Effect of Dhool Spreading Thickness on made Tea Quality in Orthodox-rotorvane Type Tea Processing

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Abstract

Tea grades produced by Orthodox-Rotorvane type processing in Sri Lanka is popularly used for production of value added products. In order to have a fine quality orthodox tea, a severe maceration is practiced during rolling process. Due to this severe maceration, leaf oxidation will increase and control of oxidized products (Theaflavin (TF) and Thearubegin (TR)) become difficult. This will be affected by the dhool spreading thickness and aeration time. Thus, the objectives of this study were to determine the optimum dhool spreading thickness and aeration time on made orthodox-rotavane type black tea by analyzing chemical and sensory properties. After rolling of withered (43% MT/WL) green tea leaves, the first dhool was extracted, and spreaded at different thicknesses (2, 2 ½ and 3 inches), and was allowed for oxidation up to 3 ½ hrs of aeration. Temperature and humidity of the aeration room was controlled and maintained. During oxidation, 250 g of dhool from each thickness was collected at every 20 minutes intervals until the maximum oxidation time, and determination of TF, TR, and sensory analysis was done after preparation of black tea. TF content of the made black tea from each thickness (2, 2 ½ and 3 inches) was found to be varied from 0.91-1.14%, 0.95-1.25%, and 0.93-1.19% respectively. According to the chemical and sensory properties, tea spreaded at 2 inches was found to have highest liquor quality and professional tea tasters gave highest price. Further, the optimum aeration time was found to be 2 hour irrespective of spreading thickness.

Key words: Dhool Orthodox-rotavane type, Theaflavin, Thearubegin,
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Introduction

Tea is popular non-alcoholic beverage commonly prepared by pouring boiling water over processed leaves of the *Camellia sinensis*. After water, it is the most widely consumed drink in the world. Sri Lanka is considered as fourth largest tea producer in the world after China, India and Kenya. Sri Lankan tea manufactures use three types of black tea processing methods namely orthodox method, orthodox-rotorvane type method and cut, tear and curl (CTC) method. According to the Ministry of Plantation Industries, out of the total production, the 93% (314.5 mn kg) of black tea was produced from orthodox method while 6% (20.33 mn kg) was produced from CTC method in year 2014.

The convectional orthodox method consists of rolling the leaf on a rolling bed and result in wiry tea fragments while orthodox-rotorvane method and CTC method results severe leaf disruption leading to production of smaller fragments and consequently more oxidation.

There are five major steps in black tea manufacturing process: withering, rolling, aeration, drying and grading. Aeration is an important step in the processing of black tea from young tender shoots of *Camellia sinensis* as most of the chemical reactions associated with the making of black tea occur during this stage. It influences the total quality and characters inherent in the respective teas. Time, temperature, pH, relative humidity and oxygen availability during aeration are the crucial factors responsible for the formation of high levels of quality products. The formation of chemical compounds (theaflavin and thearubigin) differed in their response to aeration time and temperature (Obanda *et al.*, 2001).

During the aeration step, dhool spreading thickness of 2-3 inches maintained to ensure the oxygen availability to achieve an even oxidation reaction. The spreading thickness and the aeration time are needed to determine the availability of oxygen from top to bottom layer of leaves. Therefore, it is important to study the optimum spreading thickness and corresponding aeration time to maintain levels of oxidized product in tea to provide required tea characters according to the consumer demand.

Materials and Methods

Minimum damaged green tea leaves were received by the St. Coombs factory and leaf standard was checked measuring the leaf count (Anon, 1998) and initial moisture content was also examined. Withering trough was loaded with green tea leaves at standard spreading rate of 2.5 kg/ft^2 and hygrometric difference of about 6 °F was maintained in the withering air throughout the whole withering process. Degree of wither was checked frequently by drawing samples (50 g) from a trough and moisture content was checked using the microwave oven method by Raveendran *et al.*, (2003) until 43% MT/WL was achieved.

Withered leaves were weighed and subjected to rolling in Orthodox and Rotorvane rollers. First dhool (macerated tea leaves) was extracted after rolling process and spread on the table at different thicknesses of 2, 2 ½ and 3 inch. Temperature and humidity of the aeration room was recorded and maintained at 15-22 °C and above 95%, respectively. After 1h of aeration process 250 g tea samples were collected simultaneously from different spreading thicknesses. Sample collection was continued at 20 min intervals until the total aeration time reached up to 3 ½ hrs. The collected dhool samples were dried simultaneously every time using three separate miniature fluidbed dryers (FBD).

color and brightness as described in Roberts and Smith (1963) method. An amount of 100 g of made tea from each treatment was graded using sieve shaker with mesh Nos. 12, 16, 18, 22, 25, 30, 36 and 44 and the amount of 7 g of B.O.P.F. grade from each treatments were sent for the evaluation of sensory parameters such as infused leaf, quality, strength, flavour, colour of the brew and appearance by trained tea tasters' in Colombo.

All the data were statistically analysed through General Linear Model at 95% confidence interval and the mean values compared using turkey test. Interaction effect was measured using Minitab 16 statistical software and sensory data were analysed using Kruskal-wallis non-parametric one-way ANOVA method.

Results and Discussion

The changes of the TF, TR, TR:TF ratio with the different spreading thickness and the aeration time were considered to determine the optimum spreading thickness and aeration time to produce black tea by orthodox-rotavane processing method. The changes of chemical parameters with three different thicknesses and aeration time are presented in Table 1.

TF and TR formation were significantly differed ($p \leq 0.05$) with aeration time among the different spreading thickness. However, there were no significant interaction ($p \geq 0.05$) in the effects of aeration time and spreading thickness on the formation of TF and TR in made black tea. The similar results were observed by Wahab *et al.*,

Table 1: Mean values of TF and TR percentage of made black tea in different thicknesses and aeration time

Aeration time	Thickness (inch)					
	2		2 ½		3	
	TF%	TR%	TF%	TR%	TF%	TR%
1 h	1.148 ^{a}	10.794 ^{c}	1.169 ^{a}	11.249 ^{c}	1.170 ^{a}	12.290 ^{c}
1h 20 min	1.134 ^{ab}	12.157 ^{c}	1.259 ^{ab}	10.840 ^{c}	1.198 ^{ab}	12.582 ^{c}
1 h 40 min	1.099 ^{ab}	12.723 ^{bc}	1.222 ^{ab}	13.073 ^{bc}	1.101 ^{ab}	13.667 ^{bc}
2 h	0.998 ^{bc}	16.354 ^{ab}	1.102 ^{bc}	13.140 ^{ab}	1.060 ^{bc}	14.320 ^{ab}
2 h 20 min	1.012 ^{cd}	14.950 ^{ab}	1.059 ^{cd}	13.580 ^{ab}	1.026 ^{cd}	15.602 ^{ab}
2 h 40 min	0.919 ^{de}	15.222 ^{ab}	0.966 ^{de}	13.651 ^{ab}	0.997 ^{de}	15.981 ^{ab}
3 h	0.962 ^{e}	15.003 ^{ab}	0.962 ^{e}	14.504 ^{ab}	0.978 ^{e}	15.770 ^{ab}
3 h 20 min	0.943 ^{e}	16.708 ^{a}	0.957 ^{e}	15.240 ^{a}	0.933^{e}	15.826 ^{a}

TF- Theaflavin, TR –Thearubegin, Values followed by the same letter in column are not significantly different at α =0.05 probability level.

The extraction of fiber from each made tea was done using a miniature fiber extracting machine. The amount of 20 g of made tea from each treatment was used to analyze the chemical parameters such as TF, TR, total

(2016) and stated that the interaction between aeration time and temperature was found non-significant with respect to TR contents of made black.

Considering the spreading thickness of 2 inches, it allows to occur more oxidation reactions as better availability of oxygen from top to bottom and led to part of the TF converted into TR. When the spreading thickness was increased up to 2 ½ inches availability of oxygen from top layer to middle layers of the dhool become restricted, and would have resulted in less conversion of TF into TR. Higher temperatures were observed in dhool spreaded at 3 inches and that may accelerated oxidation reactions and increase the rate of conversion of more TF into TR. The highest TF was noticed at 2 ½ inches thickness at 1 hr and 20 min aeration time. The minimum value of TF (0.933%) was noticed at 3 inches thickness at 3 hrs and 20 min aeration time.

The formation of TFs increased with time during the early stages of aeration and as time progressed, TF level reached a maximum and then declined. According to Robertson (1983), Theaflavins (TF) are continuously being formed and/or degraded during aeration process. Further, the individual TF levels are declined with extended aeration time (Wahab *et al.*, 2016). Moreover, TFs contribute to the astringency and brightness of made tea and the TFs were used to assess the market value of made black tea. High level of TF contributes to high level of astringency and the best value of TF in made black tea is 0.7%. However, TF percentage of made black tea obtained by this study varied between 1.0 – 1.06% due to severe maceration to get smaller size tea particles.

In addition to individual values of TF and TR, ratio of TF to TR is critical parameter in made tea to ensure the quality of brew. The best TF:TR ratio is considered to be 1:10 by Owuor and Reeves (1986) for CTC manufacturing method. There were significant difference ($p \leq 0.05$) observed in TR:TF ratio with aeration time among the different spreading thickness. However, there was no significant interaction ($p \geq 0.05$) in the effects of aeration time and spreading thickness on the ratio of TR:TF of made black tea. According to Wahab *et al.*, (2016), proper balance between TF and TR which is very necessary for quality and also depends upon the duration and temperature period of aeration. The main reason for having comparatively high TR:TF ratio in 2 inch thickness and having less TR:TF ratio in 2 ½" and 3" thickness were the oxygen availability at the point of spread table. However, the TR:TF ratio varied between 13.6 - 16.4 due to severe maceration in rotorvane to get smaller size tea particles.

In addition to the biochemical parameters discussed above, total color and brightness were also considered as quality parameters for evaluate the quality of made black tea. Significant difference ($p \leq 0.05$) was observed in total color with aeration time among the different spreading thickness. However, there was no significant interaction ($p \geq 0.05$) in the effects of aeration time and spreading thickness on the total color. A positive correlation is observed between total color and TR content (data not presented). TR levels and the color of the tea liquor has significant relationship, as highly polymerized substances such as TR lead to increase the color of the brew.

There were no significant difference ($p \geq 0.05$) observed in brightness with aeration time among the different spreading thickness. The highest mean value of 38.91 was recorded at 1 hr and 20 min of aeration time at 3 inches thickness and lowest mean value of 18.36 was recorded at 3 hrs of aeration time in 3 inches thickness. Muthumani and Kumar (2007), suggested that TF level contributes toward the briskness and brightness of the tea liquor.

Sensory parameters of color, infused leaf and overall acceptability statistically analyzed and all parameters in tea spread at varying spreading thickness vary significantly ($p \leq 0.05$) with aeration time. However, strength not significantly ($p \geq 0.05$) varies with time and spreading thickness. According to Wahab *et al.*, (2016), long aeration duration and low temperature favored production of more intensely colored black tea. By considering all spreading thickness 2 inches at 2 hr aeration time can be considered as a good due to most consumer acceptable black tea.

Conclusion

The made black tea produced at 2 inches thickness and 2 hrs of aeration time was found to be have desired chemical and sensory attributes. Moreover, it can be concluded that increasing the dhool spreading thickness leads to obtain low quality made tea.

References

Anon (1998) Monitoring the standard of leaf at St. Coombs factory, Tea Research Institute of Sri Lanka. Pp 188-189.

Muthumani, T., and Kumar, R. S. (2007) Influence of fermentation time on the development of compounds responsible for quality in black tea. *Food Chemistry*, 101(1), Pp 98-102.

Obanda, M., Owuor, P. O., and Mang'oka, R. (2001) Changes in the chemical and sensory quality parameters of black tea due to variations of fermentation time and temperature. *Food Chemistry*, 75(4), Pp 395-404.

Owuor, P. O., and Reeves, S. G. (1986) Optimizing fermentation time in black tea manufacture. *Food Chemistry*, 21(3), Pp 195-203.

Raveendran, K., Mohamed, M. T. Z., Botheju, W. S., Jayasinghe, L., and Priyanthi, S. H. (2003) Rapid-method to determine moisture content in green leaf, withered leaf and made tea, using a microwave oven, *Sri Lanka Journal of Tea Science*, 68 (2), Pp 44-48.

Roberts, E. A. H., and Smith, R. F. (1963) The phenolic substances of manufactured tea. IX.—the spectrophotometric evaluation of tea liquors. *Journal of the Science of Food and Agriculture*, *14*(10), Pp 689-700.

Robertson, A. and Bendall, D.S., 1983. Production and HPLC analysis of black tea theaflavins and thearubigins during in vitro oxidation. *Phytochemistry*, *22*(4), pp.883-887.

Wahab, S., Ullah, F., Khattak, M. K., Memon, M. S., and Hassan, L. (2016) Impact of temperature and fermentation period on the overall quality of black tea. *Pure and Applied Biology*, *5*(4), Pp 01.