Influence of Clone and Duration of Withering on Quality of Black Tea (*Camellia Sinensis* (L).O Kuntz) at Wush Wush, South Western Ethiopia

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ABSTRACT---- ***In Wush wush five commercial Camellia sinensis var.assamica of tea clones are under production however, most common misperception is that the different types of tea quality come from different tea plants and also from same plant. This difference in quality comes from how the plant is processed. Withering is the first processing step in the factory and is a process in which freshly plucked leaf is conditioned physically, as well as, chemically for subsequent processing stages. Indeed, withering is one of the most important tea production process steps and can be said to constitute the foundation for achieving quality in tea manufacture. These first and the most important processing (withering) step are done uniform (18h) irrespective of the type of clone to be manufacture. Furthermore, there was no research done so far on the optimum withering time for these five different types of clones grown in Wush wush tea plantation farm and hence only subjective judgment is used by factory cup taster to determine the withering time.Therefor, this study initiated with the objective of investigation of influence of clone and duration of withering on black tea quality. The research was conducted at southern part of Ethiopia, wush wush and Jimma in year 2012\13.The experiment consists of five clones and five duration of withering. The Experiment was laid out in 5x5 factorial arrangements in Randomize Complete Block Design (RCBD) with three replications. The data were subjected to the analysis of Variance (ANOVA) by using SAS version 9.2. Software and significant means separated using least significant difference (LSD) test. The result show that clone and duration of withering interaction had significantly influenced on the theaflavein(TF),thearubgein(TR),brightness(BR)*** *Infusion color(IFC)****,thickness(TH),strength(ST) ,briskness (BS),leaf appearance (LA) and color (CL) at (p<0.05) and all most all clones are give good quality between 16-18 hour. The chemical and sensory analysis result showed that the optimum withering time for clone 11\4 and 12\38 are16h and BB\35 and 6\8 are show good quality at 17 hour and 11\56 show at 18h. Therefore by considering these optimum withering hours for the different clones we can save time, many, man power and most important thing improving the quality of black tea.***

Keywords---- *Tea Clone, Withering, Theaflavine, Thearubgin*

1. INTRODUCTION

Tea is the second largest drink consumed in the world after water. Tea refers to the products of the leaves, leaf buds, and internodes of the *Camellia sinensis* or *Camellia assamica* plant prepared by different methods, such as daily preparation, infusions, decoctions etc. The plant itself is also considered as "tea" (Shapiro and Bruck, 2006).

In Ethiopia, tea is mostly grown in the highland dense forest regions where the land is fertile and thus the use of fertilizer is very minimal. Moreover, the availability of abundant and cheap labor in the country has made the use of manual weeding, instead of chemical weeding, possible. Because of this mostly organic cultivation, Ethiopian tea is increasingly sought for its aroma and natural flavors. Tea manufacturing consists of four stages, namely withering, rolling, fermentation and drying. Of these, withering is the first and most important step in tea manufacture and is the most expensive processing step in terms of time, money and energy. It is done to make the leaf ready, physically and biochemical, for effective rolling, fermentation and drying processes (Muthumani and Kumar, 2006). Withering results in an increased levels of amino acids, caffeine content, sugars and polyphenol oxidize activity (Tomins *et al*., 2010), and an increase in cell membrane permeability (Sanderson, 1968). Quality of made tea is directly influenced by the taste and aroma of tea liquor (Sanderson, 1968). Good manufacturing practices are necessary to process good quality tea. Black tea processing involves four major unit operations namely withering, rolling, fermentation and drying. Withering is very

important in black tea processing because it consumes the highest amount of electrical energy and fairly large amount of thermal energy. In addition, uniformly withered tea leaves are essential to produce good quality end product (Botheju, *et al*, 2011). In Ethiopian (Wush wush) five commercial *Camellia sinensis var. assamica* of tea clones are under production. However, during export processing, the factory treats all five clones with similar withering time 18hour. The company overcomes the quality problems by its experienced cup taster. This subjective assessment of tea tasting and visual inspection is not enough to produce competitive product in the international market. So, biochemical parameters (colorimetric approach) have been used to detect the amount of Theaflavine and thearubigins formed with different extent of withering,. So Biochemical parameter is important to determine the optimum withering time for each variety according to Wush-wush Agro ecological conditions. This biological study was done to find out whether withering duration or Clones difference could affect the individual Theaflavine, thearubigins, and brightness and infusion color of the black tea. Therefore, the objective of this experiment was

To standardize the withering time for the different clones at Wush Wush in view of improving the quality of black tea

2. MATERIALS AND METHODS

Processing procedure in factory: A 1000 Kg of tender fresh leaves (bud + two green tea leaves) were plucked from wush wush tea plantation farm (altitude 1950masl, latitude$7^0$16N and longitude $36^0$11E) in southern nation, nationality and people regional state of Ethiopia, In Kafa zone at interval of 7-10 days, each tea clone are transported to the factory after which the leaves were spread out on wire trays for withering. Leaves were withered separately for a period of withering time (16, 17, 18, 19, and 20hrs) then rolled and macerated by CTC machine. The macerated leaves were spread out in fermentation tank for 90 min for oxidation. During fermentation time, room temperature and humidity were maintained at 22^0C and 95%, respectively. The fermented tea leaves were dried according to the procedure of Wushwush fluid bed drier standard at 105°C for 25 min to stop chemical reaction. The dried product was then winnowed to remove the fiber and dust. Finally, 250g of dry made tea sample was packed from each experimental unit for further chemical and sensory analysis.

Chemical analysis: all black tea samples were subjected to chemical analysis at post harvest laboratory of Jimma University College of agriculture and veterinary medicine (JUCAVM) (Altitude 1710masl, 70^0, 42' N latitude and $36^0$50`E longitude) is located in south western parts of Ethiopia in oromiya regional state. Spectrophotometer measurement were conducted to measure quality parameter of black tea for (Theaflavine (TF), thearubigins (TR), infusion color(IC) and brightness (BR))as per procedure developed by Robert and smith (1961) following these measurement amount of quality parameter of tea samples were determined by using the following equation proposed by (Ullah *et al.,* 1984).

Theaflavine % = 2.3 x E3 (absorbance of E3 read at 380 nm)
Thearubigins %= 7.06 (4E3 - E1) (absorbance of E1 and E3 read at 460 nm)
Infusion color= 4E2x 6.25 (absorbance of E2 read at 460 nm)
Brightness= (E2/4E2) x 100 (absorbance of E2 read at 380 nm).
Where
E1= Reading obtained from the mixture of organic layer ethyl acetate and methanol
E2= Reading obtained from the mixture of tea leave infusion, oxalic acid, water and methanol
E3= Reading obtained from the mixture of tea leave infusion, water and methanol.

Organoleptic evaluation: Organoleptic evaluation can indicate the degree of acceptance of the product by the consumer (Muthumani and Kumar, 2006). Five point six grams of made tea leaves was added to 200 ml of boiled water and infused for 5min. The infusion was poured out for evaluation (Yan, 2007). The sensory evaluation for briskness, strength, thickness and color was done by three professional's taster and scores were taken on the scale of 1-5(owuor and obanda, 2003). The range value was described as fallow 1(poor), 2(satisfactory), 3(good), 4(very good) and 5(excellent) according to wush wush tasting method. During cup tasting Tea Evaluation Room requires natural homogenous and adequate lighting.

Data Analysis: Data were first checked for all assumptions and subjected to the analysis of Variance (ANOVA) by using SAS version 9.2. Software and significant means separated using least significant difference (LSD) test.

3. RESULTS AND DISCUSSION

Effects of Clones and Duration of Withering On Chemical Composition

Theaflavine: The results of this experiment showed that the interaction effect of different withering durations, and clone had showed very highly significant *(P<0.001)* differences on the theaflavin content of black tea (Table – 1).Based on the treatments applied, the highest theaflavin was recorded in clone 6\8 at 17h whereas the lowest theaflavine was registered in clone 11\56 at 20h. In addition to this, all clones attained their maximum point of theaflavine content at the withering duration between 16 to 18hrs. In this finding clone 6\8 was determined as clone with higher amount of theaflavin from clones that are produced in Wush wush farm. The longer the withering time the less theaflavin content mainly due to high production of carotenoids during the first two withering treatment. These carotenoids degrade to form volatile flavor compound responsible for tea aroma. Similar finding by Tomlins and Mashingaidze (1997) also indicated that the shorter withering time, about 16hrs resulted to tea of good flavor and quality. The amounts of theaflavin contents and rates of

development of theaflavin are highly dependent on variety (clone) and duration of withering as well as their interaction effects .The statistical analysis of the results obtained by the other work reported elsewhere using different clones showed that the longer the wither time; the lower was the TF levels (Owuor and Obanda, 2006).
The correlation coefficients (Table 8) showed that, theaflavin content was positively and strongly significantly correlated with brightness(r=0.30333**), briskness (r=0.34182**) and significantly correlated to thickness (0.25823*).

Table 1 Effects of clones and withering time for theaflavine content

	Duration of withering(hours)				
Clone	16	17	18	19	20
11\4	3.073^{ab}	3.033^{abc}	2.933 ^{abcd}	2.700^{abcdef}	2.733^{abcdef}
BB\35	2.633 ^{abcdefg}	2.793^{abcdef}	2.517^{bcdefg}	2.303^{defgh}	2.300^{efghd}
11\56	2.170 ^{fgh}	2.203^{efgh}	2.307 ^{defgh}	1.976 ^{gh}	1.800^{h}
6\8	2.563^{bcdefg}	3.283 ^{a}	2.867^{abcde}	2.800 ^{abcdef}	2.633^{abcdefg}
12\38	2.567^{cdefg}	2.3967^{cdefgh}	2.313 ^{defgh}	2.300^{efghd}	2.190 ^{efgh}
LSD (5%)			0.6729		
CV (%)			14.90		

Different letters in the columns and row indicate the difference between two means is statistically significant (P<0.001 %) for each of the treatment combinations

Thearubgine: The analysis of variance indicated that there were highly significant *(P<0.01)* difference between clones and withering durations with respect to thearubgine content (Table -2). Thearubgine content in all clones was increased as the withering period increased from 16 hr to 19hrs. This indicating that the longer the withering time the higher the thearubgin content .Table-2 below showed that fluctuating nature of thearubgine content in each clones it has own minimal and maximum point. The maximum point of thearubgine content was observed in clone 12\38 at 19hrs while the minimum was in clone 6\8 at 16hrs.For all clones there was no significant differences between durations of 18 to 20hrs and however, good thearubgine contents were observed between 18-20hrs. From this result a withering duration of 18h is ideal time for all clones to get good quality. The result found here was in line with the work Tomlins and Mashingaidze (1997), who found wither tea leaves for more than 18hrs resulted to maximum theaflavine but tea of poor quality and flavor. The table below showed that tea that withered for shorter time is lower in thearubgine content and long withered teas produce highest thearubgine content. The present finding is in line with the findings of Tomlins *et al*. (2010), who reported that, unwithered leaf is associate with teas that are lower in thearubgine. The correlation coefficients (Table 8) showed that, thearubgine content was positively and strongly significantly correlated with color (r=0.31810**), and significantly correlated to infusion color (0.25066*).

Table 2 Effect of clones and withering time for thearubgine content

	Duration of withering (hours)				
Clone	16	17	18	19	20
11\4	12.980 ^{f}	16.520^{abcde}	17.527^{abc}	17.847^{abc}	17.363^{abcd}
BB\35	14.763^{bcdef}	15.407^{abcdef}	15.780^{abcde}	16.703^{abcde}	15.237^{abcdef}
11\56	14.063^{cdef}	14.733^{bcdef}	15.403^{abcdef}	17.490 ^{abcd}	16.783 ^{abcde}
6\8	11.173^{f}	13.267^{def}	16.590^{abcde}	18.860 ^{ab}	13.923 ^{cdef}
12\38	15.163^{abcdef}	16.233^{abcde}	17.770 ^{abc}	19.240 ^{a}	19.037 ^{a}
LSD (5%)			4.2584		
CV (%)			16.99		

Different letters in the columns and row indicate the difference between two means is statistically significant (P<0.001 %) for each of the treatment combinations

Brightness: The result from brightness showed that the interaction between clones and withering durations were very highly significant at *(P<0.001)*. In addition, the separate effect of both withering duration and clone types showed very highly significant differences with respect to brightness. From the result the brightness varies depending on the type of clones. This indicates all tea clones have their own chemical compositions. Maximum point of brightness was observed in clone 11\4 at 16hrs of withering time while the lowest one was observed in clone 11\56 at 20hrs.Clone 12\38 attained its maximum point of bright at a withering time of 16h then decreases slowly. On the other hand, clone 6\8 and BB\35 reached their maximum point of brightness at 17h after which it was start to decrease. 11\56 reached its pick point at 18h and slowly decreased. This indicated that the clones vary in their responses with respect to brightness to the different withering times. Similar research by Tomlins and Mashingaidze, (1997) confirmed that unwithered leaf is associate with teas that are bright while withered teas produce less brightness. The correlation coefficients (Table 8) showed that, brightness was positively and strongly significantly correlated with theaflavin (r=0.30333**), and positively correlated to briskness(r=0.01457) thickness (r=0.15538) and leaf appearance (r=0.08546).

Table 3 Effect of clone and withering duration on brightness

	Duration of withering (hours)				
Clone	16	17	18	19	20
11\4	26.85[a]	25.167 [ab]	20.28 [cde]	20.23[cde]	17.233[ef]
BB\35	20.557 [cde]	22.37[bcd]	19.833cdef	19.66[cdef]	17.76 [ef]
11\56	20.36[cde]	22.73[abc]	22.93[abc]	18.93[cdef]	15.33[f]
6\8	19.30 [cdef]	20.07[cde]	19.57 [cdef]	18.23[def]	17.63 [ef]
12\38	23.27 [abc]	23.200[abc]	22.933[abc]	20.80[bcde]	20.500[cde]
LSD (5%)			4.4559		
CV (%)			13.19		

Different letters in the columns and row indicate the difference between two means is statistically significant (P<0.001 %) for each of the treatment combination.

Infusion color: The result from infusion color showed that the interactions between clones and withering durations were significantly different at (*P <0.05)* while the separate effect of duration of withering and clones showed highly significant different (***P***<0.001) with respect to this parameter. The maximum point of infusion color was observed for clone BB\35 at 19hrs where as the minimum point was at 16hrs in clone 6\8. From this result each clones were characterized by their own duration in attaining good color. For instant, clone 11\4 and 12\38 showed good color at 20hrs and 18hrs respectively. While In clone 6\8, 11\56 and BB\35 good infusion color was observed at a withering time of 19hrs. For all clones good color was observed between 18-20hrs withering time, therefore, a withering time of19hrs can be considered as the ideal time for production of good quality tea without compromising the other quality parameters. The correlation coefficients (Table 8) showed that, Infusion color was positively and significantly correlated with thearubgine (r=0.25066*) and positively correlated with brightness (r=0.21339) and strength(r= 0.12133).

Table.4 Effect of clone and withering duration on infusion color

	Duration of withering (hours)				
Clone	16	17	18	19	20
11\4	9.8567[abcd]	9.833[abcd]	10.000 [abcd]	10.140[abcd]	10.3433 [abc]
BB\35	9.1267[cd]	10.067 [abcd]	10.033[abcd]	11.1500 [a]	10.450 [abc]
11\56	9.800[abcd]	9.703[abcd]	10.023 [abcd]	10.500 [abc]	10.433 [ab]c
6\8	8.853[d]	9.933 [cdab]	10.033[abcd]	10.767 [a]	10.283[abcd]
12\38	9.133[cd]	9.560 [bcd]	10.543 [abc]	10.170 [abcd]	9.867[abcd]
LSD (5%)			1.4543		
CV (%)			10.36		

Different letters in the columns and row indicate the difference between two means is statistically significant (P<0.001 %) for each of the treatment combinations

Effects of Clones and Duration of Withering On Sensory Quality of Black Tea

Briskness: The result from Briskness showed that there was highly significant *(P<0.01)* interaction effect of withering time and clone (Table -5). The maximum point of briskness was obtained during the first three treatments. The best quality was obtained in clone 11\4 and 11\56 at 16hrs and 18hrs respectively and the lowest observed at 20hrs in clone 6\8. The statistical analysis of the results obtained by the other work reported using different clones showed that the longer the wither time; the lower was the Briskness (Mohammed *et al.*, 2006).

The biochemical reaction like carotinoid, protein and catechins that contribute for the formation of the tea aroma were produced during shorter period of withering and they are responsible for briskness of tea (Tomins *et al*., 2010). The correlation coefficients (Table 8) showed that, briskness was positively and strongly significantly correlated with theaflavine (r=0.34182**), and positively correlated to brightness (r=0.01457) and thickness (r=0.14326).

Table 5 Effect of clone and withering duration on Briskness of tea brew

	Duration of withering (hours)				
Clone	16	17	18	19	20
11\4	2.67[a]	2.33[ab]	2.00[ab]	2.00[ab]	1.67[b]
BB\35	2.33[ab]	2.33[ab]	2.33[ab]	2.33[ab]	2.00[ab]
11\56	2.00[ab]	2.33[ab]	2.67[a]	2.33[ab]	2.00[ab]
6\8	2.33[ab]	2.33[ab]	1.67[b]	2.00[ab]	1.67[b]
12\38	2.33[ab]	2.33[ab]	2.00[ab]	2.00[ab]	2.00[ab]
LSD (5%)			0.6759		
CV (%)			18.79		

Different letters in the columns and row indicate the difference between two means is statistically significant (P<0.001 %) for each of the treatment combinations

Thickness: The result from thickness indicated that withering duration and clones are showed very highly significant differences *at (P<0.001).* As indicated in table-6, the thicknesses of the tea were not constant within each clone having their own minimal and maximal points for thickness. For instant clone 11\4, 6\8 and 11\56 were found to be good with respect to thickness at 16-18hrs of withering duration.This indicate each clone have their own time to give good thickness. In support of the above investigation, Mohammed *et al. (*2006) explained that unwithered leaf is associate with teas that are thin. The correlation coefficients (Table 8) showed that, thickness was positively and significantly correlated with theaflavine (r=0.25823*) and positively correlated to brightness (r=0.15538) and briskness (r=0.14326).

Table 6 Effects of clone and withering duration on thickness of tea brew

Clone	Duration of withering (hours)				
	16	17	18	19	20
11\4	2.67^{a}	2.33^{ab}	2.00^{abc}	2.33^{ab}	2.33^{ab}
BB\35	2.33^{ab}	2.33 ^{ab}	2.33^{ab}	1.67^{bc}	2.00^{abc}
11\56	2.00^{abc}	2.33^{ab}	2.67^{a}	2.33^{ab}	2.33^{ab}
6\8	2.00^{abc}	2.67^{a}	2.33^{ab}	2.00^{abc}	1.33^{c}
12\38	2.33^{ab}	2.00^{abc}	2.00^{abc}	2.00^{abc}	1.67^{bc}
LSD (5%)			0.8223		
CV (%)			18.82		

Different letters in the columns and row indicate the difference between two means is statistically significant (P<0.001 %) for each of the treatment combinations

Strength: The result of this experiment show that the interaction between clones and duration of withering was very highly significant *(P<0.001)*. As can be seen from figure- 1, all clones responded differently to the withering period with respect to the strength of the brew. For example, the maximum point of strength was observed at 18hrs in clone 6\8 while the minimum were recorded in clone 6/8 at a withering period of 16hrs and clone 11/56 at 16h and 20hrs. Therefore, there is no constant hour to get good strength which is each clone have their own time to get good strength. The table blow showed that the highest strength were observed between 18-20hrs of withering. Similar finding was also observed by Tomlins *et al*. (2010), who reported that, unwithered leaf is associate with teas that are lower in strength. The correlation coefficients (Table 8) showed that, Strength was positively correlated with thearubgin (r=0.12501), color (r=0.12133) and infusion color (r=0.14326).

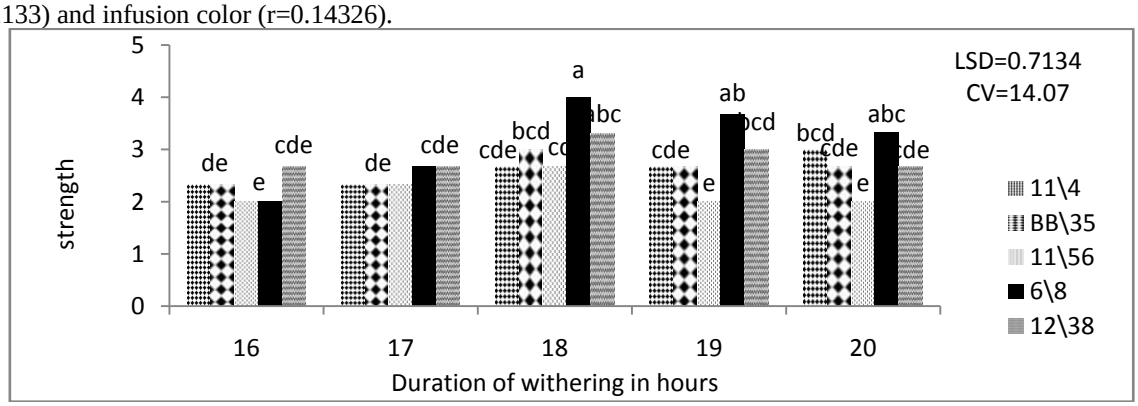

Figure. 1 Effect of clone and withering duration on Strength of tea brew

Color: Results obtained from this experiment showed that there are very highly significant differences *(P<0.001)* due to the interaction effects of clones and withering durations. The result in (figure -2) illustrated that longer withering periods are necessary to produce good colored tea as short withering periods produces grayish colored and poor quality tea. From this result, in all clones a withering period of 18 – 19hrs were the best for developing good colored tea. Withering periods greater than 19hrs though good colored teas are produced, they loss their flavor and quality. Research result of Tomlins and Mashingaidze (1997) confirmed that the longer withering period (usually above 19hrs) result in teas of good color but of poor quality and flavor. The correlation coefficients (Table 8) showed that, color was positively and significantly strongly correlated with thearubgine (r=0.3181**) and positively correlated to leaf appearance (r=0.21796)

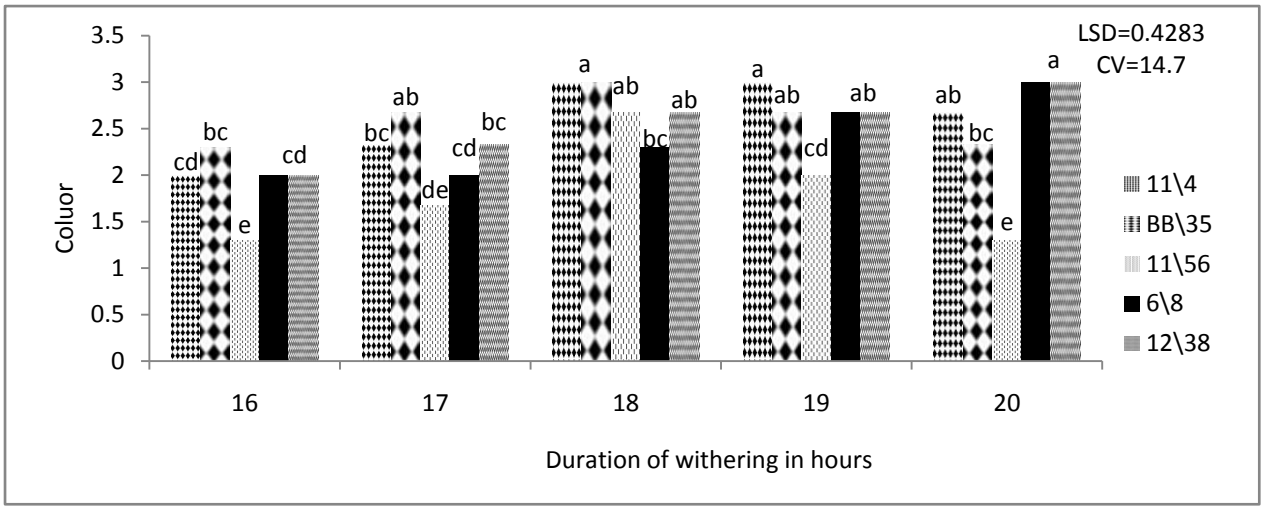

Figure 2. Effect of clone and withering duration on color of tea brew

Leaf appearance: The leaf appearance was found to be very highly significant differ *(P<0.001)* because of variation in withering duration and clones. Good leaf appearance was observed at 16hrs and 17hrs of withering duration in clone 11\4 where as poor quality teas were observed in clone 11\4 in 20h. The table showed that there was no constant time to attain good leaf appearance in each clones have their own time to develop good leaf appearance. Clone 11\4 and 12\38 develop good leaf appearances at 16hrs of withering period were as clones BB\35and 6\8 at 17hrs and clone 11\56 at 18hrs. The correlation coefficients (Table 8) showed that, leaf appearance was positively correlated with thearubgine (r=0.02892) brightness (r=0.08546) and color (r=0.21796)

Table 7 Effects of clones and withering time on the appearance of tea leaf

	Duration of withering (hours)				
Clone	16	17	18	19	20
11\4	3.667^{a}	3.667^{a}	3.333^{ab}	2.333^{cd}	2.000^{d}
BB\35	3.00^{abc}	3.33^{ab}	3.000^{abc}	3.000^{abc}	2.667^{bcd}
11\56	2.667^{bcd}	3.000^{abc}	3.333^{ab}	3.000^{abc}	2.667^{bcd}
6\8	2.333^{cd}	2.667^{bcd}	2.667^{bcd}	2.667^{bcd}	2.667^{bcd}
12\38	3.333^{ab}	2.667^{bcd}	2.667^{bcd}	2.333^{cd}	2.667^{bcd}
LSD (5%)			0.8047		
CV (%)			18.04		

Different letters in the columns and row indicate the difference between two means is statistically significant (P<0.001 %) for each of the treatment combination

Table 8. Simple correlation on quality attributes of black tea

	TF	TR	IFC	BR	LA	BRS	TH	CL	ST
TF	1	-0.24*	0.06	0.30**	-0.12	0.34**	0.25*	-0.23*	-0.19
TR		1	0.256*	-0.26*	0.03	-0.33**	-0.07	0.31**	0.12
IFC			1	0.21	-0.23*	-0.09	-0.07	-0.02	0.12
BR				1	0.08	0.01	0.15	-0.16	-0.09
LA					1	-0.20	-0.23*	0.21	-0.11
BRS						1	0.14	-0.28*	-0.31**
TH							1	-0.04	-0.37**
CL								1	0.06
ST									1

*, ** = Correlation is significant at the 0.05 and 0. 01 level respectively.
TF=Theaflavine, TR=Thearubgein, IFC=Infusion color, BR=Brightness, L A=Leaf appearance, BRS=Briskness, TH=Thickness, CL=Color, ST=Strength

4. SUMMERY AND CONCLUSION

The result of the study showed that interaction of clone and duration of withering had significantly influenced the Theaflavine(TF), Thearubgin(TR), brightness(BR), thickness(TH), briskness(BS), strength(ST),leaf appearance(LA) and color (CL)and the highest (3.2%) TF was obtained with 17h duration of clone 6\8 and lowest (1.8) with 20h for clone 11\56 on the other hand the highest (19.2%) TR at was recorded with 19h withering of clone 12\38 and lowest(11.1%) with 16h withering of clone 6\8 .The maximum value for BR (26.8) was observed with 16h withering of clone 11\4 and the minimum (15.3) was noted from clone 11\56 which was withered for 20h. On the other hand, TH was maximum (2.67) when withering duration was between 16 and18h and lowest (1.3) at 20hr. The highest BRS (2.67) developed from 16hrs and 18hrs withering of clone 11\4 and 11\56 while the lowest (1.67) was from 20h withering in clone 6\8. The strength of the tea was at its maximum (4) when the withering duration was adjusted to 18h in clone 6\8 and lowest(2) in clone 6\8 and 11\56 withered for 16 and 20h. the highest LA(3.67)when withering duration is between 16 to 17hrs Moreover, the highest value for CL (2.67) was registered when teas leaves were withered for 20h in clone 6\8 and 12\38 and lowest (1.3) in clone 11\56 withered for 16h and 20hrs. It was generally observed that almost all clones gave good quality when the withering duration was fixed between 16 and 18 hours. Both chemical and sensory analysis results showed that the optimum withering duration for clone 11\4 and 12\38 are16h and clones BB\35 and 6\8 showed good quality with 17 hour and clone11\56 with 18h withering. Clone 11\56 id somewhat slow withered than that of the 11\4 and 12\38. Clone11\4 and 12\38 needed shorter period of time than the11\56 to attained good quality. Therefore, by considering these optimum withering hours for the different clones we can save time, money, manpower and most importantly improve the quality of black tea. By considering the advantages of reducing the losses of labor, time, quality and also increases the demand difficulties in tea processing, these recommended withering durations are beneficial to the tea processing industries especially for Wush wush agro ecology.

5. ACKNOWLEDGMENTS

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