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REMOVAL OF STALK IN LEAFY GRADES OF TEA BY COLOUR MISMATCH TECHNIQUE

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The performance of a colour sorter type tea cleaning machine was compared with manual picking of stalks from leafy grades of low grown teas such as BOPI, OP and OPI.

Within the machine operational parameters, the efficiency of picking was unaffected by the output of the machine and the tasters valuation of the machine cleaned tea was not significantly different to that of hand picked teas. The machine under test had an output equal to 50 manual pickers and the required capital investment had a simple pay back period of under two years, based on a single 8 h shift per day use. Thus the machine is an efficient, cost saving method of removal of stalks from leafy grades of teas.

INTRODUCTION

Most high priced teas produced in low elevational tea factories in Sri Lanka are leafy grades such as BOPI, OP and OPI. One of the factors that influence their price level is the absence of stalks which are red in colour and easily detectable when seen against black tea leaves. In the traditional sorting of low grown tea, stalks are removed manually. The cost component of manual "Red Leaf Picking" is quite significant in the overall cost of manufacture. In a typical low elevational factory with cost of processing (excluding general charges) at Rs. 7-8/kg, the red leaf picking could account for Rs. 0.50-1.50/kg depending on the standard of leaf. Furthermore, manual picking is also time consuming and it is not uncommon to see large stocks of tea awaiting cleaning in these factories.

In this study, the performance of a tea cleaning machine which works on the colour mismatch technique was compared with manual picking of stalks from leafy grades of teas such as BOPI, OP and OPI.

The most obvious difference between stalk particles and clean black tea particles is their colour. Stalk particles are amber to brown in colour whereas clean tea particles are black. The colour sorter type tea cleaning machines exploit this difference for separation of stalk from black tea. The presence of stalk is detected by photocells which receive filtered light reflected off a stream of a single layer of

tea and stalk particles. The colour chosen for the filter is the same as the colour of the stalk particles. The photocells activate small air jets and the timing is adjusted so that the stalk particle which activated the photocell gets ejected by the force of the air jet.

EXPERIMENTAL

Specification of Experimental machine (see Fig. 1):

Model No	—	Senvec C 7500W
Number of Rows	—	42
Number of Stages	—	02
Nominal output	—	110 kg tea h^{-1}
Installed power	—	Less than 6 KW, total
Size	—	205 x 118 x 265 cm^3
Weight	—	400 kg

Essential components of the machine:

(*a*) feed hopper with variable speed feed screw,
(*b*) bucket elevator to carry tea with stalk to the top of the machine,
(*c*) vibrating conveyor for spreading tea with stalk across the width of the machine,

(*d*) electro magnetic high frequency vibrator to spread tea with stalk into a single layer - this is very important in order to minimise ejection of black tea particles,

(*e*) grooved travel track along which particles slide, one after the other, from the top to the bottom of the machine,

(*f*) flourescent lamp and photocells mounted over the paths of the particles,

(*g*) small compressed air jets mounted over the paths of the particles - the air jets being activated by photocells on seeing the presence of particles having same colour as the filter, and

(*h*) compressed air system and filter cleaning mechanism.

Controlling parameters at operators disposal:

(*a*) rate of feed of material, and

(*b*) sensitivity of picking which can be independantly adjusted for the two stages.

Generally the aim is to achieve maximum output with required cleanliness in the final product. The stalk quantity in cleaned tea as well as the black tea quantity in rejects stream are minimised by adjustment of sensitivities of the two picking stages.

The 2-stage cleaning ensures that, almost always, a single pass is sufficient to clean the stalk in teas. The rejects from the two stages are collected separately thus facilitating secondary cleaning of rejects, if necessary.

During the experiment only a single pass was employed and no secondary cleaning of rejects was done.

RESULTS AND DISCUSSION

The performance of the machine depends on output, cleanliness of the final product, recoverability and the overall value of the produce.

(a) Output

The output of the machine as well as hand picking depends on the grade to be picked, initial stalk content and the cleanliness expected in the picked grade. The latter can only be judged subjectively. The assessment becomes uncertain because of the difficulty in strictly defining what 'stalk' is. The output of hand picking was measured by taking the average red leaf picking rate of five experienced female workers. The output of the machine can be adjusted at will subject to a maximum limit of the variable speed screw feeder (see Table I).

TABLE I — *Output of hand picking and of tea cleaning machine*

Grade of tea	*Output kg/h/picker*	*Maximum feeding rate of machine kg h⁻¹*	*Typical Grade %*
OP	0.562	52	8
OPI	0.475	57	4
BOPI	0.975	140	12
PEKOE	4.298	73	12

The achieved average output for the grade mix given above (column 4) is about 90 kg h-¹.

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Fig. 1 — Senvec colour separator

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(*b*) Cleanliness

If the mass fraction of stalks in a sample is taken as the degree of contamination, then the cleanliness of that sample can be taken as 1—mass fraction of stalks. In a manual picking operation achievable cleanliness of the final product is inversely proportional to the picking rate of the worker. However, in the machine the stalk content of cleaned tea has no significant correlation with the product rate through the machine (see Fig.2). This proves that, even at the maximum rate, particles travel in a single layer and that the photocells do recognise individual particles and that the maximum feed rate is well within the expected performance of the machine. In respect of most grades, a linear relationship was found to exist between measured mass fraction of stalk in cleaned produce (X_p) and measured mass fraction of stalk in uncleaned tea (X_f) (see Fig. 3), where $X_p = a + bX_f$

The values for a and b for different grades of tea along with their correlation coefficients are given in Table 2.

TABLE 2 — *Relationship between stalk percentages of teas before and after cleaning*

Grade of tea	*Correlation coefficient*	*a*	*b*
OP	0.583 not significant at P = 0.05	0.705	0.284
OPI	0.919 significant at P = 0.001	- 5.936	0.946
BOPI	0.706 significant at P = 0.05	- 0.482	0 .540
PEKOE	0.670 significant at P =0.05	0.029	0.364

The achievable degree of cleaning in a single pass is given in Table 3.

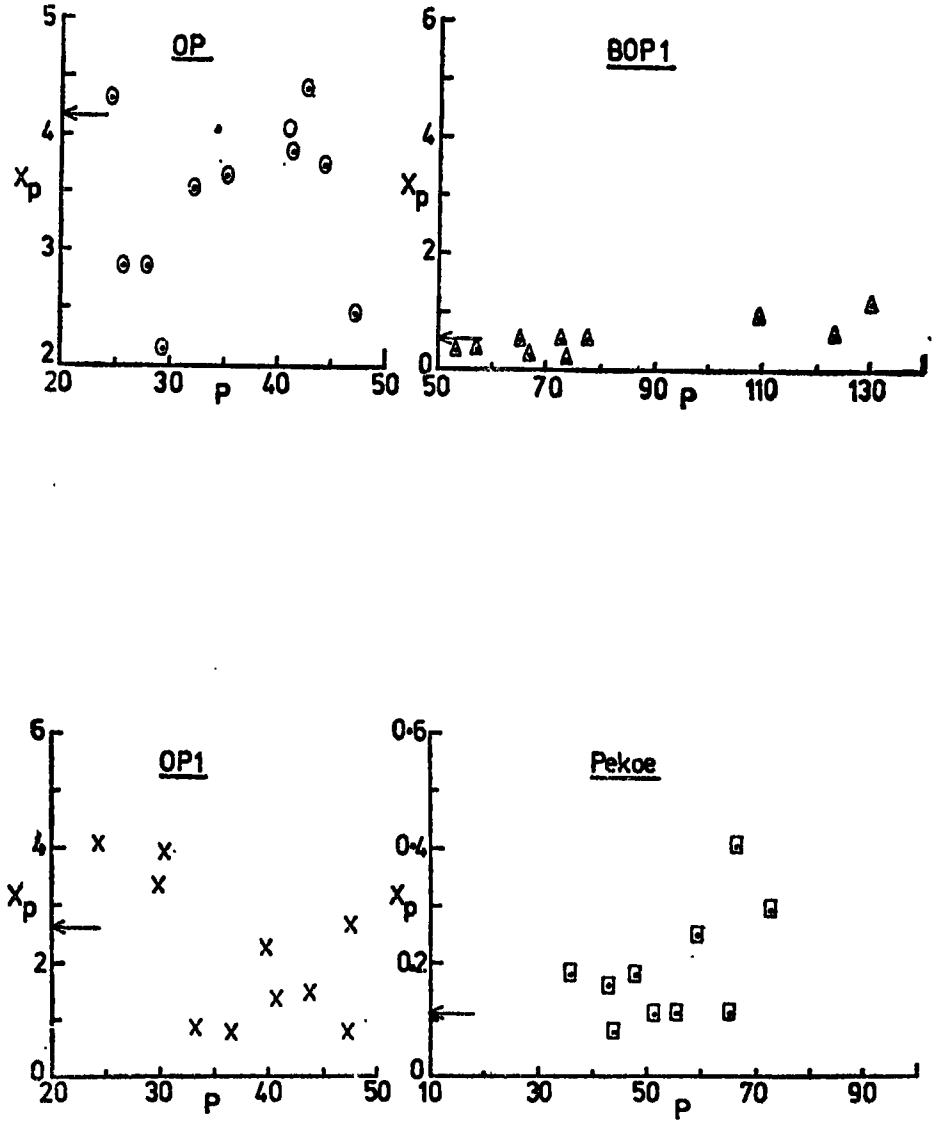

Fig. 2 — Stalk percentage, Xp Vs product rate, P (kg h^{-1})
(Horizontal arrows indicate Xp from manual picking)

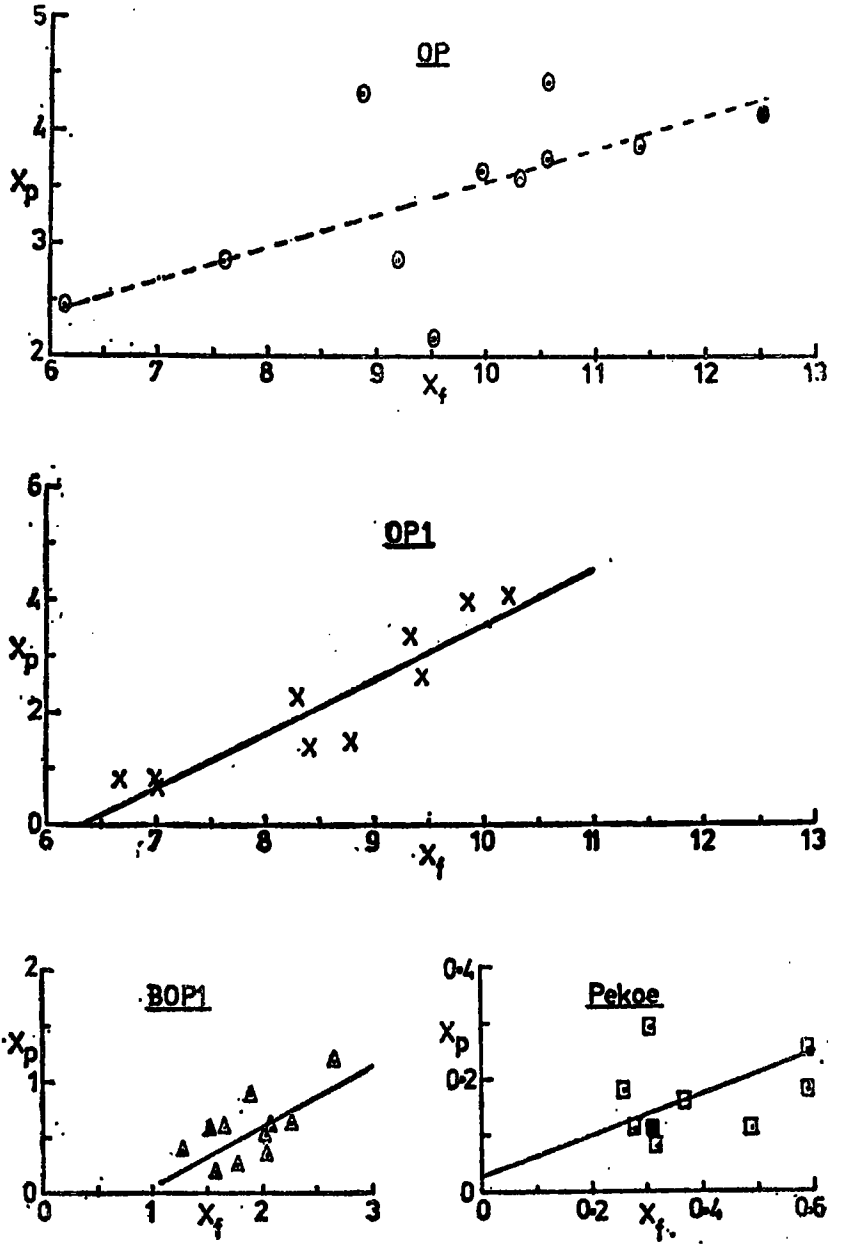

Fig. 3 — Stalk percentage in cleaned tea, Xp Vs stalk percentage in tea prior to cleaning, Xf (Shaded points indicate manual picking)

TABLE 3—*Achievable degree of cleaning in a single pass.*

Grade of tea	*Typical stalk percentage in uncleaned tea*	*Stalk percentage in cleaned tea*
OP	6-13 [1]	2-5
OPI	6-11	0.8-4
BOPI	1.5-3.0	0.2-1.2
PEKOE	0.2-1.0	0.1-0.4

(*c*) Recovery percentage

In the manual cleaning operation the rejected portion contains nearly 100% stalks. On the other hand, in machine picking, a fair quantity of clean teas get rejected along with stalks. This results in lower recovery i.e. the ratio between weight of cleaned tea to tea prior to cleaning. Typical values obtained are given in Table 4.

TABLE 4—*Recovery of material*

Grade of tea	*Recovery percentage*	
	Manual	*Machine*
OP	91	87-91
OPI	89	82-87
BOPI	97	92-97
PEKOE	99.6	98-99

(*d*) Overall effect on value of produce

The overall value of the produce needs close examination in particular due to the lower recovery of material possible with the machine. This was done by obtaining valuations on teas from a panel of three Tea Tasters. They were given blind samples of feed material, cleaned grade and rejected portions. The manual operation represented the control sample, whereas 10 treatment samples were obtained at different processing rates from the machine. Weighted average valuations were calculated using measured recovery levels.

A statistical analysis was carried out to determine a correlation between the value enhancement (Rs/kg) and the "cleaning duty, ($X_f - X_p$)" expressed as "mass fraction of stalk in feed, (X_f) minus mass fraction of stalk in cleaned product, (X_p)". From this it was concluded that no functional relationship exists between these two variables. The reasons for this situation could be due to:

(i) Teas tested are already somewhat clean and that further cleaning does not result in a proportional increase in value, and

(ii) Factors other than stalk content are also influential in determining the value of the produce.

It is evident from the above results that a claim of an improvement or a reduction in the value of the produce because of the use of this machine is unjustified.

COST - BENEFIT ANALYSIS

(a) Benefits

(i) Savings in cost of production

Expenditure incurred in manual picking is given in Table 5. The rates of picking are averages of measured working rates of five female pickers with experience in the job. Labour wage is taken as Rs. 28.00 per 8 h day.

TABLE 5—*Cost of manual picking of stalks in tea*

Grade of tea	*Processing rate kg/h/picker*	*Cost of Picking Rs/kg Grade*	*Typical Grade Percentage*	*Cost Component Rs/kg*
OP	0.562	6.22	8	0.50
OPI	0.475	7.37	4	0.29
BOPI	0.975	3.59	12	0.43
PEKOE	4.298	0.81	12	0.10

The total cost of manual picking amounts to Rs. 1.32/kg.

(ii) Savings due to reduction in accumulation

Most Low Country tea factories are faced with the problem of large quantities of teas getting accumulated in different stages of sorting. This results in cash flow problems as well as practical difficulties in the factory due to insufficiency of working space, difficulties in supervision and problems of accountability of stocks.

Prior to installation of this machine at the St. Joachim factory, the end of the month balance stock was in the region of 3-6 days while following installation, the stock was reduced to a fraction of the last days production.

Assuming a saving of 4 days delay, an interest rate of 15%, and a nominal price of Rs 40.00 per Kilo of tea, the saving on interest works out to be

$$40.00 \times \frac{4}{365} \times 0.15 = 0.065 \text{ Rs/kg}$$

(b) Cost of machine operation

i) Electricity

Assuming that the total installed power is consumed by the machine and taking a mean processing rate of 90 kg/h, and the leafy grade percentage as 36,

$$\text{Cost} = \text{kW} \times \left(\frac{\text{Rs}}{\text{kWh}}\right) \div \left(\frac{\text{kg}}{\text{h}}\right) \times \text{leafy grade percentage}$$

$$= \frac{6 \times 1.60 \times .36}{90}$$

$$= 0.038 \text{ Rs/kg}$$

ii) Personnel

Usually one person is sufficient to operate this machine.

$$\text{Cost} = \left(\frac{\text{Rs}}{\text{Person. day}}\right) \times \text{No. of persons/ Output (kg/day)} \times \text{leafy grade percentage.}$$

$$\text{Cost of personnel} = \frac{28.00 \times 1 \times .36}{(90 \times 8)} = 0.014 \text{ Rs/kg}$$

(c) Net Benefit

Saving from cost of hand picking	=	Rs 1.32/kg
Saving from interest on value of stocks	=	Rs 0.065/kg
Expenditure on electricity	=	Rs(-) 0.038/kg
Expenditure on personnel	=	Rs(-) 0.014/kg
Net saving	=	Rs 1.33/kg

(d Capital cost of machine

The capital cost of the machine, including a 45% customs duty and a 10% Turn Over Tax, is (approximately) Rs 1.7 million.

(e Simple pay back period

Assuming an annual production level of 750,000 kg, of made tea the simple pay back period works out to be

$$\frac{1{,}700{,}000 \times 12}{750{,}000 \times 1.33} = 20.45 \text{ months}$$

(f) Social implications

From the data given in Table I it can be found that, the output of the machine is 90 kg h^{-1} whereas the output of hand picking operation is 1.935 kg/h/picker. Thus the machine output is equivalent to about 50 pickers.

Therefore, substitution of the picking work force with this machine means about 50 workers would be redundant in the picking section of the factory.

CONCLUSIONS

i) Colour mismatch technique is an efficient, cost saving method of removal of stalk in leafy teas.

ii) Although there was an apparent reduction in the stalk content of teas cleaned by this machine when compared to hand picked teas, this did not realise a statistically significant improvement in the tasters valuation of the produce.

iii) The simple pay back period of the investment on this machine based on a single shift use, is less than two years and is therefore a very attractive investment. If the factory were to operate on a 2 or 3 shift basis then the pay back period would correspondingly be reduced.

iv) The machine tested has a capacity equivalent to about 50 workers (single shift).

v) Considering the social implications of laying off of workers, this machine is considered a feasible alternative to manual red leaf picking in areas where there are suitable alternate employment for workers.