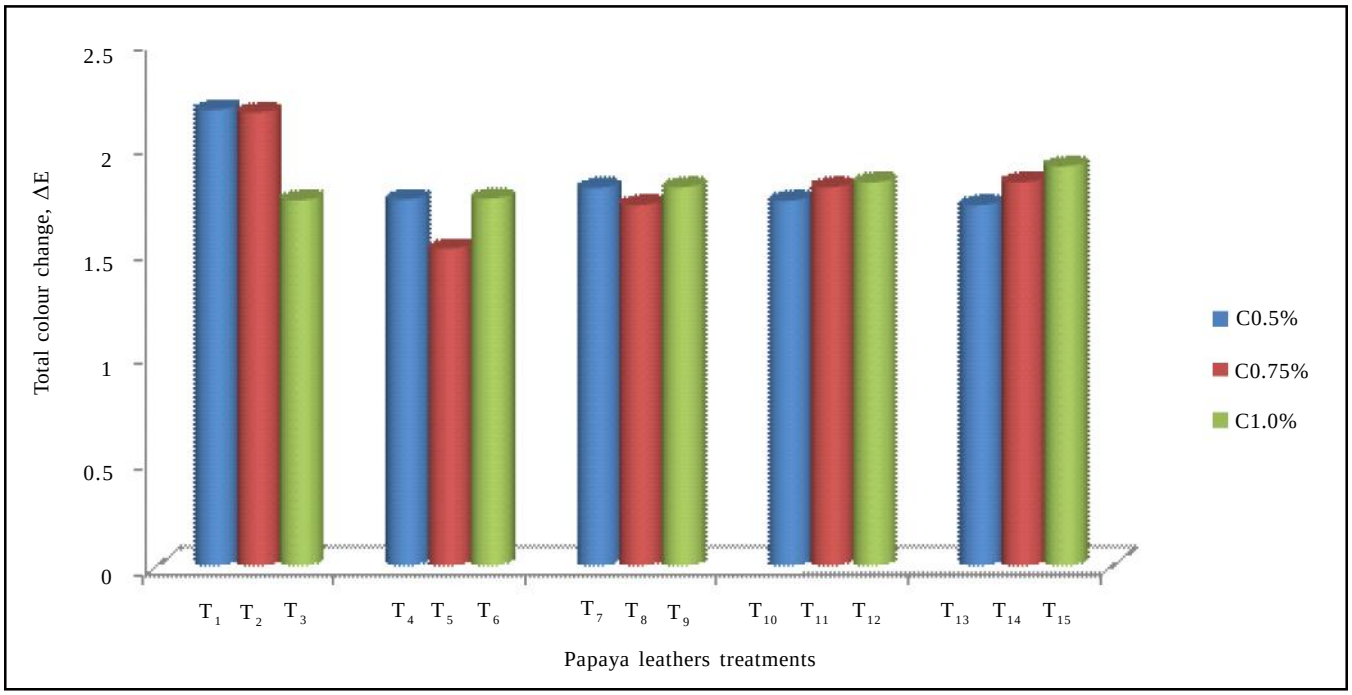

Fig. 1 : Effect on total colour change of sugar and jaggery based papaya leather at different citric acid levels

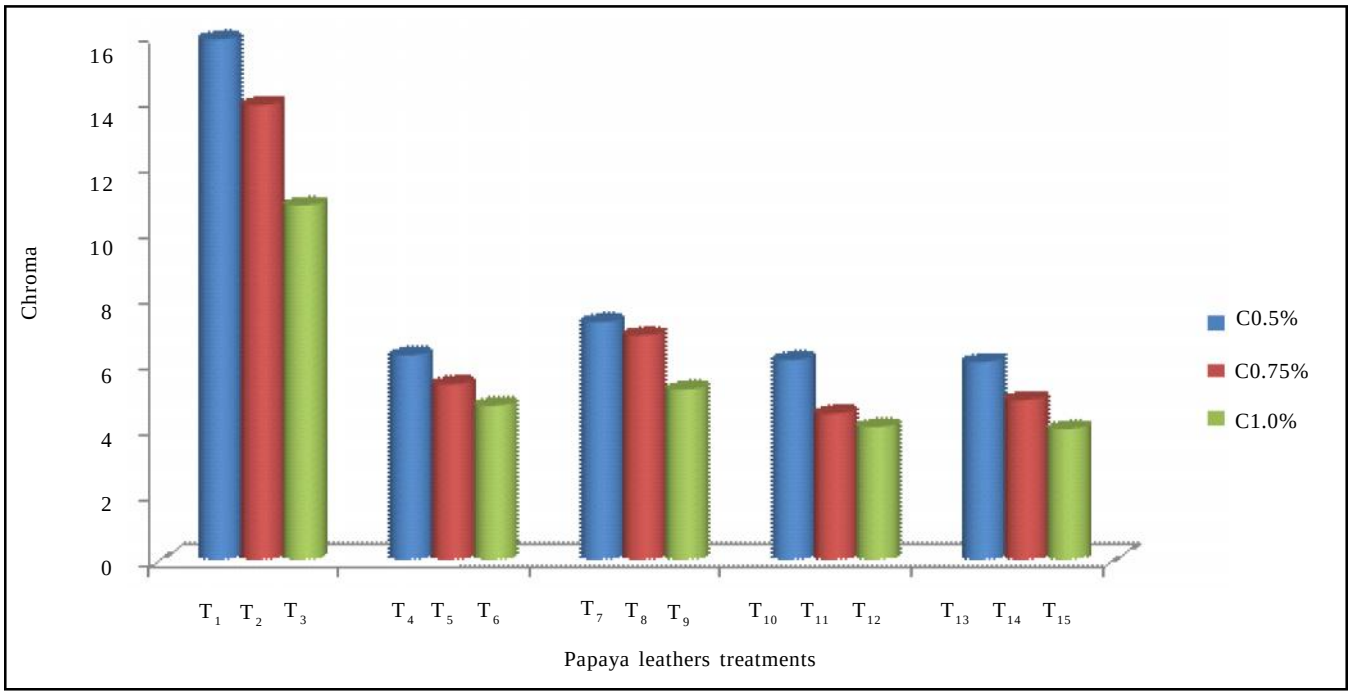

Fig. 2 : Effect on chroma of sugar and jaggery based papaya leather at different citric acid levels

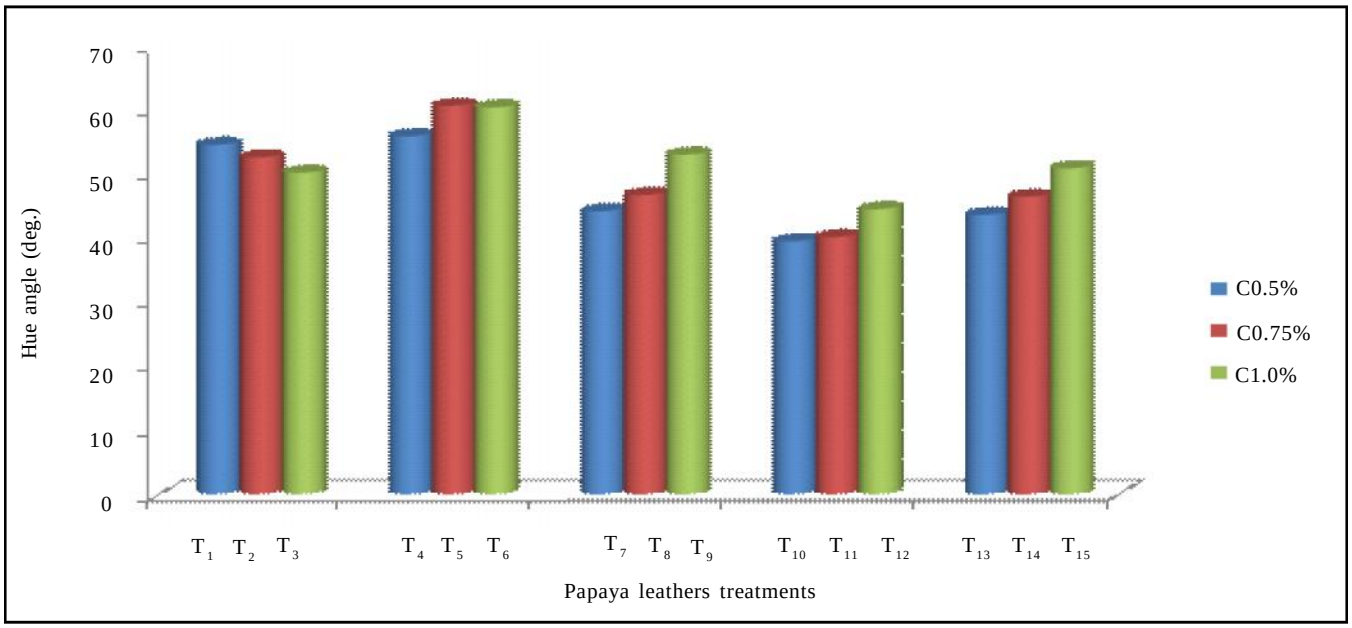

Fig. 3 : Effect on Hue angle of sugar and jaggery based papaya leather at different citric acid levels

acid in each treatment of sweetener. Higher value (22.70) of L obtained in sample of sugar as a sweetener at 0.5 % citric acid level whereas lowest value (12.93) of L was found in sample of jaggery as a sweetener of 1.0% of citric acid level in fresh papaya leather. 'a' value also decrease with increase in percentage of citric acid level in each treatment of sweetener which indicate loss of redness of the sample. During storage period, there was a slight increase in the 'a' value. This may due to loss of chlorophyll pigment on exposure of light since papaya leather samples were packed in LDPE and HDPE. 'b' value also decrease with increase in concentration of citric acid level in each sweetener treatment which implies that there was decrease in the yellowness of papaya leather sample. The yellowness ranges between 2.85 to 13.01 during 90 days of storage period.

Table 2 : Textural properties of papaya leather using different sweeteners and citric acid levels

Papaya leathers treatments	Hardness (g)	Cohesiveness (A2/A1)	Adhesiveness (g.s)	Springiness (mm)	Gumminess (g)	Chewiness (g.mm)
T_1	68.0	2.56	66.71	5.46	174.08	950.48
T_2	108.2	1.26	78.04	4.28	136.33	583.49
T_3	32.7	1.04	31.47	2.74	34.01	93.19
T_4	506.0	0.88	442.15	4.74	445.28	2110.63
T_5	216.3	1.92	191.75	3.35	415.30	1391.26
T_6	329.1	1.56	234.26	5.75	573.40	2952.05
T_7	873.3	0.91	429.76	4.08	794.70	3242.38
T_8	285.5	2.26	194.39	3.62	645.23	2335.73
T_9	191.2	2.58	155.62	7.02	493.30	3462.97
T_{10}	1285.8	1.70	461.18	4.14	2185.86	9049.46
T_{11}	945.1	2.47	567.10	5.21	2334.40	12162.22
T_{12}	332.8	1.68	210.52	3.98	559.10	2225.22
T_{13}	11260.0	2.05	556.19	3.32	23083.00	76635.56
T_{14}	1096.8	1.67	469.32	3.71	1831.66	6795.46
T_{15}	773.6	1.47	542.71	3.06	1137.19	3479.80

The study revealed that variation in colour change, chroma and hue angle obtained from L, a, b value are shown in Table 1, The bar charts for colour change, chroma and hue angle value for all treatment are shown in Fig. 1 to 3. It can be inferred from Table 1 that colour change varies between 1.5138 to 2.1748 and all treatment of sweeteners and citric acid levels. There was a slight loss in all samples during storage period. Colour change value decreased with increase of citric acid level in papaya leather sample using sugar as a sweeteners whereas colour change value increased in citric acid level in papaya leather samples using $sugar_{25}$+$jaggery_{75}$ and jaggery as a sweetener which indicates more colour loss at higher concentration of citric acid. The maximum chroma value (15.9112) was observed in papaya leather sample of sugar as a sweetener at 0.5 per cent citric acid level whereas minimum chroma value (3.9965) was obtained in papaya leather sample of jaggery as a sweetener at 1 per cent citric acid level. The colour of food product can be specified by observing the range in which the hue angle of that particular food lies. It is evident from bar chart that hue angle varies between 40.36 to 54.82^0. The hue angle increased with increase of citric acid level in papaya leather samples using $sugar_{50}$+$jaggery_{50}$, $sugar_{25}$+ $jaggery_{75}$ and jaggery as a sweeteners which have hue angle reduction 8.84^0, 5.02^0 and 7.28^0, respectively.

Texture profile curves were generated by texture analyzer for papaya leather samples using different sweeteners and citric acid levels. Textural characteristics *viz.*, hardness, cohesiveness, adhesiveness, springiness, gumminess and chewiness were evaluated by analysis of texture profile curves of papaya leathers samples are shown in Table 2. The fracturability is not shown in any texture profile curves of papaya leather samples. Hardness was highest (11260g) for papaya leather sample using jaggery as a sweeteners with 0.5 per cent citric acid level (T_{13}) whereas papaya leather samples using sugar as a sweetener with 1.0 per cent citric acid level (T_3) was least hard (32.7g). Cohesiveness was maximum (2.58) of papaya leather sample using $sugar_{50}$+$jaggery_{50}$ as a sweetener with 1.0 per cent citric acid level (T_9) followed by papaya leather sample using sugar as a sweetener 0.5 per cent citric acid level (T_1). The cohesiveness varies between 0.88 to 2.58. Adhesiveness was highest (567.10 g.s.) for papaya leather sample using $sugar_{25}$+$jaggery_{75}$ as a sweetener with 0.75 per cent citric acid level (T_{11}) whereas papaya leather sample using sugar as a sweetener with 0.5 per cent citric acid level (T_1) shown lowest adhesiveness (66.71 g.s.). Springiness (elasticity) was highest (7.02 mm) for papaya leather sample using $sugar_{50}$+$jaggery_{50}$ as a sweetener with 1.0 per cent citric acid level (T_9) and the lowest (2.74 mm) for papaya leather sample using sugar as a sweetener with 1.0 per cent citric acid level (T_3). Gumminess and chewiness were reported highest for papaya leather sample using jaggery as a sweetener with 0.5 per cent citric acid level (T_{13}) whereas lowest value shown (34.01g and 93.19g mm), respectively for papaya leather sample using sugar as sweetener with 1 per cent citric acid level (T_3).

Conclusion:

Effect of sugar and jaggery based papaya leather using different citric acid levels on colour kinetics and textural characteristics was found acceptable upto 90 days storage period. Hunter lab colour value brightness (L), redness (a) and yellowness (b) decreased with increase in citric acid level but increased during storage period at same citric acid level. Colour change value decreased with increase of citric acid level in sample using sugar as a sweetener which indicate less colour loss. The chroma value decreased with increase in concentration of citric acid whereas the hue angle increased with increase of citric and level in papaya leather sample except sample using sugar sweetener. Papaya leather sample using sugar as a sweetener with 1.0 per cent citric acid level found most soft texture whereas papaya leather samples using jaggery as a sweetener with 0.5 per cent citric acid level found most hard texture. Papaya leather samples prepared by sugar as a sweetener exhibited the highest overall sensory scores and products were under safe limit even after 90 days of ambient storage.

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