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Effect of Plucking Standard on Quality and Profitability of Made Tea Produced in the Up Country Dimbulla Region During the Cropping Season

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ABSTRACT. Effect of three plucking standards, bud and two leaves (B+2), bud and three leaves (B+3) and normal estate plucking comprising 60-65% tender shoots on the theaflavins (TF) and thearubigins (TR) contents, total colour (TC) and brightness (BR) of black tea was tested. The black tea samples were evaluated by the tea tasters. Total yield of black tea and percentages of main grades BOP (Broken Orange Pekoe), BOPF (Broken Orange Pekoe Fannings) and Dust 1 and off grades, BP (Broken Pakoe), BM (Broken Mixed) and Fannings 2 resulting from each plucking standard were recorded. Profitability of black tea manufactured from each plucking standard was calculated.

Normal estate plucking produced a significantly higher yield of black tea (4.5 kg/round) than B+2 (3.5 kg/round) and B+3 (3.7 kg/round). No significant difference in the percentages of main and off grades among three plucking standards was observed. Comparison of quality parameters showed a significantly higher TF, TC and BR contents in B+2 and B+3 than in normal plucking. The lowest TR% was obtained for teas produced from B+2 (14.20%), which was significantly different from B+3 (15.73%) and normal plucking (15.64%). The price obtained for three plucking standards showed no significant difference among them. However, B+2 fetched the highest price (Rs. 86.06) where as the lowest price (Rs. 84.50) was obtained for normal plucking standard. Teas produced from normal plucking achieved Rs. 54,449/- net return which was the highest compared to B+2 (Rs. 38,724/-) and B+3 (Rs. 40,559/-) plucking standards though quality of made tea produced from B+2 and B+3 were high. Therefore, normal plucking can be recommended for the up country Dimbulla region for the cropping season as the plucking standard.

INTRODUCTION

Tea is a popular beverage throughout the world due to its desirable flavour and liquor characteristics. Even though tea has been consumed in China as early as 350 BC, it became popular only in the 18th century when tea manufactured in India was exported to the United Kingdom.

Tea plant (*Camelia sinensis*) is grown from almost the sea level to about 2000 m above mean sea level in Sri Lanka. Tea growing areas in Sri Lanka can be broadly categorized into three regions depending on the elevation. These regions are up country

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(>1200 m), Mid country (600-1200 m) and Low country (600 m >). Tea manufactured in the up country area is known for its flavour characteristics, mid country for liquor properties and low country for made tea leaf appearance.

Two distinctive seasons, the flavour and the cropping seasons, influence the quality of tea produced in the up country Dimbulla region. The flavour season falls between January to March for the Dimbulla region (Wickremasinghe, 1975). The cropping season occurs from April to December. Withering, rolling, fermenting and firing are the major steps in black tea manufacture (Yamanishi *et al.*, 1989). Proper control of the manufacturing steps results in good quality tea, only if good quality of tea leaves are used. As such, standard of plucking, which determines the quality of leaf plays a major role in the quality of made tea. Proper standard of plucking also ensures substantial increase in yield and maintains the tea bush in good health (Odhiambo *et al.*, 1988). Rate of shoot growth, which influences plucking is affected by temperature, rainfall and the day length prevailing during the cropping season (Kandiah and Thevadasan, 1980).

Many chemical and biochemical reactions take place in the tea leaves during processing (Wickremasinghe, 1978). Plucking of undamaged, tender leaf contributes to good quality tea, as the chemical constituents necessary for quality are present at appropriate levels. Coarse plucking contributes to poor quality tea, as some chemical constituents masks the effect of desirable chemicals responsible for good quality (Basu and Choudhury, 1984).

Fine plucking is essential to produce flavoured tea during the flavour season. However, producers do not pay much attention to the plucking standard during the cropping season. As a result, tea price during this period is low. Unlike in the dry season, the third leaf of the shoot is tender during the cropping season. Therefore, the third leaf can also be plucked. However, its effect on quality has not been studied. Moreover, the effect of plucking standard on quality and profitability during the cropping period is also not available for the Dimbulla region. This study was undertaken to investigate the effect of three different standards of plucking, namely bud and two leaves (B+2), bud and three leaves (B+3) and normal estate plucking (60-65% tender shoots) on quality and profitability of black tea during the cropping season for the Dimbulla region.

MATERIALS AND METHODS

Initially a survey was carried out to find out the percentage distribution of the seedling and clonal tea in the Dimbulla region. Results of the survey revealed that the Dimbulla tea growing region consists of 52% seedling tea and 48% VP tea. The most popular clones in this region were TRI 2025, DT 1 and TRI 2024 and their percentage distribution was 30, 11 and 7 respectively. The experiment was conducted at the St. Coombs estate, Talawakelle from April to December in 1992. Experimental plots consisting of seedling (52%) and VP plants (30% 2025, 11% DT 1 and 7% 2024) were demarcated. Three thousand and fifty bushes were chosen for the whole trial and the selected fields were in the second year of the pruning cycle. Seedling and clonal fields were in close proximity. Three plucking standards used as treatments in this study were, two leaves and a bud (B+2), three leaves and a bud (B+3) and normal plucking which consists of about 60% B+2, B+3 and tender dormant shoots. Randomized complete block design was applied in this study and each trial was considered as block. Analysis of

Variance Procedure was used to analyse the data. SAS program (DOS version) was used for the calculation.

Yield data of tea flush plucked from each experimental plot was recorded at weekly intervals. The tea flush from experimental plots was manufactured every fortnight using an experimental scale Orthodox roller (capacity with 15 kg withered leaf). The yield of made tea samples for each plucking standard was recorded and then tea was graded. The BOP fractions of the graded tea samples were analysed for chemical quality parameters theaflavins (TF), thearubigins (TR), total colour (TC) and the brightness (BR). The same tea samples were also sent to professional tea tasters for evaluation.

Analysis of physical and chemical parameters

Yield of green leaves was recorded weekly and made tea yield was recorded every fortnight. The outturn was defined as the weight percentage of green leaf and made tea and it was calculated for each plucking standard. Made tea samples were separated into seven grades namely BOP, BOPF, Dust 1 (main grades), BP, BM, Fannings (off grades) and refuse tea. Grade percentage of different grades from each plucking standard was also calculated. Quantitative estimation of TF, TR, TC and BR was carried out by the method of Roberts and Smith (1963) as shown in Fig. 1. The absorbance values of the solutions A, B, C and D (Fig. 1) were spectrophotometrically measured at 380 nm and 460 nm respectively. The TF, TR, TC and BR were calculated using the equations given below:

$$TF\% = 2.25\, E_{C,380}$$

$$TR\% = 7.06\,(E_{A,380} - E_{C,380} + 1.77\, E_{D,380})$$

$$TC = 6.25\,(E_{A,460} + 2\, E_{B,460})$$

$$BR\% = 100\, E_{C,460} / (E_{A,460} + 2\, E_{B,460})$$

Where;

$E_{A,380}$, $E_{C,380}$ and $E_{D,380}$ - The absorbance values of solutions A, C and D at 380 nm respectively.

$E_{A,460}$, $E_{B,460}$ and $E_{C,460}$ - The absorbance values of solutions A, B and C at 460 nm respectively.

Coded samples from each occasion of manufacture were tasted in triplicate by professional tea tasters in Colombo and their evaluations were recorded in a semi quantitative form (Appendix 1). Each characteristic was judged on a Hedonic scale (Charley, 1978).

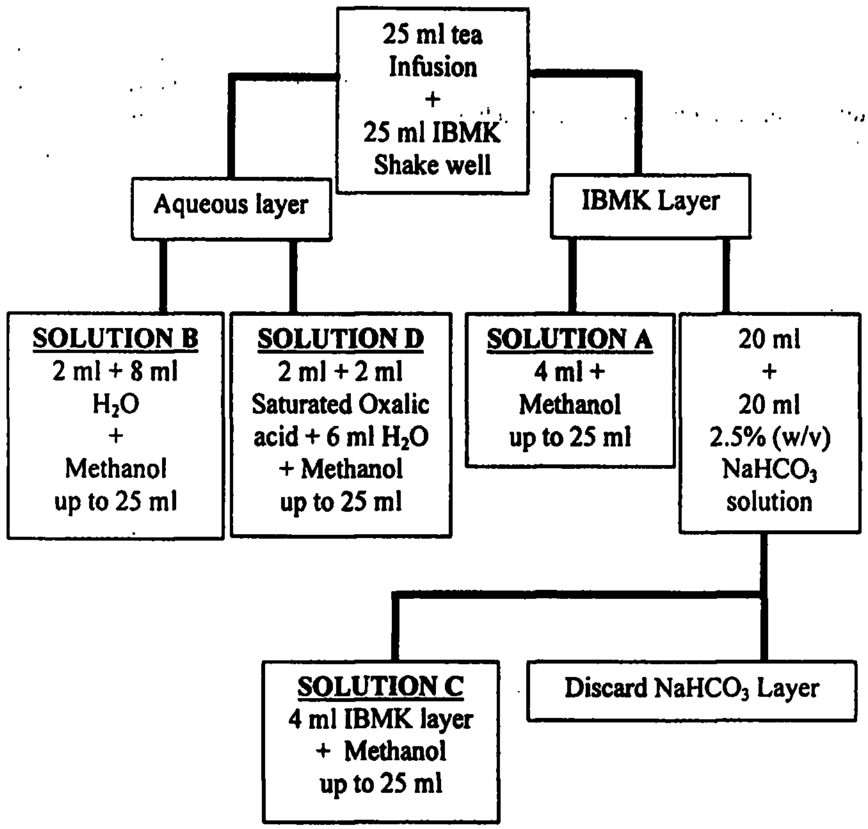

Fig. 1. Flow diagram for analysis of TF, TR, TC and BR in tea liquor (Roberts and Smith method, 1963).

Profitability was calculated using the following equation formulated by the Agricultural Economics Unit, TRI.

$$R = \sum_{i=1}^{n} P_i Q_i - Y(O \times W/I + M)$$

R = Net Return
P_i = Price of individual grades (Rs/kg)
Q_i = Quantity of individual grades (kg)
Y = Graded tea yield (kg/ha)
O = Outturn (green leaf/made tea)
W = Wage rate (Rs/kg)
I = Plucker intake (kg/day)
M = Manufacturing cost (Rs/kg)

The wage rate and the manufacturing cost were considered as constants. One kilogram of refuse tea was valued at Rs. 14/=.

RESULTS AND DISCUSSION

Normal plucking resulted in a significantly higher yield ($p<0.05$) than B+2 and B+3 plucking (Table 1). The higher yield for normal plucking may be due to non selective nature of this plucking standard, which included about 60% tender shoots and 40% coarse leaves comprising single leaves and shoots with three leaves and a bud (third leaf mature), four leaves and a bud and coarse dormant shoots. Considerable increase in the gross yield when three leaves and a bud, four leaves and bud or more were chosen as plucking standards has been reported (Grice, 1979; Willson and Clifford, 1997; Tskhvediani, 1982). Both B+2 and B+3 plucking standards were selective which included more than 80% of tender shoots resulting in a lower yield than normal plucking. However, the yields between B+2 and B+3 plucking standards were not significantly different at $p<0.05$ (Table 1). This was in agreement with the work of Sharma and Murthy (1994) where no significant difference in yield between the plucking systems of bud and two leaves and bud and three leaves was observed.

Table 1. Effect of plucking standards on total yield and grade percentage of made tea.

Plucking standard	Yield kg/round	Grade percentage				
		BOP	BOPF	Dust 1	Off grade	Refuse tea
B+2	3.5^a	35.7	19.19	10.23	28.93	5.95
B+3	3.7^a	33.51	20.29	10.57	28.43	7.2
Normal	4.5^b	31.1	1870	10.35	31.15	8.7
$LSD_{0.05}$	0.3	ns	ns	ns	ns	ns

B+2 - bud and two leaves; B+3 - bud and three leaves; ns – not significant
Means within a column with different superscripts are significantly different ($p<0.05$).

Percentages of grade mix for three different plucking standards are shown in Table 1. The percentages of main grades (BOP, BOPF, Dust 1), off grades (BP, BM, Fannings) and refuse tea in three plucking standards were not significantly different. However, there is a trend that the main grade percentage of B+2 and B+3 were higher than normal plucking. A higher off grade percentage was showed in normal plucking than B+2 and B+3.

One of the major factors that affects the percentage of main grades and off grades is the standard of plucking. Main grade percentage increases when the amount of tender parts (bud, 1st leaf, 2nd leaf, tender stems, tender 3rd leaf *etc.*) of the shoots in the leaf mixture increases. A decrease in main grade percentage with coarser plucking has been reported (Grice, 1979). Tea liquor prepared from main grades has more strength and colour compared to the tea liquor from off grades. However, the percentage of main grades (BOP, BOPF, Dust 1), off grades (BP, BM, Fannings) and refuse tea of the plucking standards used in this study was not significantly different ($p<0.05$) (Table 1).

Theaflavins (TF) and thearubigins (TR), two-principle group of compounds responsible for colour and brightness of tea liquor, are produced by enzymic oxidative condensation reactions taking place during fermentation (Sanderson *et al.*, 1972). Flavanols are the major group of polyphenol compounds in fresh tea leaves and are converted to TF and TR during black tea manufacture. The proportion of these two group of compounds present in tea brew determine the strength, colour, brightness and thickness of tea brew. Therefore, during cropping season price of the tea mainly depends on the proportion of these two groups of compounds in the tea brew.

The composition and content of flavanols affect the amount of TF synthesized during fermentation (Graham, 1983). Tender tea leaves contain a higher amount of flavanols than coarse tea leaves (Sanderson and Sivapalan, 1966). The TF content obtained for B+2 and B+3 plucking standards was significantly higher ($p<0.05$) than normal plucking standard. However, no significant difference ($p>0.05$) were seen between B+2 and B+3. This clearly indicated the relationship between TF content and standard of plucking where the TF content increased when the plucking standard become more and more selective. A similar observation has been made by Owuor and Chavangii (1986) in which the TF content decreases with increase in the coarseness of plucking standard.

A positive correlation between TF content and brightness of tea liquor has been reported (Roberts and Smith, 1963; Takeno *et al.*, 1964). A similar relationship between TF% and brightness was observed in this study, where B+2 plucking, which resulted in the highest TF%, produced the brightest tea liquor (Table 2). Moreover, the lowest brightness percentage in tea liquor was observed for tea made from normal plucking which had the lowest TF% (Table 2).

Table 2. Effect of plucking standards on chemical quality parameters.

Plucking standard	Quality parameters				
	TF%	TR%	TC	BR%	TF:TR
B+2	1.26^{a}	14.20^{b}	4.44^{b}	25.97^{a}	0.049306
B+3	1.25^{a}	15.73^{a}	4.61^{a}	24.74^{ab}	0.050694
Normal	1.13^{b}	15.64^{ab}	4.31^{b}	23.75^{b}	0.051389
$LSD_{0.05}$	0.08	0.09	0.16	1.5	

B+2 - bud and two leaves; B+3 - bud and three leaves; ns – not significant
Means within a column with different superscripts are significantly different ($P<0.05$).

A significantly lower ($p<0.05$) TR% was resulted by B+2 than by the other plucking standards (Table 3). TR% between normal plucking and B+3 was also significantly different ($p<0.05$) (Table 2). The relationship observed between plucking standard and TR% was different from the relationship between plucking standard and TF%. This may be due to the structural complexity of TR, which is heterogeneous group of chemical compounds. Robertson (1983) suggested that intermediates of TF, catechins and breakdown products of TF are directly involved in producing TR compounds. Moreover, composition of catechins, availability of oxygen, temperature and pH of the fermented dhool has been reported to affect TR formation during fermentation. Plucking standard B+3 resulted in a significantly higher ($p<0.05$) TC of tea liquor than the other plucking standards probably due to the high TR% (Table 2). However, TC between B+2 and normal plucking was not significantly different ($p>0.05$) though TR% was significantly different ($p<0.05$) in the tea produced from these standards. This indicates that TC of tea liquor not only affect TR% but also TF%. Millin (1987) also reported a direct effect TF and TR on colour of tea liquor. TC, liquor strength expressed as TF:TR and BR% improves with the progress of fermentation. However, BR% and TF:TR decline beyond a certain point of fermentation. The ratio between TF and TR contents determines the strength of liquor, which reflects the astringency and brightness of tea liquor. Decrease in this ratio reduces the brightness and increases total liquor colour. Roberts and Smith (1963) pointed out that over fermented teas give dull brownish liquor consisting of a lower ratio of TF to TR (*eg*. TF:TR = 1:16 – poor quality, strength of the liquor of a good tea is around 1:10). Roberts and Smith (1963) reported that the over fermented tea resulted in a low TF:TR of 1:16 and dull brownish liquor (strength of the liquor of a good tea is around 1:10). TF:TR is also an important parameter which affects the tasters' score and tea price evaluated by the tea tasters.

It was revealed that plucking standards did not have a significant impact ($p<0.05$) on both tasters' score and price evaluation (Table 3), which were based on quality characteristics such as strength, colour and brightness of tea liquor and also the market conditions prevailing at the time of tasting. Both taste score and prices of teas did not show significant difference between treatments. However, a trend was observed where selective plucking standards (B+2 and B+3) obtained higher values for both tasters' scores and prices.

Table 3. Effect of plucking standards on tasters' score and price of made tea evaluated by the Tea Tasters.

Plucking standard	Tasters' score	Price (Rs.)
B+2	15.95	86.06
B+3	15.9	85.02
Normal	15.1	84.5
$LSD_{0.05}$	ns	ns

B+2 - bud and two leaves; B+3 - bud and three leaves; ns - not significant

Profitability was calculated using the equation formulated by the Agriculture Economics Unit, TRI, and the results are given in Table 4. Normal plucking resulted in a higher tea sale and refuse tea income, but lower price per kg of made tea than B+2 and B+3. However, normal plucking fetched the highest total income than that of B+2 and B+3. This is due to the higher total yield of normal plucking than B+2 and B+3, caused probably by comparative selectivity in plucking of the former than the latter.

Table 4. The profitability of made tea in three different plucking standards.

Parameters	Plucking standard B+2	B+3	Normal
Yield (kg/ha/8 months)	947	1003	1132
Price (Rs.)	86.06	85.02	84.5
Tea sale income (Rs./ha/8 months)	81456	85275	95654
Refuse tea income (Rs./ha/8 months)	744	968	1234
Total income (Rs./ha/8 months)	82200	86243	96888
Out turn (GL/MT)*	5.13	5.02	4.95
Wage rate (Rs./day)	83	83	83
Plucker intake (kg GL/day)	13	13	17
Manufacturing cost (Rs./kg MT)	13.5	13.5	13.5
Total cost (Rs./ha 8 months)	43476	45684	42439
Net return (Rs./ha/8 months)	38724	40559	54449

B+2 - bud and two leaves; B+3 - bud and three leaves

* GL/MT - define the ratio between green leaf and made tea weight in kilograms

The higher prices obtained for teas from B+2 and B+3 were not enough to generate sufficient income to compensate the lower yields obtained from selective plucking involved in B+2 and B+3 plucking standards. The made tea outturn (amount of green leaf required to produce 1 kg of made tea) for B+2, B+3 and normal plucking was 5.13, 5.02 and 4.95 GL/MT respectively. The average moisture in the green leaf of normal plucking was low due to higher amount of coarse leaf present and this could be the reason for high outturn obtained for normal plucking compared to the other plucking standards. The percentage of refuse tea produced from normal plucking was higher than that made from the other two standards of plucking. Both plucker intake and outturn are important parameters responsible for the calculation of plucking cost. With the increase in plucker intake or decrease in outturn, the plucking cost would go down. The cost of manufacture for all the treatments could be considered the same since the manufacturing conditions employed were similar for all treatments. Therefore, plucking cost directly affected total cost of production, which was calculated by multiplying yield by the cost of production per kg made tea. Normal plucking resulted in a lower cost of production than B+2 and B+3 (Table 4), which was in agreement with the findings of Sharma and Murthy (1994). Based on the net outturn, normal plucking incurred higher profitability than B+2 and B+3. This was mainly due to higher yield and fairly large plucker intake of normal plucking. Net returns for B+2 and B+3 were almost the same. Results on profitability revealed that normal plucking was a better plucking standard than B+2 and B+3 for the up country Dimbulla region.

CONCLUSIONS

Normal plucking standard achieved significantly higher yield than the B+2 and B+3 plucking standards, which had a significant effect on the profitability. The teas produced by adapting normal plucking gave lower main grade percentages as result of high coarse leaf content in this plucking standard. The quality of the teas produced by adopting the B+2 and B+3 plucking standard was significantly higher than teas from normal plucking and this was reflected on the tasters' evaluation. Interestingly there was no significant price difference between teas produced from the B+2 and B+3 plucking standards indicating incorporation of the third leaf has little effect on quality during cropping season. When the profitability of teas produced from different plucking standards was compared, teas from normal plucking achieved the highest net return due to higher yields obtained. Therefore, it can be concluded that though the teas produced from B+2 and B+3 plucking standards had better quality and fetched higher prices, that could not compensate for the yield loss due to selective plucking adopted in the B+2 and B+3 plucking standards.

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APPENDICES

Appendix 1. A typical tasting (semi quantitative) form used by tea tasters.

Sample number								Appearance
INFUSED LEAF	Very Dull							....
	Dull							
	Fair colour							
	Fairly bright							
	Quite bright							
	Bright							
	Very bright							
COLOUR	Very light							....
	Rather light							
	Light							
	Fair colour							
	Quite fair colour							
	Coloury							
	Very coloury							
STRENGTH	Very light							....
	Rather thin							
	Thin							
	Fair strength							
	Quite fair strength							
	Useful strength							
	Strong							
	Very strong							
QUALITY	Plain							....
	Rather plain							
	Very little quality							
	A little quality							
	Some quality							
	Fair quality							
	Quite fair quality							
	Very fair quality							
	Quite nice quality							
	Nice quality							
FLAVOUR	No flavour							....
	Touch of flavour							
	Some flavour							
	Fair flavour							
	Useful flavour							
	Very marked flavour							
VALUATION								
TAINT (Yes/No)								