Quality Decline Associated with Non-adoption of Good Manufacturing Practices of Orthodox Black Tea in Sri Lanka

W.V.C.J. INDRARATHNE[1], N.V.B. JOHNPILLAI[2], L.B. DUNSFORD[1], K.M.H.I KARUNARATHNA[3] and B. GAJANAYAKE[1]

[1]Department of Plantation Management, Faculty of Agriculture and Plantation Management, [3]Information and Communication Technology Center, Wayamba University of Srilanka, Makandura, Gonawila (NWP), 60170, Sri Lanka

[2]John Keels Tea Department, 186, Vauxhall Street, Colombo 2, 00200, Sri Lanka

ABSTRACT

Quality in the tea industry largely subjective as it is erroneously associated with last price at the auction. The quality of the tea can be varied depending on those activities from the plant material at the field, how made tea is processed at the factory and until it reach to the final consumer. Improper processing practices are responsible for reducing the made tea quality and thus market price. The objectives of this research study were, to identify the quality related manufacturing practices, to introduce a profitable tea manufacturing process for all three elevations and to quantify the changing price of made tea per unit quality loss during manufacturing process. A survey using a semi structured questionnaire and formal discussions with factory staff on manufacturing activities to collect necessary data was done. In addition, identified supplied conditions were also recorded from each factory. The price related data were collected from John Keels tea department tea sales documents. Stratified random sampling technique was employed to select the number of orthodox factories from each elevation wise categories for the survey. The Pearson correlation analysis was done to find out the correlation between 25 tea manufacturing practices and quality representing factor (annual price of FBOP). Then the Multiple Linear Regression was employed to find out the most significant variables among the selected variables. Further, quality of made tea was evaluated using most significant variables. According to the results, 16 quality determining variables were identified as closely related and nine variables were not related with quality of the made tea. Further, four variables were identified namely weight of filled containers with leaves, best leaf percentage (<45%), best leaf percentage (45-60%), and input drier temperature (104–118 °C), which show a significant impact on the quality of made tea. Study confirmed that above four variables are significantly related to the quality of made tea and thus the auction price.

KEYWORDS: Auction price, Incorrect manufacturing practices, Tea processing, Tea quality

INTRODUCTION

Tea (*Camellia sinensis* L. O. kuntze) is predominant among Sri Lankan plantation crops. Black tea is second most popular drink in the world next to water (Anon, 2016). Sri Lanka is renowned for its high quality tea and has become the 3rd biggest tea producing country globally. It has a production share of 9% in the international sphere and one of the world's leading exporter with a share of 23% of the global demand (Anon, 2015a). Sri Lanka produces tea throughout the year and the total tea production is about 328 million kilograms in year 2013 (Anon, 2015b). More than 92% of the production in Sri Lanka is black tea (Sivaram, 2002) and more than 90% is exported.

Presently, around 702 orthodox tea factories are under operational condition. Out of them, 451 factories located in the low country region whilst 140 are located in the up country region. The rest 111 are located in mid country region (Anon, 2015a). Sri Lanka is the world largest producer of orthodox tea and more popular as "Ceylon Tea" in world market. Sri Lanka produces tea under categories of high, mid and low grown. Under the given category, each factory produce three outputs namely main grades, off grades and refused tea. Every factory focuses on producing main grades which are in high quality. Flowery Broken Orange Peko (FBOP) is one of the main tippy grades which are produced by pure orthodox tea factories in all three elevations. All grades are coming throughout the same process and only separate after the shifting process, which leads to similar quality of final made tea.

Tea is valued according to their appearance and overall quality which comprises the quality of the liquor and the appearance of both the made tea and the infusion. After the Food and Agriculture Organization's declaration of tea as an item of food in year 1995, all the exporters were required to comply with quality standards to meet the demand for safer food. Up to 1995, the basic standard on black tea exports was ISO 3720. Quality of tea is the main consideration of buyers for their demand. Quality in tea industry largely subjective as it is erroneously associated with last price at the Colombo auction. According to ISO 8402-1986 standard, quality defines as "the totality of features and characteristics of a product or service that bear its ability to satisfy stated or implied needs". Internationally accepted quality standards are available to maintain the quality of the products namely, HACCP (Hazard Analysis Critical Control Point), ISO 9001, ISO 14001, ISO 22000, GMP (Good Manufacturing Practices) and GAP (Good Agricultural Practices).

Quality and the price valuation of Ceylon tea produced in high grown area is determined by color and strength of the liquor, which brews into the tea cup and also the blackness of made tea whereas degree of twist, blackness, evenness, cleanliness (without fibers, stalks, red and ragged leaves, flakes) and the tip content of made tea are important for low grown teas (Muthugala, 2008). Tea tasting is the most common evaluation method to judge its price and quality. Improper processing practices are responsible for reducing the made tea quality and thus market price.

Therefore, the objectives of this study were to identify the quality related manufacturing practices, to introduce a profitable tea manufacturing process for all three elevations and to quantify the changing price of made tea per unit quality losses during manufacturing process.

MATERIALS AND METHODS

Materials

The necessary measurements from each processing factory were taken using hygrometers, thermometers, a foot ruler and a stop watch.

Data Collection

This research was conducted with the involvement of 28 tea factories which are included in John Keels tea sales catalogues, representing all three tea growing elevational categories in Sri Lanka. The 28 factories which were selected with no seasonal price variation. Further, those factories, showed small monthly wise price variations within small range. A survey was conducted using a semi structured questionnaire and formal discussions with factory staff on manufacturing activities and supplying conditions to collect necessary data from February to March, 2016.

Further data were collected using instrument measures. Secondary data were collected from monthly split sheets, monthly grade wise sale averages documents of John Keels tea department. Stratified random sampling method was used to select the total 28 respondents from each main elevation category under three strata from a population of 702 pure orthodox black tea manufacturing factories. According to stratified random sampling, 17 low country orthodox factories, five mid country orthodox factories and six up country orthodox factories were selected for data collection. It is assumed that the FBOP grade manufacturing process represents the whole made tea production process. The FBOP main tippy grade was selected and its average prices were taken for 2015 financial year, from April 2015 to March 2016 as the quality representing parameter. Some of the critical processing conditions were selected randomly as variables from the questionnaire.

Tablel. Description of the variables

Variable	Description
PRICE	Quality of the tea (RS)
WEIGHT	Total weight (Kg)
TH_1	Trough height (<_1 feet)
TH_2	Trough height (1-2 feet)
SR_1	Spreading rate (<30 Kg/m^2)
SR_2	Spreading rate (30-35 Kg/m^2)
BL_1	Best leaves % (<45 %)
BL_2	Best leaves % (45-60 %)
TM_1	Turning method (Layer method)
TM_2	Turning method (Bundle method)
HM_1	Hygrometer difference (1-3 °C)
HM_2	Hygrometer difference (3-6 °C)
RT_1	Rolling room temperature (<26 °C)
RT_2	Rolling room temperature (26-30 °C)
TNH_1	Number of humidifiers (one)
TNH_2	Number of humidifiers (Two)
FT_1	Fermentation time (2-3 h)
FT_2	Fermentation time (3-4 h)
DS_1	Dhools spread thickness (1-2 inches)
DS_2	Dhools spread thickness (2-4 inches)
DT_1	Input dryer temperature (<104 °C)
DT_2	Input dryer temperature (104 °C-118 °C)
WS_1	Winnower speed (1000-1150 rpm)
WS_2	Winnower speed (1150-1300 rpm)
HDP_1	Packing room hygrometer (2-3 °C)
HDP_2	Packing room hygrometer (3-5 °C)

Data Analysis

Collected data from primary sources and secondary sources were analyzed using Statistical Analysis System software (SAS Version 9.2).

Then the Pearson correlation analysis was done to find out the correlation between quality determining factor (average price of FBOP tea) and 25 tea manufacturing parameters (Table 1). The multi-collinearity was checked among variables which were related with quality of the made tea. Then the variables were selected without multicollinearity. Then the most significant variables among the selected variables were determined using a multiple linear regression analysis. Further, the quality of made tea was evaluated using most significant independent variables. Thereby, a statistical function was extracted (Equation 1).

Regression Model

$$Yi=\beta_0 + \beta_1 WEIGHT + \beta_2 TH_1 + \cdots + \beta_n X_n + e[1]$$

Where, β_n are coefficients to be estimated and X_n are covariates for representing the most significant quality effective tea processing conditions. Y_i is dependent variable which is representing quality of the black tea by average price of FBOP grade for 2015 financial year. Predicted probabilities were calculated for each of the significant variable. Finally, weight of the carrying bucket with leaves was assumed as a critical quality declining effect of the final output. Then the non-linear regression was done in between only quality of made tea (average prices of FBOP grade) and weight of the filled carrying bucket, to identify optimum weight of filled carrying bucket.

RESULTS AND DISCUSSION

According to the Pearson correlation analysis, 14 of the quality determining variables were related and 11 of them were not related with quality of the made tea (Table 2).

Table 2. Pearson correlation values

Variable	Pearson Value
WEIGHT	-0.79062 *
TH_1	0.49410 *
SR_1	0.49251 *
BL_1	-0.71268 *
BL_2	0.51213 *
TM_2	-0.48812 *
HM_1	0.68939 *
RT_1	0.54855 *
TNH_1	-0.67888 *
DS_1	0.55182 *
DT_2	0.60473 *
WS_1	-0.55475 *
WS_2	0.55475 *
HDP_1	-0.52214 *

**At 0.05 significant level; WEIGHT- Total weight. TH_1- Trough height (<1 feet), SR_1- Spreading rate (<30 Kg/m²), BL_1- Best leaves % (<45 %), BL_2- Best leaves % (45-60 %), TM_2- Turning method (Bundle method), HM_1- Hygrometer difference (1-3 °C), RT_1- Rolling room temperature (<26 °C), TNH_1- Number of humidifiers (one), DS_1- Dhools spread thickness (1-2 inches), DT_2- Input dryer temperature (104 °C-118 °C), WS_1- Winnower speed (1000-1150 rpm), WS_2- Winnower speed (1150-1300 rpm), HDP_1- Packing room hygrometer (2-3 °C)*

According to the results, Weight, BL_1, TM_2, TNH_1, WS_1 and HDP_1 were inversely related with the made tea quality. And also TH_1, SR_1, BL_2, HM_1, RT_1, DS_1, DT_2 and WS_2 were positively related with the quality of made tea. When tea pluckers put plucked leaves into a bag or containers, the maximum or optimum capacity of container or bag should be considered. Beyond the optimum level, the quality of final made tea will be reduced. Accordingly, the price will be reduced. When loading the trough, the height should be considered. If it is less than one foot, it will positively effect for the quality of the final output. Spreading rate also very important. According to the result, SR_1 is profitable than SR_2. The quality showed a positive impact when spreading rate is less than 30 kg/m^2. Therefore the spreading rate should be less than 30 kg/m^2. It is important to maintain an even air flow. The even air flow leads to even moisture evaporation which enhances smooth rolling process and ultimately results in accurate shape and color.

A negative relationship was shown between BL_1 and made tea quality. If best leaves percentage is less than 45% (when other factors are constant), the made tea quality will be reduced. As a result, price also get reduced. In the same scenario, BL_2 showed a positive relationship with quality of made tea. When best leaves percentage is being improved, the quality of the tea also increased. The reason of reducing quality could be higher amount of below best (best but damaged leaves) and poor leaves (Course leaves, *bungi*, Single leaves, Leaves with stalks). Because of those, final made tea contains many fibers, stalks, flacks, uneven particles, ragged leaves, red ends and brown color open leaves. Those are leading to reduction in made tea quality.

When turning the trough, bundle method is not suitable. If factory follows bundle method, it affect negatively to the quality of final product. The reason could be unbroken/partial broken tea lumps. These types of lumps are restricted in air penetration through leaves. Therefore, moisture evaporation rate reduces and resists. Ultimately, soft withered leaves were remained. So, made tea become less weight and brown in color.

Hygrometer differences in withering trough were related with the quality of the final made tea. The 1-3 °C difference was better than 3-6 °C difference. The 1-3 °C difference can improve the quality of made tea. Because medium wither can be achieved using 1-3 °C hygrometer difference. Medium wither is essential to produce high quality made tea. When hygrometer difference shows a higher value, the rate of moisture evaporation would increase. Thereby, hard withered leaves can be found. Those will be very difficult in rolling and unable to acquire exact shape. This cost higher percentage of off grades.

Rolling room temperature was related with made tea quality. According to the results, a positive effect of RT_1 (<26 °C) with made tea quality can be observed. When rolling room temperature is less than 26 °C, quality of the product will be high. The reason may be the rollers which are working without heat and efficiency increases at the low temperature. And also, there should be a cool condition in the rolling room to take a wiry or curly shape (to achieve the optimum rolling). If not leaves can be opened. To keep the rolling room in high humid condition, factories generally use humidifiers. Those will be essential for fermentation also. According to the results, one humidifier was negatively affects for the quality (price) of made tea. It's better to have more than one humidifier to make a wet condition in rolling or fermentation rooms. If not rolling and fermentation processes will affect unfavorably. Under few humidifiers in action (when rolling room temperature is more than 26 °C), over fermentation could be observed. It leads to bad odor and unpredictable color formation which cause to reduce the price and the quality of made tea. When considering the dhools spreading thickness, 1-2 inches is considered the best. It was positively related with quality of the made tea. When thickness is high, bottom area of the spreaded dhools might be over fermented. This leads to change the color of bottom level leaves to turn dark black, whilst top level color remains light brown. Ultimately the quality gets reduced.

According to the results, 104 °C-118 °C dryer input temperature was positively related with quality (price) of made tea. It is suggested that all three elevational factories can use this temperature range and thus can produce the best quality tea without under fired or highly fired tea. Under low temperature, less fired tea can be seen. Under high temperatures highly fired tea can be seen. This leads to reduce the tea quality. After drying process, fired tea is sent to the shifting room. All factories use fibro mat and 3T machine to remove fibers and stalks. Additionally color separators are used. Thereafter, made tea is sent through a winnower to clean the made tea to increase the quality.

According to the results, 1000-1150 rpm speed was inversely related with tea quality but 1150-1300 rpm speed was positively related with tea quality. Second option is the beneficial winnower speed for making optimum quality tea product. If the speed is too low, dust like particles cannot be flown far away. They also mixed and fall down with quality tea particles. Moreover, mixing of second grades with superior grades cannot be controlled and ultimately affects as low quality produce.

After color sorting, made tea is sent into the packing room for packaging. This room's hygrometric value was significantly related with the made tea quality. Normally, the humidity of the packaging section should be in lower value. According to the results, the 2-3 °C difference was negatively related with tea quality. The reason could be when room get wet, the moisture level of fired tea could also going up. This leads to the growth of mold inside packages and changing tea flavor, color, structure from desired level.

After checking the multicollinearity, six variables were selected without multicollinearity. Those were namely WEIGHT, TH_1, BL_1, BL_2, RT_1 and DT_2. According to the regression analysis, four variables showed significant impact on the quality of made tea. They were; weight of tea leaves which are in a bag (WEIGHT), BL_1% (<50%), BL_2% (50-60%) and DT_2 (104-118 ^{0}C). The quality measuring function can be illustrated as below (Table 3).

Table 3. The means, upper, lower price changing values for the variables

Variable	Mean value	Upper value	Lower value
Intercept	525.87	557.60	494.14
WEIGHT	-2.70	-3.97	-1.43
BL_1	-56.47	-81.3	-31.64
BL_2	-27.39	-49.2	-5.58
DT_2	26.14	42.76	9.52

At 95% confidence level; WEIGHT- Total weight, BL_1- Best leaves % (<45 %), BL_2- Best leaves % (45-60 %), DT_2- Input dryer temperature (104 °C-118 °C)

$$Yi = (525.87) - (2.70)\ WEI - (56.48)\ BL1 - (27.4)\ BL_2 + (26.15)\ DT2 \qquad [2]$$

According to the results, tea leaves which are plucked and overloaded to the collecting containers by 1kg, it can cost the price by Rs.2.70. But it is not a linear reduction. According to the results price showed a non-linear reduction with over weight of leaves (Figure 1).

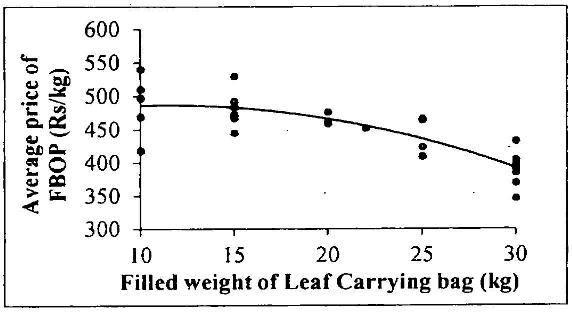

Figure 1. Price changes over the filled bucket weight

From the first derivation, X value was estimated as 11.50 kg. Also the desired maximum filling capacity of 1.5 feet×3 feet average size bag is 11.50 kg. If it passes this value, prize will get deducted. Further, BL_1 increases by 1 kg; the final output price decreased from Rs. 81.3 to 31.64. And also BL_2

get increased by 1 kg of raw tea leaves, the final output quality get decreased from Rs.49.2 to 5.52. So the best leaves percentage could be the most critical control factor when considering others. According to the results when 1 kg of tea is being dried within DT_2 temperature range, the quality of final output get increased from Rs. 9.52 to 49.2.

CONCLUSIONS

According to the results following conclusions were made which are crucial to manufacture high quality made tea. Weight of leaves filled container should be 11.5 kg average weight (only for 1.5feet×3feet bag size). And also height of the leaves on withering trough should be less than 1 feet. Spreading rate should be less than $30 kg/m^2$. Best leaves percentage should be more than 60% to control the losses of quality. The bundle method is not good to turn the trough. The best hygrometer difference is 1-3 °C. The best rolling room temperature is less than 26 °C. The one humidifier is leading to reduce the made tae quality. The 1-2 dhools spreading thickness is more profitable than others. The drier temperature should be maintained in between 104 °C-118 °C to produce high quality tea. The winnower speed should be 1,150 rpm to 1,300 rpm. The packing room hygrometer difference should be maintained in higher value to take good quality made tea. Finally, among these processing conditions, weight of filled container, best leaves percentage and dryer temperature are critical quality determining factors.

ACKNOWLEDGEMENTS

Authors wish to express their gratitude to Mr. Nishantha de Mel CEO, John Keels Tea Department for granting permission to conduct the research. First author wishes to express his gratitude to Mr. Kumar barathi, manufacturing consultant (Low Country), Mr. Dasarath Dasanayake, manufacturing consultant (Uva high and Uva medium) of John keells PLC, for their grateful support throughout the research project.

REFERENCES

Anon. (2015a). Annual report 2015, Colombo, Sri Lanka Tea Board.

Anon. (2015b). Annual report of Central Bank, Colombo, Sri Lanka, Central Bank.

Anon. (2016). Black tea. Available from: http://www.the-color-of-tea.com/black-tea. html (Accessed 10 May 2016).

Muthugala, M.P.U.A. (2008). Evaluation of dhools out turn using roll breakers mesh no. of 3 and 4 combination in low country tea manufacture. In: proceedings of 7th Agricultural Research Symposium, 13-14 August, 2008, Makandura Wayamba University of Sri Lanka. 345-349.

Sivaram, B. (2002). Plantation Management in the New Millennium, M.D.H. Jayewardene Mawatha, Athurugiriya, Sri Lanka. 99-100.