CHAPTER 5
PROCESS RESEARCH

5. Process Research

Process research is as essential as production research as it has a significant bearing on the quality of made tea. The factory research programme during the period under review therefore aimed at developing improved methods of tea processing to produce a higher quality product at lower production costs. This was achieved through:

- Identifying factors leading to increased market value at each stage in the post-harvest process.
- Investigating methods for maximizing the out-turn percentage of made tea per unit of plucked leaf.
- Establishing ways of reducing costs by improved use of resources
- Developing improved methods of monitoring and controlling tea processing.

5.1 Investigation of Tea Processing Methods

5.1.1 Investigations into the Effect of Maintenance Leaf on the Quality of Made Tea

Background

The inclusion of maintenance leaf is known to affect the briskness and strength of made tea liquors. The presence of under-fermented green flakes gives the liquor a harsh taste, as well as muddy and flat characteristics. As the proportion of maintenance leaf increases, the amount of theaflavin decreases, probably because catechin concentration decreases with leaf age.

An experiment was therefore conducted to determine the minimum amount of maintenance leaf that affects the quality of made tea.

Methodology

Maintenance leaf was added to fresh samples of good leaf from clones SFS 204, PC 108 and SFS 150 at rates between 0 and 20%. The combined leaf was withered and manufactured in the mini-process unit (MPU). The dhool (macerated by CTC) was fermented for 50 minutes (SFS 204 and PC 108) or 70 minutes (SFS 150) at 25C and dried. One made tea sample per batch was analysed for theaflavin content and total colour at TRF. A second sample was sent to a professional taster for organoleptic assessment.

Results

The results from this experiment are presented in Table 5.1. The mean theaflavin content of the three cultivars was reduced by 17% and 34% respectively when 10 and 20% coarse leaf was added. Total colour was also adversely affected. The value of the made tea was reduced from 131 USc with no coarse leaf to 118 and 92 USc respectively when 10 and 20% coarse leaf was added.

Table 5.1 Effect of maintenance leaf on made tea parameters for three different cultivars.

Cultivar	Maintenance Leaf (%)	Total Theaflavin (umol/g)	Totai colour (x10)	Valuation (US cents)
SFS 204	0	25.5	4.6	143
	10	18,2	3.7	123
	20	21.2	3.4	103
	Mean	**21.6**	**3.9**	**123**
PC 108	0	32.1	5.1	135
	10	27.1	4.5	123
	20	15.8	3.4	97
	Mean	**25.0**	**4.3**	**118**
SFS 150	0	13.7	3.0	115
	10	13.9	3.1	107
	20	9.7	2.5	77
	Mean	**12.4**	**2.9**	**100**
Mean of three cultivars	0	23.8	4.2	131
	10	19.7	3.8	118
	20	15.6	3.1	92

5.1.2. Effect of Aeration Time on Quality

The objectives of two experiments to study the effect of aeration time on quality were:

- To assess the effect of aeration time during fermentation on theaflavin (TF) and total colour (TC) formation in made tea.
- To assess whether an excess supply of air during the normal period of fermentation affected the quality of made tea.

Methodology

Experiment 1: Dhool from cultivar SFS 204 was exposed to positive aeration for 5, 10, 15, 20, 25, 30, 35, 40, 45 and 50 minutes immediately after maceration. The fermented dhool was then dried. Made tea samples were analysed for theaflavin content and total colour and also valued by a Broker (TBCA, Limbe).

Experiment 2: Samples of dhool from cultivars SFS 204, SFS 150 and PC81 were exposed to positive aeration for 25, 50, 75 and 100% of the total standard fermentation time immediately following maceration. The standard fermentation times for SFS 204, SFS 150 and PC 81 are 50, 70 and 80 minutes respectively. After fermentation, the dhool was dried. Made tea samples were analysed for theaflavin content and total colour and valued by the Broker.

Results

Experiment 1

Theaflavin formation in SFS 204 was greatest during the first 10 – 20 minutes of the 50-minute fermentation period (Table 5.2). It should therefore be ensured that ample air is available for fermentation in the early stages. Theaflavin formation was almost complete after 25 minutes. Further, fermentation process was continued in order to allow for the subsequent formation of thearubigins. The development of 'quality' during the latter stages of the fermentation was demonstrated by the increasing valuation of the made tea.

Table 5.2 Effect of different amount of aeration on made tea quality parameters of SFS 204

Aeration time	Total TF (umol/g)	Total colour (x 10)	Valuation (USc)
0	7.9	1.6	70
10	14.2	2.5	105
20	22.3	3.6	107
25	25.2	4.3	110
30	25.8	4.4	110
35	26.1	4.8	128
40	26.0	4.5	135
45	26.3	4.8	135
50	25.6	4.6	125

Experiment 2

For cultivar PC 108, aeration for 50% of the fermentation time was sufficient to maximise theaflavin content and the formation of total colour (Table 5.3). However, for SFS 204 and SFS 150, aeration for 75% of the fermentation time was necessary to achieve a TF content and total colour similar to the total fermentation time.

Tea valuations generally reflected the formation of quality parameters, although for clone PC aeration for 100% of the fermentation time appeared to increase the value of the tea without any apparent further enhancement of TF content or total colour beyond the levels achieved with 25 or 50% aeration. There was no indication of any loss in quality due to excessive aeration.

Table 5.3. Effect of aeration on the quality parameters of three cultivars

Cultivar	Aeration time (min)	Total TF (umol/g)	Total Colour (x 10)	Valuation (US cents)
SFS 204	12.5	12.6	2.1	82
	25.0	17.1	2.9	112
	37.5	22.2	4.1	118
	50.0	21.5	4.2	122
PC 108	17.5	10.9	2.1	65
	35.0	11.8	2.3	65
	52.5	14.5	3.0	75
	70.0	13.7	3.0	62
SFS 150	20.0	13.6	2.3	62
	40.0	18.6	3.5	80
	60.0	18.0	3.6	88
	80.0	19.0	3.7	100

Conclusion

There are practical implications from these results. The air supply to the first section of the fermenter must be adequate, as theaflavin formation is greatest during this stage.

5.1.3. The Effects of Fermentation Time on the Made Tea Quality of Mixtures of Two Cultivars

The objective of studying the effects of fermentation time on the made tea quality of mixtures of two cultivars was to determine the effect of processing mixtures of cultivars on the quality of tea using the fermentation time of the slower one.

Methodology

Leaf from cultivars SFS 204 and SFS 150 were mixed in the ratios of 1:0, 3:1, 1:1, 1:3 and 0:1 and developed separately. The green leaf was withered using air at prevailing ambient conditions. The samples were fermented for 0 minutes, dried in a gas burner and the fibre removed using a PVC roller extractor. The made tea samples were analysed for TF content and total colour, and also valued by Brokers' tasting.

Results

The results in Table 5.4 suggest that the presence of even 25% of a better quality cultivar (SFS 204) mixed in with one of inferior quality (SFS 150) raises the value of the made tea considerably – by 11% - despite there being no appreciable effect on total TF content, although the total colour was improved. Additional proportions of better quality leaf has a marginal effect on the value of the made tea, although the pure cultivar SFS 204 achieved the highest valuation of any of the samples.

Table 5.4 Effect of different green leaf mixtures of SFS 204 and SFS 150 on quality parameters of made tea.

Mix of cultivars (%)		Total colour (x 10)	Total theaflavin (mol/g)	Valuation (US cents) per kg
SFS 204	SFS 150			
100	0	4.9	24.1	163
75	25	4.6	21.3	158
50	50	4.7	21.8	158
25	75	4.9	19.5	156
0	100	11.4	20.2	140

5.1.3 Studies of the Effect of Temperature on Fermentation

An experiment was conducted to study the effect of temperature on quality of tea. To achieve this objective, optimum combinations of temperature and time for the fermentation period were determined.

Methodology

Leaf was withered normally and then macerated using three passes through a CTC. The resulting dhool was fermented at three temperatures (20, 25 and 30°C) and over four time periods (30, 40, 50 and 60 minutes). Drying was done using a mini fluid bed dryer. Two replicates were prepared for each treatment. Made tea samples were analysed for total theaflavin content and total colour, and also valued by a Broker.

Results

The highest theaflavin content was achieved when the dhool was fermented at 20°C and the highest total colour when fermented at 30°C (Table 5.5), suggesting that in order to allow full development of theaflavins (which are responsible for the briskness and brightness of the made tea liquors) dhool temperatures must be reduced as quickly as possible following maceration; dhool fermented at higher temperatures result in dull liquors.

The made tea valuations show that dhool fermented at a higher temperature and for a short period (30 minutes at 30°C), as well as at a lower temperature for a long period (60 minutes at 20°C) were not valued highly, as compared to those fermented at the standard time and at medium temperature (50 minutes at 25°C).

5.5 *Effect of temperature and fermentation time on made tea valuations*

Fermentation		TF content	Total colour	Briskness	Strength	Brightness	Valuation (US cents)
Temp (ºC)	Time (min)	(unol/g)	(x 10)				
20	30	23.5	3.3	1.5	4.0	2.5	105
25	30	23.7	3.5	1.0	4.0	2.5	105
30	30	24.1	3.8	2.5	4.5	1.5	118
20	40	24.7	3.5	2.0	5.0	3.0	130
25	40	26.2	3.9	2.0	5.0	2.5	140
30	40	25.2	4.2	3.0	5.0	3.0	140
20	50	26.3	3.9	3.0	5.0	3.0	150
25	50	26.2	4.4	3.0	4.5	2.5	140
30	50	23.3	4.5	2.5	5.0	3.0	135
20	60	25.8	4.3	2.0	5.0	2.0	120
25	60	24.7	4.5	2.0	5.0	2.0	120
30	60	22.0	4.6	3.0	5.0	2.0	130

Conclusion

In a study of the development of theaflavins, Jose (1999) found that these compounds reach a maximum concentration approximately 20 – 30 minutes after the commencement of fermentation. It is therefore essential to regularly monitor dhool temperatures in order that proper control measures may be implemented, such as opening of air vents and maintaining the correct depth of dhool in the fermenter.

5.1.4 Two-Stage Chemical Withering

Two-stage chemical withering affects the quality of tea. Two separate experiments were therefore conducted to determine the effect of including a chemical withering stage on the quality of made tea, as compared to physical wither alone. *Chemical wither* refers to the biochemical transformation, which occurs within the leaf after being plucked, whereas *physical wither* refers to loss of moisture in the green leaf.

Methodology

Two separate experiments were conducted using TRF's mini processing unit applying cultivars SFS 204 and PC 81. In both experiments, standard plucking was used to obtain the leaf using three leaves and a bud. The buckets for chemical wither were covered and aerated only during the first two hours, in order to cool down the leaf and prevent red leaf formation. After 18 hours, dry air at 35ºC was passed through the buckets to bring the moisture content down to 71%. Three replicates for SFS 204 and two for PC81 for each wither treatment were used. This took one hour and 10 minutes. The buckets for normal wither were not covered and air was passed through for 10 minutes every hour until the moisture content was down to 71%. The times were 50 minutes for SFS 204 and 80 minutes for PC 81. The fermented dhool was dried in a mini fluidised bed dryer. The made tea samples were analysed for theaflavins and valued by a broker.

Results

For SFS 204, the wither method made no difference to price, whereas for PC 81, the chemically withered tea was valued about 12% higher than that produced using the normal method of withering (Table 5.6 and 5.7). The various made tea attributes upon which the valuation was based, particularly strength and briskness, were not markedly affected by the wither method, nor was the total theaflavin content. If a chemical wither can produce teas at least of similar quality to those from a normal wither, it may possibly be considered as a means of withering during the peak season.

Table 5.6 The effects of chemical wither on the made tea quality of SFS 204

Wither method	Strength of liquor	Colour of liquor	Brightness	Briskness	Total colour	Total TF (umol/g)	Value (USc)
Chemical	60	50	3.0	4.0	5.1	28.8	195
Normal	60	50	3.5	3.5	4.6	27.9	195

Table 5.7. The effects of chemical wither on the made tea quality of PC 81

Wither method	Strength of liquor	Colour of liquor	Brightness	Briskness	Total colour	Total TF (umol/g)	Value (USc)
Chemical	4.0	4.0	2.5	2.5	4.7	19.8	140
Normal	4.0	4.0	2.0	2.0	4.0	20.3	125

5.2 VSTP Evaluation

A VSTP (Vertical Sniechowksi Tea Processor) is a tea cutting machine with a vertical orientation, manufactured in Argentina (Insumos Agroindustrales, Zona Centrol RL, Rivadavia 946, Obera, Missiones, Argentina).

During the period under review, there was an on-going assessment of the VSTP macerator in comparison to an LTP at the Manufacturing Research Facility. 1500kilogram batches of green leaf from both vegetatively propagated cultivar tea and seedling tea were withered using ambient air to a moisture content of 71%. During manufacture, dhool temperatures at the mouth of the cutting unit and dhool moisture content were determined every 30 minutes. Fermentation of the dhool was for the standard times for each leaf type. Drying was done in fluidised bed dryers. Fibre removal and sorting of the made tea was done sequentially from the two lines. The resulting grades were kept separate, and invoices were produced for all teas run on VSTP and LTP cutting methods.

Results

Auction valuations

The auction results showed that the VSTP had the potential to produce high quality tea, although not always consistently (Table 5.8).

Table 5.8 Auction valuations for PF1 grade teas produced using the VSTP and LTP cutting methods

Sale date	invoices	VSTP	LTP
7/3/2000	1	188	180
	2		187
14/3/2000	1	130	151
21/3/2000	1		
	2	190	191
28/3/2000	1	160	165
	2		160
4/4/2000	1	155	155
	2		130
2/5/2000	1	130	130
	2	191	130
	3	180	135
Mean		166	156

Main Grades

The average main grade yield for the VSTP and LTP cutting methods did not differ significantly (Table 5.9). The highest average main grade yield difference recorded was only 3.0% (for PF1). BP1 and PF1 grade yields from the LTP were slightly higher than those from VSTP, but this was compensated for by slightly higher PD and D1 percentages from the VSTP.

Table 5.9 Main grade yield or VSTP and LTP manufactured made tea

Leaf type	cuter	Total main grade (%)	BP 1 (%)	PF 1 (%)	PD (%)	D 1 (%)	Dhool temp (ºC)
Clonal	LTP	83.9 (6.2)*	1.8 (0.9)	60.5 (8.5)	8.6 (3.4)	13.0 (5.5)	37.0 (2.2)
	VSTP	82.8 (6.3)	1.3 (0.9)	57.8 (6.4)	9.8 (2.2)	13.8 (3.4)	34.8 (1.7)
Seedling	LTP	79.9 (9.2)	2.0 (1.1)	57.3 (9.6)	8.1 (5.2)	12.5 (5.6)	37.3 (2.2)
	VSTP	83.4 (6.0)	1.6 (0.9)	58.0 (5.5)	8.5 (3.9)	15.2 (4.3)	34.7 (1.4)

NB: Figures in the brackets indicate the standard deviation.

Dhool Temperature

The average temperature of the dhool emerging from the VSTP was 2.0-2.5ºC lower than that from the LTP, which may be in part responsible for the higher prices obtained by the VSTP cutting method.

Maintenance

Unlike LTP beaters and knives, which require refurbishment once every 1 – 2 weeks, the VSTP beaters and knives have been used since installation without any refurbishment apart from minor adjustment.

5.3 Tea Drying

A study of tea drying was conducted by Temple in the year 2000. The problem of the variation in moisture content at the drier mouth was addressed, with the aim of devising a control system. To assist in understanding the process, a simulation model was developed and validated. The finding was used to develop a temperature feedback system to improve control. The robustness of this system was tested under various operating systems.

The simulation model was also used to compare different drying systems currently used in the tea industry. The fluidised bed dryer with re-circulation was found to give the best results.

As part of the study, the methods of monitoring the stages in tea processing were improved, including the development of the 'SLOGGER' system.

5.4 Fermentation studies

A study of the physical properties of dhool was conducted by van Dijk (2001). The main findings were:

- During fermentation, the dhool loses about 1% moisture, as compared to 3.4% during maceration.
- The dhool temperature rises at the beginning of fermentation, and subsequently decreases to near the ambient wet bulk temperature. This rise and fall is accelerated by increasing the air velocity through the dhool.
- The final theaflavin content of the made tea was not affected by either airflow or moisture loss.

5.5 Publications

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