Influence on Color Attributes of Freshly Brewed Tea with Time due to Variations in Temperature Conditions

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ABSTRACT
The effects of time and temperature over the color of freshly brewed Indian tea liquor using spectrophotometer were evaluated. The study suggests that after brewing, the tea samples undergo a color change which was measured in CIE L*a*b* color model. To find out the temperature effects, the experiment was done under two conditions i.e. normal cooling and imposed cooling of the sample to room temperature immediately after brewing. Change in the color was found less prominent in the latter case and it is concluded that the color changes rapidly after brewing and can pose difficulty in quality assessment of tea samples by tea tasters during visual inspection, if time and temperature are not taken into account.

Keywords
Brewed tea liquor, Time, Temperature, CIE L*a*b* color model, Tea quality

1. INTRODUCTION
Tea is the most widely consumed beverage throughout the world and India is among the top manufacturers of high quality black CTC tea. The color and brightness are the critical quality attributes which are useful for fixing rank and price during tea trading [1, 2]. Black tea is fermented tea and during fermentation an enzymatic oxidation of tea polyphenols, especially tea catechins takes place which lead to formation of color generating compounds such as Theaflavins(TFs) and thearubigins(TRs). Usually, black tea liquor color attributes determined by colorimetric methods does not always corresponds to the tea tasters evaluations and rankings. These observations have led to the suspicion about the contributions of the physical parameters with respect to other standard laboratory methods involving chemical analysis. Although, attempts have been made to explain the correlations between black tea color and chemical compounds imparting color such as TFs and TRs [3]. Therefore, color is an important attribute in determining black tea quality which is directly related to the TF by TR ratio [4, 5, 6]. During the assessment of tea quality, tea tasters observe the appearance of both dry tea leaves along with infused tea liquor. The experimentation was based upon the measurement of color of the freshly brewed tea liquor made by standard method. The changes were observed in liquor color and brightness, measured by spectrophotometric method by considering variations in time and temperature. This study also explains the probable differences between the tea taster's results and spectrophotometric approach. Attempts were made to explain the difference in color of the freshly brewed tea with time, difficult for humans to detect through their naked eyes. The changes in CIE L*a*b* color values with time might be related to the oxidation of tea catechins and degradation of chlorophyll. Literature also suggest change in color for green and black tea but no further explanation was given to minimize this change [7, 8]. The final conclusions were based upon authors observations that if the freshly made brewed tea liquor is immediately cooled down to room temperature, degradation in color will be less prominent.

2. MATERIALS AND METHODS
Indian black tea samples of Cut-Twist-Curl (CTC) variety were bought from the tea manufacturers across north-eastern India. All the tea samples used for present work were manufactured in April 2011 harvest season. The tea samples obtained were having mechanical grading of Broken Pekoe (BP). These samples were stored in the vacuum bottles under laboratory environment to avoid any deterioration of quality.

2.1 Sample Preparation
The tea samples were prepared into liquor very carefully and according to the Indian standards. The procedure for conversion of tea grains into liquor followed measurement of 0.500 grams of each tea sample using semi-microbalance (Shimadju Corporation, Japan) upto an accuracy of ± 2 % of the mass to be measured, brew it into 25 ml of fresh boiling distilled water for 6 minutes, and then filtered using general purpose filter paper into the sampler. The preparation of tea samples was done carefully and each sample was made in duplicate.

2.2 Measurement of Color using Spectrophotometer
The measurement of brewed tea liquor color was carried out on the spectrophotometer (CM-3600d, supplied by Konica Minolta). The white calibration plate (Model-11076125, supplied by Konica Minolta) was used as background. The temperature of the samples was kept under scanner using non-invasive IR thermometer (Fluke). The CIE L*a*b* color model was selected for measurements of the liquor color. The L* value for any substance is an indicator of lightness if high or darkness if low. The a* value represents redness when positive and it is indicator of greenness when negative. The b* value is an indicator of yellowness when positive and blueness when negative. The L*, a* and b* values for each sample were saved to the database.

2.3 Calculation of Change in Color with Time

In order to understand the effect of time on infused color of the tea samples, the color of each tea sample was measured at the delay of 30 seconds time interval up to 5 minutes duration. The CIE L*, a* and b* of brewed tea liquor were found positive for the CTC tea samples as the infused liquor has characteristics of redness and yellowness with high lightness. The color values in terms of L*, a* and b* were calculated in duplicate at each time interval for each tea sample.

2.4 Calculation of Change in Color with Temperature

To investigate the effect of temperature on the color of infused tea liquor, spectrophotometric measurement was done over the tea samples. After brewing each tea sample was divided into two quotients which were observed under two different temperature conditions. The first quotient of the infused tea liquor was measured by normal cooling of tea sample from 70 degree Celsius i.e. the brewing temperature and at the delay of 30 seconds time interval up to 5 minutes duration as done in earlier experimentation. The second quotient was imposed cooling to room temperature immediately after brewing and measurements were done. The temperature was kept constant at room temperature for the second quotient throughout the measurements. The tests were carried out in duplicate for each tea sample and saved to the data base for analysis.

3. RESULTS AND DISCUSSIONS

3.1 Effect of Time on Color

The sharp decrease in the color of infused tea samples were observed with time delay of every 30 seconds along with the increase in haziness/decrease in brightness. This change can be explained in terms of CIE L*, a* and b* values (figures 1 to 3). The spectrophotometric values L* and b* tended to decline very sharply, but the value of a* remained almost constant with very little change with time. It has been observed that the change in color of the liquor seems to be negligible to the naked eyes but the instrument resolved it with ease and accuracy. This suggests that there were chemical changes in tea infusions with passage of time after brewing, which caused change in color of tea liquor. The change in a* and b* values may be related to the concentration of TRs and TFs as per literature available as TRs were red pigments and TFs imparted yellow color [9]. The sharp decrease in b* implies that TFs were reducing due to precipitation during creaming process as tea infusion cools down gradually. The positive values of a* suggest high percentage of TRs in the infused tea liquor which remains almost unchanged with time up to 5 minutes observation period.

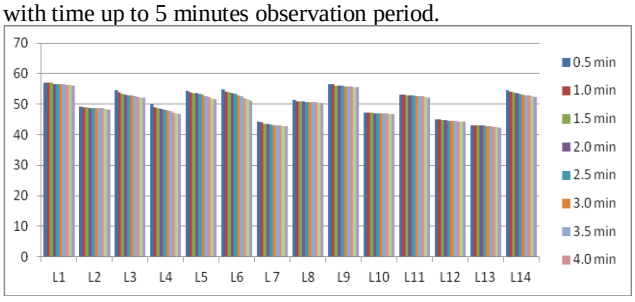

Figure 1: Variation in CIE L* values with time

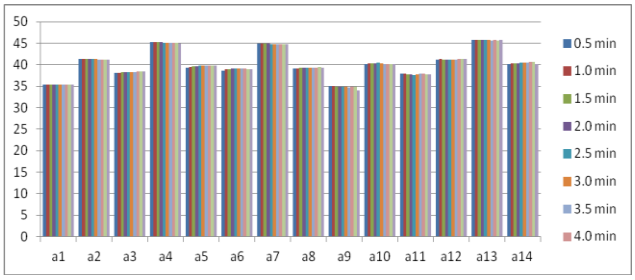

Figure 2: Variation in CIE a* values with time

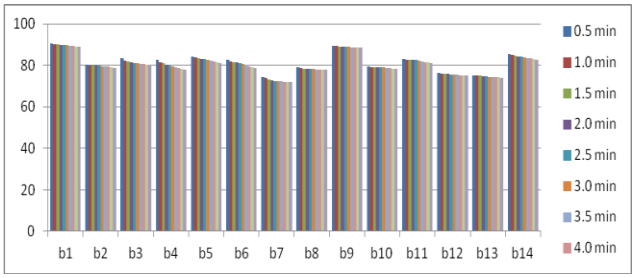

Figure 3: Variation in CIE b* values with time

3.2 Effect of Cooling on Color

The results obtained after imposed cooling of the infused tea liquor confirmed that chemical changes were slowed down that involved in tea color changes (Figures 4 to 6). The formation of tea cream was also decreased due to cooling which results in the slowing down of color changes with time and the haziness was less prominent.

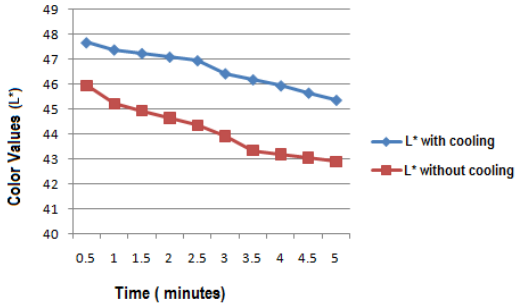

Figure 4: Effect of cooling on CIE L* values with time

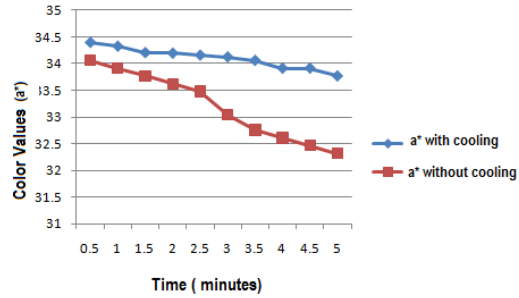

Figure 5: Effect of cooling on CIE a* values with time

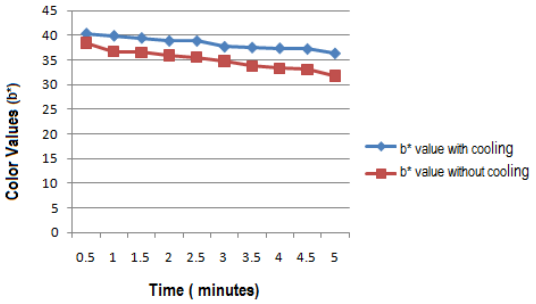

Figure 6: Effect of cooling on CIE b* values with time

3.3 Data Analysis and Statistics

It has been proved from the results that the time and temperature affects the brewed tea liquor color significantly. However, the change was slowed down by cooling the infused tea liquor to room temperature. The statistical analysis of the data confirmed the significant change in the color values due to two factors viz. time and temperature. As the variance for CIE L*a*b* values with imposed cooling (L*= 0.64897, a*= 0.083166 and b*=1.644114) were found lower than color values without cooling (L*= 1.074631, a*= 0.412665 and b*=3.445136) due to the reason that change in color was greater under normal conditions with no cooling applied to the samples. Therefore, the change in CIE L*, a* and b* is less significant due to imposed cooling condition.

4. CONCLUSION

The experiment proved that with the passage of time the color of freshly brewed tea liquor changes rapidly, which can significantly affect the quality assessment of made tea by tea taster's visual inspection. This can be explained in other words as to delay the degradation of tea properties brewed tea liquor should be cooled down to room temperature. The future work will include mimicking the tea tasters physical verification technique for the above experiments through 3CCD color camera, operating in visible region of electromagnetic spectrum in dark and closed housing.

5. ACKNOWLEDGEMENTS

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