

Quality characteristics of Black Tea Processed by Orthodox Rotorvane Type of Manufacture at Different Degrees of Wither

D C J Suduwelage¹, W S Botheju² and D C Abeysinghe¹

(¹Department of Plantation Management, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, Makandura, Gonawilla, Sri Lanka,

²Process Technology Division, Tea Research Institute of Sri Lanka, Talawakelle, Sri Lanka)

ABSTRACT

Quality characteristics of made tea produced by Orthodox Rotorvane (RV) mix type of tea processing at five different degrees of wither (36%, 40%, 43%, 45% and 47%) was studied in laboratory scale experiment. Graded tea samples (BOP, BOPF and Dust No. 1) were organoleptically assessed and analyzed for chemical quality parameters such as theaflavins (TF) and thearubigins (TR). Results were statistically analyzed. Tasters' score results revealed that the blackness of Dust No. 1 was significantly low at 47% wither compared to 40%. However, there was no significant difference in blackness of BOP and BOPF grades at different degrees of wither. Overall quality of BOPF and Dust No. 1 was significantly low when the degree of wither was 36%. Further ungraded teas had significantly low TF content and significantly high TF:TR when the degree of wither reduced from 40% to 36%. This concluded that very low degree of wither was not suitable to produce Orthodox RV mix type of tea manufacture.

Based on the above results from laboratory scale experiment, three different degrees of wither (40%, 43% and 45%) were selected for the commercial scale experiment with Orthodox Rotorvane (RV) mix type of rolling process. Results of the experiment revealed that BOPF and Dust No. 1 had significantly higher blackness at 40% wither compared to 45%. However, there was no significant difference in blackness of both BOPF and Dust No. 1 at 40% and 43% while blackness of BOP was not significantly affected by three degrees of wither.

This paper was presented at the 10th Agricultural Research Symposium in Wayamba University of Sri Lanak, on August 12th-13rd, 2010.

Overall quality of BOP was significantly higher at 40% and 43% degrees of wither than at 45%. However, BOPF had significantly higher overall quality at 40% wither. Dust No. 1 did not show significant difference in overall quality at three different degrees of wither. Both BOP and BOPF at 40% and 43% withers fetched higher prices. However, Dust No. 1 obtained higher price at 43% degree of wither.

Therefore, it can be concluded that a degree of wither between 40% and 43% would be more beneficial for Orthodox RV mix type of tea manufacture in the up-country region.

Key words: Degree of wither, orthodox rotorvane mix type of manufacture, overall quality, theaflavins, thearubigins

INTRODUCTION

Tea, *Camellia sinensis* (L.) O. Kuntze is the most popular non-alcoholic and healthy beverage across the globe and an important revenue source. Tea can be grown under wide range of agro ecological regions (AERs) in Sri Lanka, broadly categorized under three groups according to the elevation of cultivation namely Low, Medium, and High grown teas. The black tea, which is produced in Sri Lanka is known as 'Ceylon Tea'. More than 92% of tea produced in Sri Lanka is black tea. Three types of black tea processing methods viz. Orthodox, Orthodox and Rotorvane (RV) mix type and CTC (Crush, Tear and Curl) are popular in Sri Lankan tea industry. Orthodox and RV mix type of tea processing is the most popular method in Up country Western and Nuwara-Eliya regions and over 50% of the tea factories in Uva region are also now practicing this manufacturing method. The steps in black tea processing can be broadly categorized as withering, rolling, fermentation, drying and sifting. Withering is the first and most important unit operation in black tea manufacture.

Quality and the price valuation of Orthodox Rotorvane mix type of tea produced in Up country region are determined by color and strength of tea liquor, which brews into the tea cup and also the blackness of made tea (Muthugalage, 2008). Tea tasting is the most common evaluation method to judge its price and quality. Chemical components, which are responsible for the quality of black tea, are oxidized polyphenols such as theaflavins (TF) and thearubigins (TR), caffeine, amino acids, carbohydrates etc. (Sanderson, 1965). During the rolling operation, polyphenoloxidase and polyphenols are mixed together and produce TF and TR, which directly affect the quality of made tea (Owuor, 1987). The TF:TR ratio is normally used to evaluate the quality of made tea. When the fermentation period increases, TF content decreases with a corresponding increase in TR content and as a result, TF:TR ratio also increases (Roberts and Smith, 1963).

Presently tea factories in the Western region adapt softer wither to produce tea with more blackness by Orthodox and RV mix type of tea processing. Previous studies have also shown that softer wither (40-43% degree of wither) was more preferable to produce good quality tea using methods of Orthodox or Orthodox and RV mix types processing (De Silva and Kirtisinghe, 1966; Thevathasan and Kirtisinghe, 1974). To verify this conclusion further and to determine most suitable degree of wither for the present style of Orthodox and RV mix type of tea processing that produces higher percentage of small grades, a study was conducted to assess the quality characteristic of tea produced at different degrees of wither using Orthodox and RV mix type of tea processing.

MATERIALS AND METHODS

The experiments were conducted at the Process Technology Division and St. Coombs tea factory managed by the Tea Research Institute of Sri Lanka (TRISL), Talawakelle, Sri Lanka.

Laboratory scale experiment

Four different tea cultivars popular in the Western region namely TRI 2025, TRI 2023, DT 1 and DN were selected from the fields in St. Coombs estate (altitude 1382 m, latitude 6° 55' N and longitude 80° 40' E) in a close proximity according to the following ratio satisfying cultivar mix in the region.

$$\text{TRI 2025 : TRI 2023 : DT 1 : DN} = 2 : 1 : 2 : 2$$

Tea leaf was plucked (~4.0 kg) from each cultivar ensuring over 65% of good standard of leaf and to match the above ratio for each trial and a known quantity of leaf sample (50 g) from the mixed leaves was drawn to determine initial moisture content of green leaves. The balance was equally divided into five fractions (F₁, F₂, F₃, F₄ and F₅). Each fraction was then withered to the following degrees of wither by using Environmentally Controlled Chamber (ECM). In this chamber, predetermined temperature (23 °C) and RH (75%) were set throughout withering period. Degree of wither defined as the ratio of made tea to withered leaf (MT/WL) on percentage basis was

$$F_1 = 36\% \quad F_2 = 40\% \quad F_3 = 43\% \quad F_4 = 45\% \quad F_5 = 47\%$$

Moisture content (w. b.) of tea leaves during withering process was tested by drawing a sample (50 g) from each fraction and using the microwave oven method (Mohamed *et al.*, 2003). Each withered leaf sample was separately rolled using miniature Orthodox and RV rollers. Macerated tea particles were sieved using 2.5 mm hand sieve to extract dhools. The dhool samples were fermented using ECM which was pre-adjusted to 25 °C and 95% RH for all dhool samples. Fermentation period varied from 2½- 2¾ hr. Once the fermentation was

progressed to its optimum level (coppery brown color particles having typical smell), fermented dhool samples were fired using miniature fluidized bed drier (FBD). The inlet and exhaust temperatures of the drier were maintained at 125 °C and 98 °C respectively. The extraction of fiber from each fired tea sample was done using a miniature fiber extracting machine. Made tea samples were then graded using hand sieves with no. 12, 16 and 32 meshes.

The graded tea samples were packed separately in triple laminated aluminium foil bags prior to sending for tea tasters' evaluation. Samples were also analyzed for chemical quality parameters. This experiment was repeated five times and results were analyzed.

Commercial scale experiment

Three commercial scale withering troughs (58'x 6'), located closely at the factory were selected and 800 kg of green leaves was loaded in each trough. The leaf standard was determined using leaf counting method (Anon, 1998). Leaves in each trough were withered by maintaining dry bulb temperature in the range of 22-25 °C and the hygrometric difference in the range of 6-9 °F and the degree of wither of leaves was brought to the following levels.

$$T_1 = 40 \% \quad T_2 = 43 \% \quad T_3 = 45 \%$$

When the leaves in each trough reached the pre-determined moisture content as per the degree of wither (leaf moisture was intermittently tested using microwave oven method), the withered leaf was weighed and charged to 46.5" Orthodox roller for pre-conditioning rolling. Rolled leaf was conveyed to 15" Rotorvane (RV) roller setting 'Iris' end plates closing 30% aperture and then passed through twin 8" RV rollers with full pressure closing the aperture about 90%. The macerated leaves were passed again through twin 8" RV rollers having 'Cone arrangement' and conveyed via ball breaker to the roll breaker machine which consisted of no. 8 meshes. Extracted 1st dhool was weighed and spread on stainless steel table for fermentation. The bulk was further macerated using 8" RV roller with full pressure to extract the 2nd dhool which was also weighed and spread for fermentation. Likewise, process was continued until the quantity of bulk was about 10% of the total quantity of withered leaf charged for one batch. Hygrometric difference in the rolling room was maintained to be less than 3 °F.

After the correct fermentation period (2½-2¾ h) which was judged by smelling the dhool and observing dhool color, dhools were immediately fed to commercial scale FBD having inlet temperature, 122-127 °C and the outlet temperature 93-98 °C. The dried teas were separately graded and three main grades viz. BOP, BOPF and Dust No. 1 were collected and packed in triple laminated aluminum foil bags

until the samples were analyzed for chemical quality parameters and also sent for tasters' evaluation. This experiment was repeated three times.

Organoleptic assessment (Tasters' evaluation)

The blackness and the liquoring properties of each graded tea sample were evaluated by two independent professional tea tasters in Colombo. In addition to that, tasting panel at the Process Technology Division also evaluated the samples. A modified version of evaluation form (Annexure 1) was prepared for this study and it was used to evaluate the different characteristics of tea.

Analysis of chemical quality parameters

Roberts and Smith (1963) method was used to analyze the chemical quality parameters of tea samples. In laboratory scale experiment, ungraded tea samples were used while samples of BOP, BOPF and Dust No. 1 grades were separately analyzed in the commercial scale experiment.

Statistical analysis

All data were statistically analyzed using ANOVA followed by Duncan's Multiple Range Test at $P < 0.05$ using SAS 8.3 software (SAS Inc., Cary, USA).

RESULTS AND DISCUSSION

The blackness of graded tea, infused leaf color, liquor color, strength and quality of liquor and overall quality estimated based on tasters' reports of three different main grades (BOP, BOPF and Dust No. 1) processed at five different degrees of wither in laboratory scale experiment are given in Table 1. Overall quality was calculated based on tasters' score assigned for each characteristic such as blackness, liquor colour, liquor strength and liquor quality and infused leaf colour.

When the degree of wither was 40%, the blackness of Dust No. 1 obtained significantly higher score compared to 47% degree of wither (Table 1). However, no significant difference was observed for BOP and BOPF at five different degrees of wither studied. The Dust No. 1 obtained the lowest score, when the degree of wither was 47%. Past research work on Orthodox rolling has also shown that liquor quality is improved due to lower temperatures attained by the rolled leaf mass of softer withered leaf than that of harder withered leaf (Thevathasan and Kirtisinghe, 1974).

Results obtained from the laboratory scale experiment showed that both BOPF and Dust No. 1 grades had significantly higher overall quality at 40% degree of wither than at 36% wither (Table 1). In the present market scenario, these two grades fetch higher prices.

Table 1. The blackness, infused leaf color, color, strength and quality of liquor and overall quality of graded tea processed at five different degrees of wither

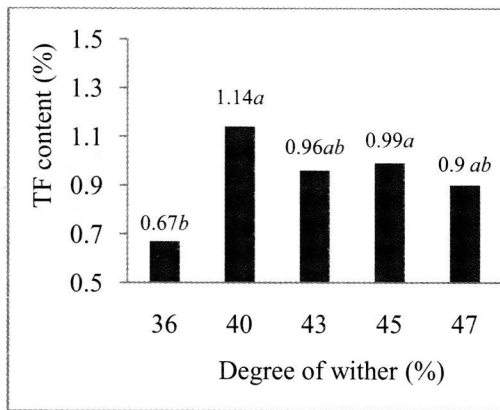
Characteristics	Grade	Degree of wither (%)					Level of significance (p=0.05)
		36	40	43	45	47	
Blackness of Graded tea	BOP	3.66a	3.92a	3.72a	3.85a	3.68a	ns
	BOPF	3.73a	4.43a	3.67a	4.02a	3.73a	ns
	Dust 1	3.72ab	4.33a	3.55ab	3.95ab	3.42b	0.1768
Infused leaf Color	BOP	3.80a	3.60a	3.50a	3.40a	3.30a	ns
	BOPF	3.60a	3.60a	3.50a	3.50a	3.30a	ns
	Dust 1	3.80a	3.70a	3.60a	3.50a	3.50a	ns
Liquor color	BOP	3.00b	3.20ab	3.30ab	3.40ab	3.60a	0.1971
	BOPF	3.10a	3.40a	3.50a	3.60a	3.50a	ns
	Dust 1	3.10a	3.20a	3.50a	3.30a	3.40a	ns
Liquor strength	BOP	3.30a	3.60a	3.50a	3.60a	3.80a	ns
	BOPF	3.50b	3.80ab	4.10ab	4.20a	4.10ab	0.1599
	Dust 1	3.90a	4.50a	4.30a	4.50a	4.60a	ns
Liquor quality	BOP	4.50a	5.10a	4.80a	5.10a	4.70a	ns
	BOPF	4.40a	5.00a	4.70a	4.90a	5.10a	ns
	Dust 1	4.60b	5.40a	4.90ab	5.00ab	4.80ab	0.1693
Overall quality	BOP	18.07a	19.52a	18.98a	19.45a	19.22a	ns
	BOPF	18.47b	20.37a	19.63ab	20.32a	19.87ab	0.0492
	Dust 1	19.05c	21.03a	20.22ab	20.55ab	19.85bc	0.0120

Means with a same letter within the column are not significantly different at P<0.05

The TF content and TF:TR ratio of made tea estimated using the data for chemical quality parameters at five different degrees of wither in the laboratory scale experiment are given in Figure 1. Significantly lower TF content and higher TF:TR ratio was found in the made tea processed at 36% degree of wither than at 40% to 45% degrees of wither (Figure 1). When the degree of wither was 40% and above, no significant variation of TF and TF:TR ratio were observed. The highest TF content and the lowest TF:TR ratio were obtained when the degree of wither was 40%.

Laboratory scale experimental data revealed that when degree of wither was reduced below 40%, the overall quality including blackness of BOPF and Dust No. 1 were significantly reduced (Table 1). This conclusion was further elaborated by analyzing the data on chemical quality parameters in which the TF content was significantly lower and TF:TR ratio was significantly higher in teas processed from very softer withered leaves (36%). On the other hand, when the degree of wither increased from 40% to 47% the blackness of Dust No. 1 significantly reduced. Increasing the wither from softer (40%) to harder (47%) at the present style of Orthodox Rotorvane mix tea manufacture which is intended to produce more Dust No. 1, has a negative impact for its quality.

(a)



(b)

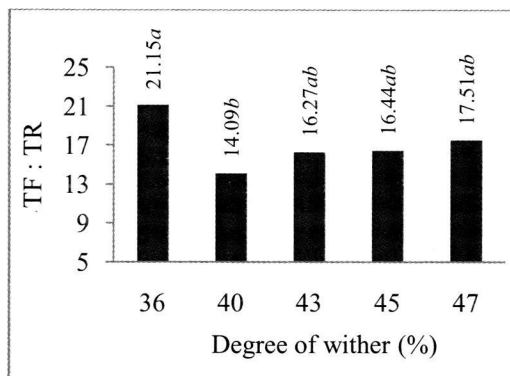


Figure 1. (a) TF content and (b) TF:TR ratio of made tea processed at five different degrees of wither in laboratory scale experiment

The commercial scale experiment was carried out with selected three different degrees of wither (40%, 43% and 45%). Blackness and overall quality based on tasters' score and chemical quality parameters of BOP, BOPF and Dust No. 1 samples manufactured at three different degrees of wither under commercial (factory) scale experiments are presented in Table 2.

There was no significant difference in blackness of BOP grade among three different degrees of withers. However, when the degree of wither was 40%, a significantly high blackness was observed with BOPF and Dust No. 1 as against 45%. However, no significant difference was observed with same grades between 40% and 43% degrees of wither.

Table 2. The blackness of graded tea processed at three different degrees of wither in commercial scale experiment

Degree of wither (%)	Tea grade		
	BOP	BOPF	Dust No. 1
40	4.50a	4.61a	4.72a
43	3.66a	3.84ab	4.11ab
45	3.50a	3.67b	3.66b

Means with a same letter within the column are not significantly different at $P < 0.05$

Liquor colour and strength of BOP and Dust No. 1 produced at three different degrees of wither had no significant difference (Figure 2). For BOPF, a significantly higher colour was observed at 43% compared to 40% wither, whereas a significantly higher strength was obtained at 40% compared to other two degrees of wither. De Silva and Kirtisinghe (1966) has shown a significantly higher liquor colour of BOP with softer (40.7%) and medium wither (43.4%) over harder wither (46.7%). However, liquor strength of BOP and BOPF was not significantly affected by three different degrees of wither.

The rolling process which produces higher percentage of small grades adapted presently in Orthodox Rotorvane mix tea processing is more vigorous than in the past. Therefore, BOP grade produced in 1970s'-1980s' may have more colour and strength.

When comparing overall quality of BOP at three different degrees of wither, a significantly lower value was obtained at 45% wither and there was no significant difference between 40% and 43% wither (Figure 3). The BOPF produced at 40% wither had given significantly higher overall quality than other two degrees of wither. However, overall quality of Dust No. 1 was not affected by three different degrees of wither (40%-45%) studied.

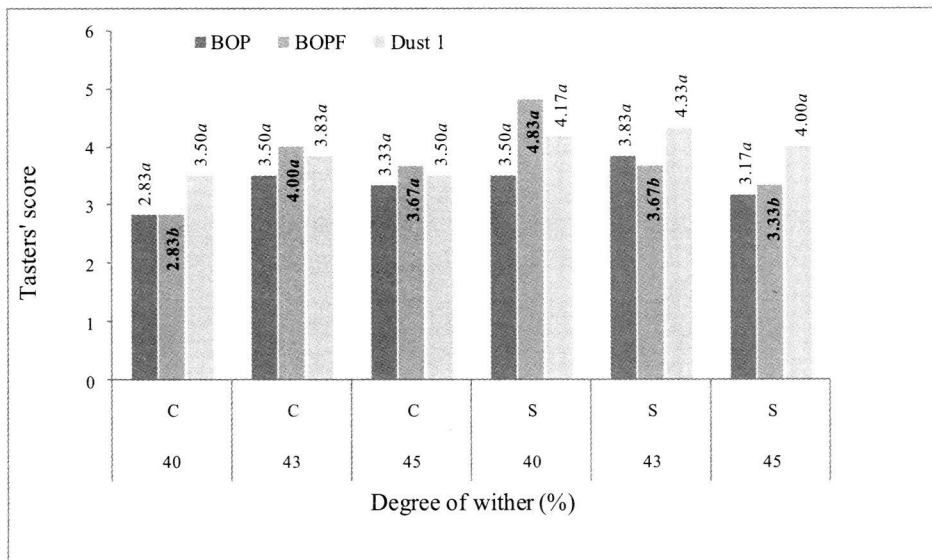


Figure 2. Tea liquor colour (C) and strength (S) of graded tea manufactured at five different degrees of wither in commercial scale experiment (means with a same letter are not significantly different at $P < 0.05$)

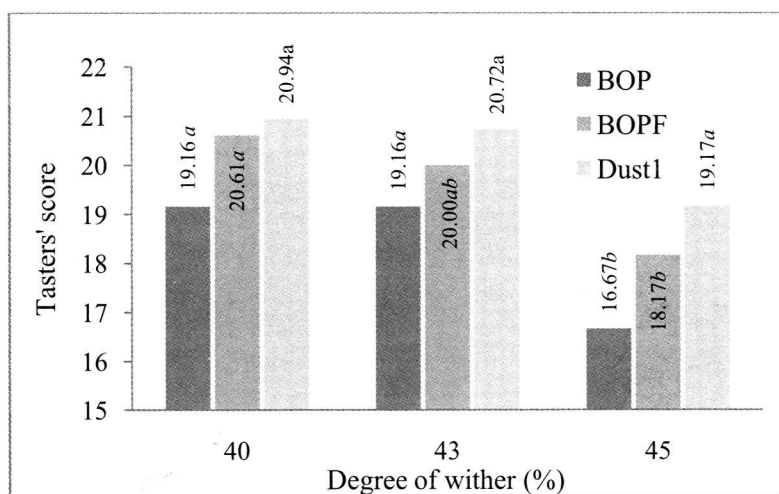


Figure 3. The overall quality of graded tea manufactured at five different degrees of wither in commercial scale experiment (means with a same letter are not significantly different at $P < 0.05$)

No significant difference was observed for TF content and TF:TR ratio for BOP (Table 3). Both BOPF and Dust No. 1 contained a significantly higher TF at 40% wither than at 45% wither. TF:TR ratio was significantly lower for Dust No.

1 at 40% wither than at 45% wither. When TF content was high, TF:TR ratio reaches closer to 1:10 that results in higher quality (Robert and Smith, 1963).

Table 3. TF content and TF:TR ratio of graded tea processed at three different degrees of wither under commercial scale experiment

Degree of wither (%)	Tea grade					
	BOP		BOPF		Dust No. 1	
	TF	TF:TR	TF	TF:TR	TF	TF:TR
40	4.50 <i>a</i>	1:12.43 <i>a</i>	4.61 <i>a</i>	1:14.43 <i>a</i>	4.72 <i>a</i>	1:14.69 <i>b</i>
43	3.66 <i>a</i>	1:14.83 <i>a</i>	3.84 <i>ab</i>	1:15.15 <i>a</i>	4.11 <i>ab</i>	1:16.66 <i>ab</i>
45	3.50 <i>a</i>	1:15.72 <i>a</i>	3.67 <i>b</i>	1:15.52 <i>a</i>	3.66 <i>b</i>	1:18.38 <i>a</i>

Means with a same letter within the column are not significantly different at $P < 0.05$

Table 4 presents the price of BOP, BOPF and Dust No. 1. No significant difference was observed for all three main grades produced at three different degrees of wither studied. Nevertheless, BOP, BOPF and Dust No. 1 grades at 40% degree of wither fetched comparatively higher prices than other two degrees of wither.

Table 4. Mean price of BOP, BOPF and Dust No. 1 processed at three different degrees of wither in commercial scale experiment

Degree of wither (%)	Mean price (Rs.)		
	BOP	BOPF	Dust No. 1
40	326.07	326.67	398.33
43	315.00	320.00	385.00
45	307.50	317.50	376.67

CONCLUSIONS

Results of the laboratory scale experiment concluded that the overall quality of tea processed at 36% and 47% degrees of wither is poorer than that of tea processed at 40-45% degrees of wither. Further investigation by commercial scale experiment revealed that the optimum degree of wither for production of good quality tea by Orthodox Rotorvane mix type of tea processing is 40-43%.

ACKNOWLEDGEMENTS

The authors wish to express their gratitude to Mr. Yshan Fernando, Forbes & Walker Tea Brokers (Pvt) Ltd. and Mr. Anil Cook, Asia Siyaka Commodities (Pvt) Ltd for tasting the tea samples of this research project. The authors would also like to acknowledge Mr. Mahasen Ranathunga, Senior Research Officer, Plant Breeding Division in TRISL, for the support given to analyze the data.

REFERENCES

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

De Silva W C A and Kirtisinghe D 1966 The influence of the degree of wither in the rotorvane manufacture of high-grown leaf. *Tea Quarterly*. 37(3), 114–120.

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

Muthugalage M P U A 2008 Evaluation of dhool out-turn and grade out-turn using roll breaker mesh no. 3 and 4 combinations in Low country tea manufacture. Proceedings of 8th Agricultural Research Symposium in Wayamba University, 13rd -14th August 2008, Makandura Wayamba University of Sri Lanka. 345-349.

Owuor P O 1987 The evaluation of photometric methods and organoleptic assessment for optimizing fermentation during black tea manufacture. *Tea*. 8(1), 21–26.

Robert E A H and Smith R F 1963 The pheolic substances of manufactured tea. IX. The spectrophotometric evaluation of tea liquorors. *J. Sci. Food Agric*. 14, 689-699.

Sanderson G W 1965 On the chemical basis of quality in black tea. *Tea Quarterly*. 36(4), 172-182.

Thevathasan A and Kirtisinghe D 1974 On the method of Orthodox manufacture and its effect on grade outturns and made tea characteristics. 1. Influence of withers and rolling process on dhool and grade outturn and made tea characteristics. *Tea Quarterly*. 44 (2 & 3). 122–127.