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The effects of blending clonal leaf on black tea quality

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Abstract

Although most clones are selected for quality and yields, there are clones in production with superior yields but producing inferior black tea quality and *vice versa*. Some of these clones with superior yield give very poor black tea quality characteristics. Such clones are normally not progressed in selection programmes. Blending the clonal leaf prior to maceration results in the production of black teas with average quality relative to the amount of the clonal leaf in the mixture. There is no evidence of clonal incompatibility. Slow fermenting clones with superior yields may therefore be selected and planted, provided they are not planted in single stands. © 1999 Elsevier Science Ltd. All rights reserved.

1. Introduction

Cultivation of tea has undergone dramatic transformation in terms of plants used. Whereas the early plantations were wholly from seedling material of unproven quality and yields, recent planting is done using vegetatively produced clonal tea. Thus, seedling teas are now used only for breeding purposes. The transformation from seedling to vegetatively-produced clonal plants has been made necessary by many factors. The seedlings took over three years from propagation to reach the size for planting in the field (Eden, 1954; Child, 1955; Othieno, 1981). Vegetatively-produced clonal plants, however, take as little as nine months after propagation to be ready for planting in the field (Goodchild, 1960; Othieno, 1981; Green, 1964; Njuguna, 1988, 1992). The change has drastically shortened the juvenile stages of the plants in the nursery, helped to cut down the costs of running tea nurseries and made the expansion of tea cultivation a faster process. Because vegetatively-produced plants are obtained from plants with known agronomic advantages, they are used either because they are high yielding or lead to good quality or resist some adverse environmental hazards or give a combination of the above characteristics. Such agronomic advantages are of economic value. In most breeding programmes, attempts are made to select plants that possess a combination of the above characteristics (Wachira, 1994; Seurei, 1996; Othieno, 1992; Green, 1971).

Occasionally clones are produced which either have very high yields but produce poor quality or *vice versa*. The economics of tea production have yet to clarify when to ignore the selection of high-yielding but poor quality or high quality but low-yielding clonal teas. Thus, there are producers processing such tea clones in mixtures while others process them as separate clonal teas. Where clones with large variations in quality characteristics are produced separately and the final products mixed, uneven quality black teas result. Where clonal leaf is mixed prior to processing, some producers speculate that some clones may not be compatible, low quality clones exerting dominant effects on the good quality clones, thus reducing the overall quality of the resultant black teas. These claims are, however, unproven.

For small-holder tea producers in Kenya, the recommendation is that when buying and/or propagating clonal material for planting, the design should be such that the clones are planted in mixtures. This is to safe-guard the farmers from total loss due to natural hazards like drought, pests and diseases. Indeed, in recent studies some clones susceptible to natural hazards like drought (Green, 1971; Njuguna, 1982), pests (Othieno, 1992; Sudoi, 1990; Sudoi, Khaemba, & Wanjala, 1994), and diseases (Othieno, 1992; Otieno, 1996) have been identified in Kenya. When the clones are planted in mixture, it is impractical to harvest the individual clones separately, as could be done if the clones were planted in pure stands. It is not documented whether planting clones in mixtures results in quality averaging or whether there

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are clones whose black tea quality characteristics dominate other clones.

It has been observed that, when processed separately, some clones, planted in pure stands, are not easily blended with others into a uniform black tea (Owuor, unpublished). This is particularly so when mixing a clone that generally makes black tea of low bulk density with one with high bulk density. Indeed, the mixing of such clones results in made black teas that are of uneven appearance, and hence reduced in price, even when their chemical quality parameters are ideal.

There are clones which show very high yield potential, but are poor fermenters, as assessed by chloroform test. Such clones are normally not progressed in breeding trials to stages where their true yields can be assessed, because it is assumed there would be no practicable method of processing such clones into black tea.

A processing experiment was done using combinations of clonal leaf materials in different ratios to assess the effect of mixing clones on black tea quality; whether a clone can have a dominant quality effect when mixed with another prior to maceration; whether there is noticeable unevenness in the black tea produced due to mixing the clonal leaf prior to maceration; and whether poor fermenting clones can be processed normally after blending the leaf.

2. Materials and methods

Clonal leaf was plucked from the clonal field trials and clonal herbarium at the TRFK, at an altitude of 2178 m above mean sea level, latitude 0°15′ South and longitude 35°21′ East. The plants were in normal production and were receiving NPKS 25:5:5:5 fertilizer at 150 kgN $ha^{-1}year^{-1}$ applied in a single dose. Leaf was plucked to conform to normal plucking standards of over 70% acceptable leaf of up to two leaves and a bud. Clones used were 12/2, 6/8, S15/10 and SC12/28 in combinations of 12/2 and 6/8; S15/10 and 6/8; SC12/28 and S15/10. S15/10 and 6/8 were mixed so that there was 0, 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100% of Clone 6/8, while S15/10 and SC12/28 were mixed in the ratio 100, 90, 10, and 0% S15/10. Clones 6/8 and 12/2 were mixed in the ratio 0, 25, 75 and 100% 6/8. Each treatment weighed 600 g fresh leaf and was processed in triplicate.

Table 1
Characteristics of clones used

Clone	Characteristics
6/8	This is a fast-fermenting, good quality clone. However, it is of moderate yield and is known to be drought-susceptible (Njuguna, 1982). In most Tea Research Foundation of Kenya trials it is used as quality standard
12/2	This is a poor-fermenting clone which cannot even pass the chloroform test. It therefore could not be assessed for yield potential, which remains unknown
S15/10	This is a high yielding clone and up to 10,995 kg made tea per hectare has been obtained from it under commercial production (Oyamo, 1992). It is however, a relativelyslow fermenter and very difficult to blend into other black teas when processed separately
SC12/28	This is a high yielding and fast-fermenting clone

The leaf was withered for 14–16 h to achieve 70–72% physical wither, followed by CTC maceration. For the mixture of 12/2 and 6/8 and S15/10 and 6/8, fermentation was done for 90 min. The unique characteristics of the clones are presented in Table 1. For the S15/10-SC12/28 mixtures, fermentations were done for 90 and 150 min. Fermentation was terminated by firing using miniature fluid bed dryer (Teacraft, UK), with inlet air temperatures set at 120°C until the exhaust temperature reached 50°C, followed by lowering the inlet air temperature to 90°C until the exhaust temperature reached 80°C, by which time the ‘dhool’ had dried into black tea with a moisture content between 2.5 and 3.5%.

The black teas were subjected to chemical analyses and sensory evaluations without sorting. Theaflavins and brightness were assayed by the Flavognost method (Hilton, 1973), and thearubigins and total colour by the Roberts and Smith method (Roberts & Smith, 1963). The volatile flavour compounds (VFC) were extracted by the modified Likens and Nickerson (1964) apparatus, as explained by Baruah, Hazarika, Mahanta, Horita,

Table 2
Effects of mixing leaf from clones 12/2 and 6/8 in different ratios on black tea quality parameters

Mixture (%)		Theaflavins ($\mu mol\ g^{-1}$)	Thearubigins (%)	Brightness (%)	Total colour (%)	Flavour index	Sensory evaluation	
6/8	12/2						Taster A	Taster B
0	100	4.43	7.68	16.01	1.48	1.70	37	20
25	75	9.32	9.78	17.84	2.26	1.93	82	30
75	25	14.7	13.1	22.45	3.18	1.96	138	43
100	0	17.3	13.6	23.47	3.43	3.13	141	45
SE	–	2.26	1.96	1.67	0.36	0.33	37	4
LSD ($p \leq 0.05$)	–	3.62	3.15	2.68	0.58	0.66	59	11

Table 3
Variation of clonal tea quality by blending leaf from Clones 6/8 and S15/10 during manufacture

%		Theaflavins (μmol g^{-1})	Thearubigins (%)	Brightness (%)	Total colour (%)	Flavour Index	Sensory evaluation	
S15/10	6/8						Taster A	Taster B
100	0	17.05	11.58	16.00	5.02	1.11	151	36
90	10	19.47	10.50	19.02	4.97	1.22	161	39
80	20	20.41	11.59	20.52	5.19	1.23	155	42
70	30	21.71	11.52	21.16	5.53	1.31	183	41
60	40	22.60	12.28	21.56	5.19	1.37	183	39
50	50	23.26	14.52	22.46	5.50	1.44	198	43
40	60	23.76	12.47	23.16	4.94	1.48	217	41
30	70	24.34	11.65	23.72	5.55	1.60	217	41
20	80	25.00	14.60	24.38	5.75	1.66	219	44
10	90	26.30	13.67	24.97	5.16	1.77	245	46
0	100	27.41	14.26	27.76	5.66	1.75	263	48
SE	–	1.00	1.39	1.13	0.41	0.06	38	3
LSD, ($p \leq 0.05$)	–	1.45	n.s.	1.64	n.s.	0.09	55	5

Table 4
Changes in the black tea quality due fermentation duration and blending of clone S15/10 and SC12/8

Parameter	Fermentation time (min)	Mixture (%)					
		S15/10 SC12/28	100 0	90 10	10 90	0 100	Mean
Theaflavins (μmol g^{-1})	90		12.6	12.69	16.7	16.0	14.0
	150		12.9	15.0	16.0	15.7	14.9
	Mean		12.7	13.83	16.4	15.9	
	SE				1.29		
	LSD ($p \leq 0.05$)				1.36		n.s.
Thearubigins (%)	90		12.52	12.8	13.1	14.0	13.1
	150		12.92	13.4	13.5	14.0	13.43
	Mean		12.72	13.1	13.3	14.0	
	SE				0.62		
	LSD ($p \leq 0.05$)				0.49		0.35
Total colour (%)	90		3.27	3.63	3.64	4.03	3.64
	150		3.73	3.76	4.13	4.20	3.96
	Mean		3.50	3.70	3.85	4.11	
	SE				0.40		
	LSD ($p \leq 0.05$)				0.31		0.22
Brightness (%)	90		27.24	24.5	28.7	31.2	27.9
	150		23.4	24.1	25.3	29.2	25.5
	Mean		25.3	24.3	26.7	30.2	
	SE				1.64		
	LSD ($p \leq 0.05$)				0.33		0.23
Flavour index	90		0.56	0.66	0.81	0.87	0.72
	150		0.57	0.63	0.70	0.73	0.66
	Mean		0.57	0.65	0.76	0.80	
	SE				0.05		
	LSD ($p \leq 0.05$)				0.12		0.08
Taster A	90		221	193	231	261	226
	150		226	211	233	243	228
	Mean		224	202	232	252	
	SE				26		
	LSD ($p \leq 0.05$)				32		n.s.
Taster B	90		30	25	34	35	31
	150		27	27	33	35	31
	Mean		28	26	33	35	
	SE				4		
	LSD ($p \leq 0.05$)				4		n.s.

and Murai (1986). Analysis of the aroma concentrate was done as outlined in earlier publications (Owuor, 1992; Owuor, Orchard, & McDowell, 1994; Baruah et al., 1986) and the aroma quality quantified by Owuor's flavour index, as a ratio of the sum of gas chromatographic peak areas of compounds imparting a sweet floral aroma to those imparting a green grassy smell (Owuor, 1992). Sensory evaluation was done using professional tasters at two tea brokerage firms in Mombasa. The evaluations were based on brightness, briskness, colour, infusion, flavour, thickness and overall quality in a scale of 0–20 and 0–10 for each attribute for taster A and B, respectively.

3. Results and discussion

The choice of clonal materials used in the experiment was deliberate to combine clones with diverse fermenting and/or quality characteristics. The characteristics of the clones are presented in Table 1.

Table 5
The volatile flavour compounds[a] of black tea from blending different ratios of Clones S15/10 and 6/8

% S 15/10	100	90	80	70	60	50	40	30	20	10	0
2-Methylbutanal	0.08	0.06	0.07	0.07	0.12	0.07	0.07	0.08	0.13	0.12	0.06
Pentanal	0.04	0.03	0.04	0.14	0.05	0.04	0.03	0.07	0.06	0.06	0.04
Hexanal	0.55	0.38	0.62	0.50	1.06	0.52	0.52	0.53	0.96	0.76	0.48
E-3-penten-2-one	0.09	0.13	0.31	0.23	0.20	0.25	0.18	0.25	0.22	0.19	0.22
Z-2-penten-3-ol	0.22	0.17	0.22	0.25	0.24	0.18	0.17	0.23	0.27	0.32	0.21
Heptanal	0.03	0.01	0.12	0.01	0.11	0.01	0.02	0.07	0.04	0.02	0.01
Z-3-hexenal	0.09	0.09	0.12	0.13	0.15	0.12	0.08	0.12	0.10	0.13	0.09
E-2-hexenal	1.98	2.02	2.78	2.82	2.73	2.85	2.09	2.11	2.27	2.87	2.13
n-Pentylfuran	0.04	0.02	0.02	0.02	0.05	0.02	0.03	0.06	0.07	0.02	0.03
n-Pentanol	0.08	0.05	0.07	0.08	0.17	0.05	0.06	0.11	0.10	0.09	0.06
3,6,6-Trimethyl-cyclohexanone	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.02	0.02	0.01	0.01
Z-3-penten-1-ol	0.06	0.03	0.05	0.04	0.08	0.03	0.05	0.05	0.09	0.04	0.05
n-hexanol	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.01	0.01
Z-3-Hexen-1-ol	0.07	0.08	0.13	0.11	0.13	0.10	0.08	0.11	0.21	0.04	0.08
Nonanal	0.03	0.02	0.03	0.01	0.03	0.03	0.02	0.04	0.05	0.02	0.04
E-2-hexen-1-ol	0.04	0.02	0.04	0.08	0.06	0.05	0.05	0.05	0.06	0.03	0.06
E,Z-2,4-heptadienal	0.10	0.04	0.07	0.06	0.09	0.02	0.07	0.04	0.17	0.02	0.07
E,E-2,4-heptadienal	0.17	0.07	0.12	0.12	0.21	0.07	0.12	0.10	0.25	0.05	0.11
Sum of group 1 VFC	3.69	3.24	4.83	4.69	5.52	4.43	4.66	4.07	4.87	4.80	3.76
Linalool oxide (*Z*-furanoid)	0.06	0.02	0.05	0.03	0.05	0.02	0.04	0.03	0.07	0.01	0.04
Linalool oxide (*E*-furanoid)	0.07	0.06	0.11	0.08	0.12	0.04	0.05	0.07	0.08	0.04	0.06
Benzaldehyde	0.08	0.05	0.14	0.08	0.11	0.07	0.05	0.06	0.06	0.05	0.11
Linalool	0.33	0.30	0.53	0.44	0.61	0.45	0.33	0.43	0.47	0.30	0.30
α-Cedrene	0.57	0.73	1.37	1.19	1.39	0.91	0.73	0.83	0.95	0.58	1.20
β-Cedrene	0.12	0.09	0.15	0.15	0.17	0.12	0.09	0.11	0.14	0.08	0.20
3,7-Dimethyl-1,5,7-octatrien-3-ol	0.01	0.07	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.01	0.02
β-Cyclocitral	0.03	0.02	0.03	0.03	0.04	0.03	0.03	0.03	0.04	0.01	0.02
Phenylacetaldehyde	0.32	0.26	0.42	0.42	0.44	0.35	0.31	0.35	0.44	0.24	0.45
Neral	0.03	0.01	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02
α-Terpineol	0.03	0.02	0.04	0.03	0.04	0.03	0.02	0.03	0.04	0.03	0.04
Linalool oxide (*Z*-pyranoid)	0.03	0.02	0.02	0.03	0.03	0.03	0.02	0.02	0.02	0.02	0.02
Linalool oxide (*E*-pyranoid)	0.04	0.05	0.06	0.05	0.06	0.04	0.07	0.07	0.08	0.05	0.10
Methyl salicylate	0.14	0.11	0.24	0.18	0.27	0.19	0.17	0.20	0.22	0.09	0.17
Nerol	0.03	0.02	0.04	0.03	0.08	0.03	0.06	0.04	0.06	0.03	0.07
Geraniol	1.22	0.98	1.20	1.68	2.07	1.21	0.86	1.30	1.28	1.26	0.82
Benzyl alcohol	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.07	0.03	0.02	0.03
2-Phenyl ethanol	0.35	0.41	0.81	1.02	1.09	0.76	0.87	1.24	1.09	0.99	0.90
β-Ionone	0.20	0.10	0.19	0.23	0.20	0.17	0.21	0.26	0.20	0.77	0.12
Epoxy-β-Ionone	0.13	0.14	0.26	0.33	0.32	0.26	0.33	0.41	0.32	0.39	0.38
Nerolidol	0.03	0.02	0.07	0.06	0.07	0.05	0.05	0.06	0.06	0.04	0.08
Cedrol	0.12	0.21	0.33	0.64	0.44	0.22	0.10	0.22	0.19	0.19	0.37
Bovolide	0.04	0.01	0.03	0.02	0.04	0.02	0.03	0.06	0.04	0.03	0.02
Methyl palmitate	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.02	0.01	0.01	0.01
6,10,14-Trimethylpentadecan-2-one	0.04	0.04	0.17	0.10	0.10	0.08	0.10	0.14	0.10	0.11	0.11
E-Geranic acid	0.07	0.07	0.30	0.14	0.26	0.18	0.18	0.28	0.33	0.17	0.30
Sum of group II VFC	4.04	3.75	6.48	7.02	8.26	5.32	4.72	6.31	6.36	5.04	5.91
Flavour index (group II/I)	1.09	1.15	1.34	1.50	1.50	1.20	1.07	1.55	1.33	1.05	1.57

[a] As ratio of gas chromatographic peak area of the componds to that of an internal standard.

The effect of mixing Clones 12/2 and 6/8 on the resultant black tea quality parameters are presented in Table 2. The poor fermentability of Clone 12/2 would render it useless in black tea production if it were to be processed on its own. Indeed, after 90 min of fermentation, it was still basically green, implying that it would be more suited to green tea production. When mixed with Clone 6/8, it produces black tea and there was no evidence of greenness in such mixed black tea, provided adequate amounts of Clone 6/8 were present. Blending Clones S15/10 and 6/8 caused changes in the chemical quality parameters of the black tea produced (Table 3). Such variation in quality seemed to be related to the quality potential of the individual clones.

Like the plain black tea quality parameters, there were changes in the black tea volatile flavour compounds composition and quality due to mixing Clones 6/8 and S15/10 (Table 5) and Clones 6/8 and 12/2 (Table 6). Such variations were dependent on the amount of clonal quality potential of leaf added.

The effects of mixing slow-fermenting Clone S15/10 with fast-fermenting Clone SC12/28 are presented in Table 4. There was change in fermentability in proportion to the degree of mixing. Thus, Clone S15/10 slowed the fermenting rate of Clone SC12/28 and Clone SC12/28 enhanced fermenting role of Clone S15/10. The mixing only resulted in reducing their optimal fermentation time (Cloughley, 1979, 1980; Owuor et al., 1994; Owuor & Reeves, 1986; Owuor, 1984). As shown in Table 4, after 90 min fermentation, there was still development of theaflavins in slow-fermenting Clone S15/10, but they had reached a peak in Clone SC12/28; mixing the clones produced a situation in which optimal theaflavin formation was in between.

Mixing clonal leaf resulted in averaging the quality of the resultant black tea. There was no clone whose quality dominated the quality of the other. Therefore, the notion that some clones may have a quality-dominating effect does not apply to the clones used in this study. The observation that a slow-fermenting clone like Clone 12/2 can be used to produce black tea if its leaf is mixed with a fast-fermenting clone shows that, provided such clones have yields very mich higher than average, they are appropriate for commercial planting. However, such clones must be planted in mixed stands with fast-fermenting partners. The extent of mixing the clones in the field will be determined by the balance between yield (production) and quality (value) desired.

When processed separately, Clone S15/10 blends poorly with other black teas due to its low bulk density (Owuor, personal observation). However, it is noted in this study that, when Clone S15/10 leaf is mixed with that of another clone, there was no evidence of poor mixing of the black teas. Indeed, the resultant black tea looked uniform. Again the poor fermentability of the clone was overcome by mixing. Thus due to its exceptionally high yields (Oyamo, 1992), it can be useful in commercial estates provided that it is adequately mixed (blended) with fast-fermenting clones.

Although it had been thought some clones would be incompatible and their mixed leaf would not be able to be processed into black tea, the results presented here demonstrate compatibility. Mixing clones averages their contribution to fermentation during black tea manufacture. Indeed, the clones used in this study were very diverse. Despite their great diversity, their leaf was able to incorporate into black teas of reasonable quality.

Table 6

The volatile flavour compounds[a] of black tea from blending different ratios of Clones 6/8 and 12/2

% Clone 6/8	0	25	75	100
2-Methylbutanal	0.04	0.06	0.07	0.04
Pentanal	0.13	0.10	0.04	0.12
Hexanal	0.35	0.36	0.34	0.32
E-3-penten-2-one	0.07	0.06	0.07	0.06
Z-2-penten-3-ol	0.16	0.15	0.16	0.15
Heptanal	0.01	0.02	0.01	0.01
Z-3-hexenal	0.09	0.09	0.08	0.04
E-2-hexenal	2.10	1.86	1.82	1.44
n-Pentylfuran	0.01	0.02	0.03	0.02
n-Pentanol	0.02	0.03	0.05	0.05
3,6,6-Trimethylcyclohexanone	0.01	0.01	0.01	0.01
Z-3-penten-1-ol	0.05	0.06	0.06	0.05
n-Hexanol	0.01	0.02	0.02	0.02
Z-3-hexen-1-ol	0.13	0.12	0.10	0.10
Nonanal	0.01	0.02	0.02	0.03
E-2-hexen-1-ol	0.02	0.02	0.02	0.03
E,Z-2,4-heptadienal	0.03	0.03	0.04	0.05
E,E-2,4-heptadienal	0.05	0.07	0.08	0.09
Sum of Group 1 VFC	3.29	3.10	3.02	2.63
Linalool oxide (*Z*-furanoid)	0.11	0.10	0.08	0.06
Linalool oxide (*E*-furanoid)	0.52	0.52	0.45	0.18
Benzaldehyde	0.06	0.06	0.06	0.07
Linalool	0.67	0.77	0.68	0.77
α-Cedrene	2.06	2.12	2.17	3.07
β-Cedrene	0.05	0.07	0.06	0.08
3,7-Dimethyl-1,5,7-octatrien-3-ol	0.01	0.01	0.01	0.01
β-Cyclocitral	0.02	0.02	0.02	0.03
Phenylacetaldehyde	0.13	0.25	0.32	0.37
Neral	0.01	0.01	0.01	0.01
α-Terpineol	0.04	0.04	0.03	0.03
Linalool oxide (*Z*-pyranoid)	0.01	0.01	0.01	0.01
Linalool oxide (*E*-pyranoid)	0.03	0.01	0.01	0.01
Methyl salicylate	0.26	0.32	0.31	0.38
Nerol	0.01	0.02	0.02	0.03
Geraniol	0.09	0.22	0.32	0.55
Benzyl alcohol	0.02	0.01	0.01	0.01
2-Phenyl ethanol	0.64	0.61	0.56	0.54
β-Ionone	0.16	0.16	0.29	0.21
Epoxy-β-Ionone	0.28	0.23	0.23	0.20
Nerolidol	0.07	0.07	0.09	0.06
Cedrol	0.23	0.25	0.21	0.17
Bovolide	0.05	0.02	0.02	0.02
Methyl palmitate	0.02	0.02	0.01	0.01
6,10,14-Trimethyl-pentadecan-2-one	0.07	0.07	0.05	0.06
E-Geranic acid	0.02	0.08	0.12	0.58
Sum of group II VFC	5.64	6.09	6.15	7.52
Flavour index (group II/I)	1.71	1.96	2.04	2.86

[a] See Table 5.

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